ELEMENTS OF A PLANETARY EMERGENCY

Environment of Peace
Part 1

Lead author
Dan Smith

Contributing authors
Noah Bell, Jakob Faller, Victor Galaz, Albert Norström, Corey Pattison and Cibele Queiroz

Project led by
Claire McAllister

Secretariat
Noah Bell, Karolina Eklöw, Andrea Gadnert, Jannis Ruoff, Jürg Staudenmann and Caspar Trimmer

This project was funded by the Norwegian Ministry of Foreign Affairs, the Swedish Ministry for Foreign Affairs and the Swiss Federal Department of Foreign Affairs.

DOI: 10.55163/MDEB4357

Suggested citation
Smith, D., Bell, N., Faller, J., Galaz, V., Norström, A., Pattison, C., Queiroz, C., *Elements of a Planetary Emergency: Environment of Peace (Part 1)* (SIPRI: Stockholm, 2022), <https://doi.org/10.55163/MDEB4357>.

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About the Environment of Peace research report

This research report is a product of the Environment of Peace initiative launched by SIPRI in May 2020. It sets out the evidence base that provided the foundation for *Environment of Peace: Security in a New Era of Risk*, a policy report published in May 2022. The report is published in four parts—Elements of a Planetary Emergency (part 1); Security Risks of Environmental Crises (part 2); Navigating a Just and Peaceful Transition (part 3); and Enabling an Environment of Peace (part 4)—as outlined below.

Elements of a Planetary Emergency

This part, part 1, lays out the conceptual and evidential landscape for Environment of Peace. Led by Dan Smith, SIPRI Director, it brings together data on a wide range of indicators, showing that both security and environmental stresses are increasing. These include markers of decline in the natural environment: pollution, climate change, species loss and associated issues. On the security side, this part of the report provides data on 'hard' security questions such as militarization, the collapse of international arms controls and military spending, and on 'human' security concerns such as hunger and development. It considers the failures of governance to address these pressing crises and argues that the health of the global biosphere should be recognized as a core national security interest.

Security Risks of Environmental Crises

Part 2 shows how combinations of environmental and security phenomena are generating complex risks and discusses options for responding to them.

Navigating a Just and Peaceful Transition

Part 3 focuses on needed transitions towards sustainability and climate resilience, with special attention given to areas such as land use, energy and climate response.

Enabling an Environment of Peace

Part 4 examines the legal and institutional landscape within which the twin crises—and humanity's responses to them—play out.

Other related materials

Separate annexes assemble a number of in-depth case studies and other input papers that were commissioned to inform the research and analysis of the report. An annex corresponding to each part can be downloaded from the SIPRI website. A comprehensive overview of the report's four parts and the Environment of Peace initiative is also available at the SIPRI website.

1. ELEMENTS OF A PLANETARY EMERGENCY

1.1. Planetary emergency

We face a planetary emergency made up of a compound environmental crisis, in which climate change is prominent but by no means the only element, and a darkening security horizon. Behind them, linking to both, lies a chronic problem in deficient mechanisms and instruments for addressing these environmental and security challenges.

The planetary emergency is deepening as each year goes by, without any decisive action being taken to mitigate it. Communities across the world are already suffering the consequences of climate change and other forms of environmental deterioration, as well as of worsening insecurity, both separately and in combination. Thus, while this report spotlights a present danger, the problems of today may simply be the early stages of a growing global malady.

The twin crises of the environment and security are linked in multiple ways. This has long been understood. There were even passing references to peace and security at the 1972 Stockholm Conference on the Human Environment—one in the declaration and a handful in debate.[1] In 1977, a Worldwatch Institute paper systematically linked the issues, including the challenge to peace and stability of a changing climate.[2] Among other efforts to move this discussion forward, a major article in 1989 concluded that environmental change was like the discovery of nuclear fission in that it would be a key determinant of security and policy in the decades ahead, and—as Einstein had said about nuclear weapons—necessitated 'a substantially new manner of thinking if mankind is to survive'.[3] In 1990 the journal of the traditionalist Royal United Services Institute in London carried an article exploring the conflict and security implications and consequences of climate change.[4]

This report explores those linkages, some of which are subtle while others could hardly be clearer. An example of clear linkage is that 6 of the 10 largest United Nations peace operations and more than 80 per cent of UN peace operations personnel are deployed in countries recognized as being highly vulnerable to climate change.[5] If they do not take the impact of climate change into account, their work will be hampered and less likely

to be effective. More subtly and sometimes elusively, both in global forums and at more local scales, confrontational politics and a context of conflict and insecurity make it even harder than it already was—because of vested interests and competing policy priorities—to agree and cooperate on measures to slow down climate change and protect the environment.[6]

Understanding these linked risks constitutes the first step towards actions both to address the underlying causes at source and ameliorate the short-to-medium-term impact. In addition, identifying and understanding the risks may make it possible to reduce the chances that corrective action has unexpected, unwanted and negative side-effects.

Part 1 of the report outlines today's landscape of unfolding environmental crisis and security challenges. Seen through an environmental lens, this is the world the 1972 Stockholm Conference was convened in order to avoid; the conference's stated aim was 'to limit and, where possible, to eliminate the impairment of the human environment'.[7] Through a peace and security lens, as explained below, the past decade has been marked by rising dangers. And seen through the lens of human experience, the world is in the midst of a global pandemic that has touched us all in one way or another, exposing both our vulnerability and the inter-connectedness of all countries and societies.[8]

This report explores the problems and how they interact with each other, and sets out to answer the question of how to generate effective action to address the challenges discussed. Looked at the other way round, the question is also: Why has it been so hard to get that action going? As we shall see, the evidence of profound and wide-ranging harm to people due to the damage that human activity has inflicted on the natural environment is clear. The risks and consequences of armed conflict are likewise clear. And, as this report goes through the material, the linkages between these issues will become manifest.

One aspect of the problem is the way many people think, both reflecting and reflected in the model of economic development since the industrial revolution began. In just over two centuries, economic growth has drained natural resources and produced increasingly destructive consequences in the natural environment. While the exploitative and extractive human relationship with nature has generated enormous profits for some and economic opportunity and improvement for many, it imposes an unsustainable burden on nature and, in turn, upon us. Thinking about the human interaction with nature needs to recognize that, as humans, whatever our many differences, we are all also a part of nature. We are part of the biosphere. That is an old insight that modernity has obscured—we need to get back to it.

Similarly, there is a need to think differently about security and international relations compared to the norm prevalent in much of the world for at least two centuries and, in some accounts, for more than two millennia. State and national self-interest, understood in terms of power, form too shallow and narrow a foundation on which to base international policy

in a world challenged by far-reaching environmental crisis. Sustainability and cooperation have to move to the forefront. This could be seen as the fundamental insight that this report offers. The challenges to wellbeing, peace and security that come from political rivalries are real and profound, yet they are ultimately less significant than the challenges to wellbeing, peace and security that come from the environmental crisis our predominant model of economic development has produced.

Different realms of knowledge need to link up. Since the start of the Age of Enlightenment some three centuries ago, divisions between different branches of knowledge have widened and deepened to become self-isolating scholarly disciplines not only in Europe but throughout the world. This is no longer fit for purpose in a world of inter-connecting problems. The integrated solutions that are required are possible only if they have a multi-disciplinary foundation. That requires cooperation between exponents of different disciplines and a connective way of thinking.

Accordingly, different communities of thought and practice have to rethink and think together. They need to develop a shared vocabulary and set of basic concepts. Treating the environmental crisis and security as separate arenas, insulated against each other, is inaccurate, and policies based on that false assumption will be self-defeating. Likewise, it is no longer acceptable to pit environmental and economic benefit against each other. If a course of action is environmentally damaging, it will eventually be economically damaging too. The question is not whether we can afford environmental sustainability, but how anybody thinks we can do without it.

Although we face a planetary emergency and although corrective action is urgent, another necessary cognitive adjustment is to get beyond crisis thinking. In a crisis, temporary measures are required to fix the immediate problem—to staunch the flow of blood, plug the leak in the dyke, defuse the bomb. Facing up to the planetary emergency means acknowledging the need, beyond quick fixes, for action to be not only urgent but also persistent.

Within today's environmental crisis, climate change rightly garners a great deal of concern and attention. The crisis has built slowly. The increase in greenhouse gas (GHG) emissions has continued for two centuries. The identifiable rise in average global temperatures has continued for more than half a century. Changing economic, industrial, agricultural, construction and transport activities so that GHG emissions decline will take decades before a slowdown in global warming is clearly seen. And it will be decades more before the consequences that are stacked up in the natural environment have played out. This is part of the reason why measures to address climate change have been so hard to sell politically: the impact is slow and the results of any action taken are not immediate. However, on the one hand, it is also why action to reduce GHG emissions is acutely urgent and, on the other hand, why the impact of climate change on human security will remain a priority issue for many years to come.

Environmental and security challenges are in part a reflection and consequence of how key institutions—governments, not least—and actions relate to each other and to nature. Easing out of the current crisis means finding a different way for that multiplicity of relationships to be conducted—a different way of governing them, in short. Thus, cognitive shifts are a starting point for action and for transforming governance at multiple levels.

The next section of part 1 looks at how human interactions with the natural environment have damaged it and thereby ourselves. The section that follows then reports on the security dimensions of the planetary emergency, before the concluding section turns to matters of governance. Each of these is a complex issue, and so can only be summarized here—parts 2, 3 and 4 of the Environment of Peace report are tasked with picking up the connections between them and exploring them more deeply. In light of the recognition that different communities of thought and practice need to understand each other's issues and focus, it may be that a degree of patience is required on the part of the reader. Hopefully, those who focus on security issues will recognize the enormity of the environmental crisis depicted below, while those who focus on environmental questions will be willing to engage with the discussion of conflict, peace and security dilemmas.

The broad narrative here is a story of connectedness in the sense that:

- The biosphere is a network of interdependent fauna and flora of which we humans are a part and on which we fully depend;
- The inter-connectedness of the biosphere means that, where human activity has been damaging, negative consequences may cascade together;
- Similarly, the security space is characterized by inter-connected elements that link human security and wellbeing with political stability within and between states;
- Limiting and reversing the damage done to the biosphere so that people may thrive will require cooperative action between groups and between states that are currently adversaries; and
- Thus, two spaces—security and the biosphere—that are each characterized by complex inter-connections are also connected to each other.

The task of part 1 is to lay out this landscape, illustrating the connectedness of the issues but not saying much about the details of the linkages. That is the business of part 2. Part 3 builds on that to explore how the much needed economic transition to environmental sustainability carries risks that need to be anticipated and managed. Part 4 offers our answer to the question of what kind of governance is required in order to facilitate an environment of peace.

1.2. The environmental crisis and beyond

The dominant mode of thinking worldwide about the natural environment draws on the European Enlightenment tradition that tends to break problems down into component parts. Though more holistic views are found both in traditional societies and in environmental sciences—and were to be found, indeed, among some Enlightenment thinkers[9]—there is today a widespread tendency to think not of nature (except, perhaps, metaphorically) but of the oceans, the forests, the deserts, the different zones—polar, tropical, sub-tropical, temperate—and so on. Likewise, when thinking about the degradation that human activity causes in the natural environment, it is often convenient to compartmentalize issues (pollution, plastic bags, climate change, loss of wildlife). These are not, however, separate problems. They are closely related, inter-acting, causing and exacerbating each other. That is because the natural environment itself is a set of systems whose various components support each other. To think about the environmental aspect of the planetary emergency, we need to start by looking at the whole. This section, therefore, does not begin with climate change but gets to it in due course.

1.2.1. The biosphere

The Earth's biosphere encompasses all ecosystems (terrestrial, freshwater and marine) and their plant, animal and microbial life.[10] This resource base supports human wellbeing in all its dimensions. Accordingly, changes in the biosphere—for example, in the abundance, distribution or diversity of species—have profound implications for humankind. Too often, this relationship is depicted as if humanity and the biosphere are exterior to each other. In fact, humanity is one of the species in the biosphere. People, communities, economies, societies, cultures are embedded in the biosphere and part of what shapes it. At the same time, people, communities, economies, societies and their cultures are shaped by, depend on and evolve with the biosphere. Both sides of the relationship are visible in the climate, in agriculture, in health and in general wellbeing. Just as there is no economy without a society in which it is embedded, there is no society that is not embedded in the biosphere. For example, food, timber, fibre, clean air, drinking water and medicines can only be available given a functioning biosphere.[11] Regardless of human ingenuity and technology, human development cannot be decoupled from the biosphere.

The biosphere plays a key role in the rest of the Earth system, including stabilizing atmospheric carbon dioxide concentrations and thereby the global climate system. In 2021 the Intergovernmental Panel on Climate Change (IPCC) reported the estimate that some 56 per cent of carbon emissions since 1850 have been safely locked away in the land and the oceans.[12] Put another way, half our 'climate debt' is removed, for free, by the biosphere every year.[13] Accordingly, action to mitigate climate change must be integrated with protection of these 'carbon sinks' provided by the biosphere.[14] There are other

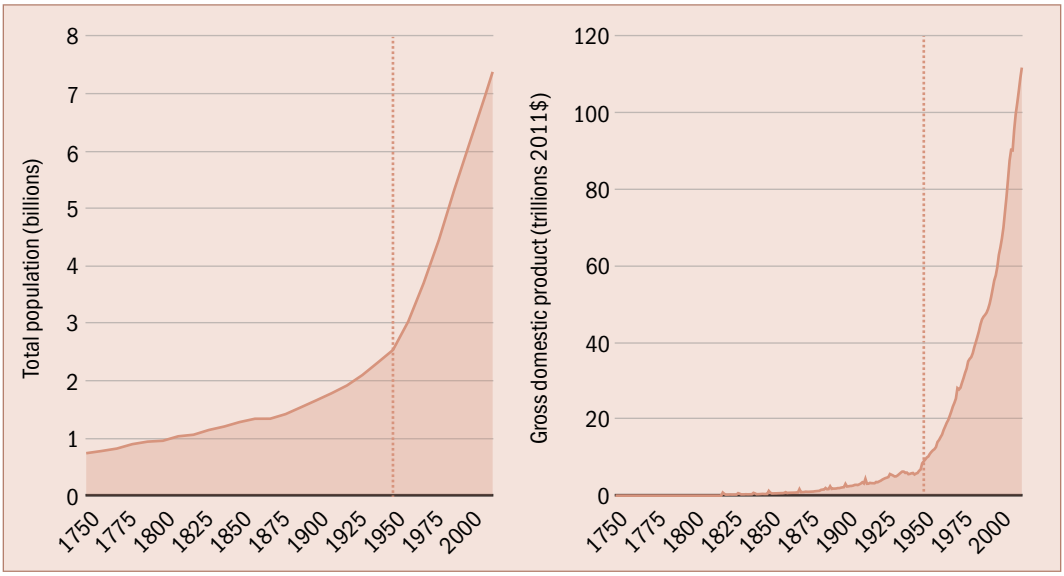

Figure 1.1. Global population and global gross domestic product before and after 1950, the year demarcating the 'Great Acceleration'

Sources: For global population 1750–1940: International Geosphere-Biosphere Programme, 'Great acceleration', Global Change, 2015; and 1940–2015: UN Department of Economic and Social Affairs, World population prospects 2019. For GDP 1750–2015: Bolt, J. and van Zanden, J. L., 'Maddison style estimates of the evolution of the world economy: A new 2020 update', Oct 2020.

important elements of the dynamic interplay between the biosphere and the atmosphere, the water cycle and biogeochemical cycles. For instance, the biosphere drives global biogeochemistry (e.g. carbon, nitrogen or phosphorus cycling between air, water and land), which affects global climate, soil fertility and ocean productivity.[15] The biosphere also moderates the water cycle, affecting where it rains, how heavily, how rainwater flows across the land and where it ends up, as well as influencing the rate at which it evaporates and returns to the atmosphere.[16]

The biosphere is thus a network of interactions, many of them as strange at first sight and as hard to grasp—yet surprisingly, even astonishingly, real—as the connections to be found between trees and the Earth's rotation, or between wolves' behaviour and the course of a river.[17] In this complex, delicate system, humanity is one species among 1.2 million that have been identified and an estimated further 7.5 million that are hitherto unidentified.[18] As a species, however, humanity is a big beast with an out-sized impact on the natural environment. Humans have altered 75 per cent of the world's land surface and had a major impact on 66 per cent of its oceans.[19] Since 1990 some 420 million hectares of forest have been lost (around 10 per cent of the total), primarily so that the land can be used for agriculture (though the rate of deforestation has decreased significantly in recent years, down to 10 million hectares annually compared to 16 million each year in the 1990s).[20] As a result, the 20th and 21st centuries have seen large declines in animal life—terrestrial, avian and aquatic, big and small, everything from large primates to insects. Reasons range from over-hunting and over-fishing, to loss of habitat as land is cleared for timber, settlement or agriculture, to chemical pollution. As a result, there has been a decline in what are often called 'ecosystem services',

meaning, roughly, the benefits people get from the natural environment, such as clean air, food and water.

The unfolding impact of human activity on the natural environment has not proceeded at an even pace. Globally aggregated datasets combining indicators of human activity and variables critical to the Earth system reveal a sharp increase in biosphere deterioration after approximately 1950.[21] This step-change, often known as the 'Great Acceleration', has been driven by economic growth over the 70-year period. The 2021 Dasgupta report on the economics of biodiversity summarizes what has happened:[22]

- World population in 1950 was around 2.5 billion and global gross domestic product (GDP) at 2011 prices was around $9 trillion; by 2019, global GDP was just over $120 trillion in 2011 prices and the human population was 7.7 billion people (see figure 1.1).
- The proportion of the world's population living in extreme poverty was nearly 60 per cent in 1950; today it is less than 10 per cent (though it increased in 2020 and 2021 as a direct result of the Covid-19 pandemic).
- The global average for life expectancy in 1950 was 46 years; today it is around 73.

To sum up this extraordinary story, over seven decades—a drop in the ocean of human time, let alone planetary time—population has trebled, economic output has risen 13-fold and average life expectancy has increased by 50 per cent. Thanks to the most successful period in economic history if measured by output, more people live longer and better than ever before.

The statistics above are, of course, averages that mask wide variations. The Central African Republic (CAR) has the lowest average life expectancy of any country; at 54 years, it is some 31 years lower than Japan's, which is the highest.[23] Yet CAR has a higher average life expectancy than any country had in 1800, at the start of the industrial revolution.[24]

We look at the impact of social inequality on security and peace below (see section 1.3.6). The process of poverty reduction has produced uneven results and has been neither smooth nor steady. In 1820 some 75 per cent of the world population lived in extreme poverty—an estimated total of 756 million people. The proportion dropped to about 60 per cent by the end of the 19th century and was not much lower till the mid-1950s; although the proportion then started to fall more quickly, the numbers of extremely poor people increased, reaching 2 billion by 1995.[25] Thereafter, the fall in both the proportion and number of extremely poor people accelerated. By a statistical quirk, although the proportion of extremely poor was down to 10 per cent by 2018, the number was 764 million—barely different from the figure two centuries earlier.[26]

However we assess the social balance sheet of progress and injustice, the further problem is that the cost for nature has been spectacularly high.

Success in the economic sphere is destroying the biosphere, on which we all depend. The sixth mass extinction in the planet's history is well under way.[27] The 2019 global assessment report on biodiversity and ecosystem services showed that an average of around 25 per cent of species in assessed animal and plant groups are threatened; the rate of extinction is between tens and hundreds of times higher than it has averaged over the past 10 million years.[28]

The focus on the loss of biodiversity (how many different species there are), which is reasonably well covered in popular news media, may to some degree distract attention from the loss of biomass (how much animal and plant life there is). The latter is not so well covered but is at least equally important. It has been estimated that 83 per cent of wild mammal biomass has been lost since the dawn of human civilization.[29] More recently, the abundance of wild vertebrates (fish, amphibians, reptiles, mammals and birds) fell by 60 per cent between 1970 and 2014.[30]

Concern about animal life understandably focuses on large mammals and birds but the bulk of animal life consists of invertebrates like insects. They are vital for ecosystem function and indispensable parts of the networks and interactions through which our food is generated—they control pests, pollinate plants and recycle nutrients.[31] Detailed local observations over almost three decades reveal local declines in flying insect biomass of over 75 per cent.[32] Decline in the biomass of insects and spiders in rain forests from the mid-1970s to the early 2010s has been estimated at between 75 and 88 per cent depending on the time of year.[33] In sum, research has identified a multi-continental crisis of insect biomass and diversity,[34] which some researchers refer to as an 'insect apocalypse', though there remain many gaps in knowledge about it.[35] Indeed, knowledge about current and historical biomass of all kinds is strikingly incomplete.[36] Among the things that we do know, about 75 per cent of crop types grown by humans require pollination by insects. The annual economic value of this service is variously estimated at between $235 and 577 billion.[37] Its full human value may be incalculable, but a fact of which we can be sure is that humans are being systematically careless about it.

1.2.2. Biosphere degradation and human health

Human mistreatment of the biosphere has implications for our health, through direct and indirect consequences alike. Changes in land use interact with climate change and loss of biodiversity to increase our exposure to infectious disease, including through water-borne diseases, scarcity of food and water, and natural disasters.[38] There is also a serious impact on human health through non-infectious diseases.[39] Much of the ill-health impact of environmental deterioration is due to pollution and loss of ecosystem services.[40] The quality of health service provision varies widely between and within countries, especially on the basis of wealth and social class and the impact is greatest where health services are weak.[41]

Chemicals and plastic can be grouped together under the heading of 'novel entities' in the natural environment, meaning new materials not previously known in nature, as well as some naturally occurring elements that have been displaced by human activity such as mining. The production and presence of novel entities has exceeded the limits estimated as the planetary boundaries needed for safe operation and sustainability.[42] We can begin unpacking the issue by looking at waste nominally defined as non-hazardous.

Worldwide, about 2 billion tonnes of non-hazardous waste is produced annually; the figure is forecast to increase to almost 3.5 billion tonnes by 2050.[43] Currently, the world recycles or composts about 19 per cent of that waste and half of the rest (about 740 million tonnes annually) is put in landfills.[44] The biggest problem with non-hazardous waste is plastics—indeed, it is questionable whether the term 'non-hazardous' is appropriate in this context. Since the Great Acceleration began in 1950, the world has produced an estimated 8.3 billion tonnes of plastic.[45] Depending on its type, size and the features of the environment where it is stored or abandoned, plastic may take anything from a couple of years to several centuries to perhaps millennia to degrade.[46] Microplastics—tiny plastic particles—are everywhere. They invade the bodies of fish, birds and terrestrial animals, including humans, who have been estimated to consume in the vicinity of 50 000 microplastic particles each year;[47] they have been found in the placenta of pregnant women and in breast milk.[48] Studies agree that there are serious grounds for concern about the toxic effects of microplastics but there is a lack of precise knowledge about their effects.[49] Ocean currents pull microplastics into enormous areas of soupy pollution; the extent of the soup in the North Pacific, often known as the Great Pacific Garbage Patch, was estimated in 2018 to be 1.6 million square kilometres,[50] which is about three times the size of France or twice the size of Texas in the United States.

Chemical pollution has widespread effects on air quality, water and soil, yet it is under-researched. Humans encounter thousands of pollutants in our food and water intake; through workplace exposure to toxic chemicals; as by-products of industry, transport and energy production; through agriculture; and from ingredients and materials used in detergents, textiles, cosmetics, construction materials and furniture.[51] According to a 2017 UN report, only a few of the tens of thousands of chemicals on the market have been thoroughly analysed for their effects when released into the environment.[52] The same publication reports that, among the effects we are aware of, more than 100 000 people die annually from exposure to asbestos, while lead in paint is known to affect the IQ of children. Further effects from pollutants include neurological damage and cell mutation, weakened immune systems, digestive disorders and pulmonary disorders. Another growing concern is the use of antibiotics in farming, which is thought to be driving the emergence of bacteria resistant to anti-biotic medication. This has serious implications for human health, though some research finds it hard to identify negative clinical outcomes.[53]

The 2017 UN report rated poor air quality as the greatest global environmental risk to health.[54] Some 90–95 per cent of the world's population breathe outdoor air that is polluted beyond the acceptable standards set by the World Health Organization (WHO).[55] Some air pollutants, including black carbon and ground-level ozone, contribute to climate change and affect ecosystems. Climate change exacerbates air pollution by creating conditions in which pollution disperses slowly. The main sources of air pollution are fossil fuel emissions, transport, industrial furnaces, brick kilns, agriculture, domestic solid fuel heating, burning waste materials and wildfires. Indoor air pollution is also a lethal health issue, though death rates are declining as more households get access to non-toxic energy sources such as gas and electricity for cooking.[56] By contrast, deaths from outdoor air pollution have increased by some 57 per cent this century; the death toll in 2019 was 4.5 million people.[57] Air pollution can affect every organ in the body.[58] It causes mental ill health and disorders including depression;[59] increases the risk of premature birth;[60] and is associated with reduced fertility.[61] Moreover, there is clear if not yet conclusive evidence that it increases the risk and incidence of dementia among those aged 50–79.[62]

Soil pollution is particularly important because an estimated 95 per cent of food is directly or indirectly produced on our soils.[63] It is defined as the presence in the soil of chemicals and other substances that are out of place or in abnormally high concentrations.[64] It happens both accidentally (e.g. toxic leakages and oil spills) and deliberately (e.g. pesticides used to increase farm output). With a growing global population, agricultural production needs to increase by as much as 70 per cent globally by 2050 to meet needs and demand, but 33 per cent of the Earth's soils are already degraded by erosion, salinization, acidification and chemical pollution.[65] By 2050, over 90 per cent of the planet's land surface could be degraded.[66] A 2016 UN report cited a death toll of 3.3 million in 2013, especially among impoverished rural workers, due to excessive exposure to and inappropriate use of pesticides.[67]

The health risks produced by damage to the biosphere go beyond the effects of pollutants. An estimated 4 billion people rely primarily on natural medicines for healthcare, while about 70 per cent of the drugs used to treat cancer are either natural products or, if synthetic, were first identified because of the effects of natural products and inspired by them.[68] The loss of biodiversity and biomass is a clear, direct health hazard.

Worse, infectious disease risks are dynamic and subject to multiple and complex drivers. Deforestation, urbanization and construction of new water infrastructure are continuing features of contemporary economic life; they spawn zoonotic pathogens, which are a significant cause of emerging and re-emerging infectious diseases, such as coronaviruses, avian influenzas and the West Nile virus.[69] The risks of vector-borne infectious disease (meaning, essentially, diseases spread by the bite of small, invertebrate animals such as insects) are affected by changing temperatures and sea-level rise. The geographical distribution of African trypanosomiasis disease is predicted to

shift due to temperature changes induced by climate change. Biodiversity loss may lead to an increase in the transmission of infectious diseases such as Lyme disease, schistosomiasis, Hantavirus and West Nile virus.[70] Estimates indicate that increasing temperatures could expose more than 1.3 billion new people to the risk of Zika virus by 2050.[71]

1.2.3. Climate change

The facts are simple and brutal. By 2021, taking the average global temperatures over the course of a year,

- 19 of the 20 hottest years on record had occurred since 2000;
- 29 of the 30 hottest years on record had occurred since 1990;
- 38 of the 40 hottest years on record had occurred since 1980.[72]

In short, each of the last four decades has been hotter than the previous one.

Global warming and climate change are at the forefront of many—perhaps most—people's thinking about environmental deterioration. To date, the deepest damage inflicted on the biosphere probably arises from changes in land use due to agriculture and the felling of forests for timber and land clearance, and from over-fishing. Looking ahead, however, climate change poses the biggest risk to the biosphere, and therefore to humanity, and its impact is already being felt in a variety of ways. As already discussed, the climate is a critical influence on the biosphere, defining how long the air holds pollutants, for example, and influencing the availability of water in any area, thus determining the habitat that the locality offers to flora and fauna. As the climate changes, areas become less habitable to some species and more so to others, possibly interrupting food chains by introducing or removing predators. Insects such as mosquitoes and other small creatures that are vectors for disease may migrate to new areas where people are less prepared for the infections they carry.

The first instalment of the Sixth Assessment Report (AR6) of the IPCC was published in 2021.[73] It reflects, as its five predecessors did, the latest state of scientific knowledge and thought on what is happening in climates around the world. From one Assessment Report to the next, the science that each one collates has developed. More is known, more is understood and, with the passage of time, the scientific models of how climate change would unfold have been tested in practice. Based on the latest climate science and evidence, AR6 concluded that climate change is now an unequivocal fact and that the measurable global heating is human-made (anthropogenic), causing widespread, rapid changes to the Earth's oceans, ice and land surface, and the biosphere. Advances in knowledge mean that, for the first time, the IPCC

states unequivocally that human activity is influencing the climate system.[74] There is, in short, no room for doubt or scepticism.

The IPCC finds that global concentrations of carbon dioxide, methane and nitrous oxide—the main GHGs—have increased to levels unprecedented in at least 800 000 years. It also expresses 'high confidence' that, within that picture, current levels of carbon dioxide have not been experienced for at least 2 million years.[75] As a result of these GHG emissions, the global average surface temperature in 2010–19 was 1.1°C higher than the average for 1850–1900 (often referred to as the pre-industrial level).[76] This is the highest global average temperature since the human species first emerged. It is important to note that the 1.1°C average is made up of 0.9°C warming on the ocean surface, while the global land surface—where people live—has heated up on average by 1.6°C.

Climate change is now occurring rapidly, with global mean surface temperatures warming at a rate of 0.1–0.3°C per decade.[77] Sea-levels are rising more quickly and extreme storms are occurring more frequently than models anticipated even a few years ago.[78] In the Southern Hemisphere, the intensification of winter storms has already reached levels that were projected to occur in 2080.[79] New records and unprecedented events have become frequent, such as the first ever recorded rainfall on Greenland's highest peak in 2021 and the melting of enough ice in Greenland in one day to cover the US state of Florida (70 000 square kilometres) in 5 centimetres of water.[80] Based on current trends, by the early 2030s the global average temperature will have increased by more than 1.5°C compared to pre-industrial times, the limit aimed for in the 2015 Paris Climate Agreement.[81]

Human-induced climate change now affects weather in every region across the globe. Everywhere, the current climate 'is already distinct from the climate of the early or mid-20th century'.[82] Recent advances in climate science have made it possible to start answering the tricky question of attribution; that is, knowing whether a specific event—such as a hurricane, drought or heatwave—is in a knowable sense *caused by* or *attributable to* climate change. Attribution is especially clear for heatwaves, heavy rainfall, droughts and tropical cyclones. The severe heatwaves in Siberia (2020) and in western Canada and the USA (2021) would have been nearly impossible without the climate crisis.[83]

Extreme weather, made more frequent by climate change, is having devastating impacts in both industrialized and developing countries. Areas where drought has always been a major concern, such as the Horn of Africa, are experiencing even longer dry periods. While attributing the cause of individual droughts to climate change has been contentious, the rate of drying in the Horn of Africa is unusual in the context of the last two millennia and, if nothing more, coincides with recent global and regional warming.[84] As time goes by, the climate change signal is getting clearer.[85]

Rainfall volatility confounds farmers' expectations about seasonal rains, with wet seasons starting earlier or later and often being shorter and more

intense. This has effects on food security (on which, see more in section 1.3.6). Climate change is increasing the proportion of the growing world population exposed to flood risk,[86] with, for example, millions dislocated in different parts of Asia due to major floods. In 2022 Pakistan faced floods that displaced 33 million people and killed more than 1200.[87] In July 2020 seasonal flooding in China led to the temporary displacement of more than 40 million people,[88] and in June and July the following year flooding was almost as severe.[89]

In 2022 China experienced a record heatwave and consequent drought, while Europe's heatwave and drought led to the European Commission warning that 'the current drought still appears to be the worst since at least 500 years'.[90] Since 2017 wildfires have hit western USA, Australia, Bolivia, Brazil, southern Europe and Russia. Wildfires are made more intense and frequent by climate change, although continued land clearance for agriculture means the total area of land hit by wildfires is actually falling as available burnable land diminishes.[91] Surges in local sea level when storms and hurricanes occur are also on the increase due to climate change.[92] A 2019 report by the IPCC concluded that historically rare (once a century) extreme sea-level events are likely to occur at least once a year in many places by 2050.[93]

Research studies in recent years have consistently reported that climate change is a health hazard.[94] Rising temperatures are themselves a cause of ill health, regardless of storms, wildfires, floods or droughts. The heatwave in Europe in 2003 killed more than 70 000 people,[95] while the heatwave in India and Pakistan in 2015 killed at least 3500.[96] Of particular concern in the latter case was the observed wet bulb temperature (TW), which measures the combination of heat and humidity. It has generally been estimated that the maximum habitable TW level is 35 °C, though some recent experiments suggest the limit of human adaptability may be significantly lower than that.[97] Until recently, climate modelling forecast that a TW of 35 °C would start to occur in currently inhabited regions around 2050. However, some coastal regions have already experienced TW above that level. More generally, the frequency of extremes of heat and humidity has more than doubled compared to 40 years ago.[98]

Further direct health effects of climate change include the increasing incidence of noncommunicable maladies such as respiratory and cardiovascular disease,[99] and the impact of extreme heat on the risk of premature births and birth defects.[100] Climate change also alters the spread of climate-sensitive infectious diseases, increasing the infectious capacity of some disease vectors such as mosquitoes, ticks and parasites.[101] In addition, climate change affects water and sanitation, leading to malnutrition and food insecurity.[102] Climate variation and extreme weather are among the leading causes of severe food crises, second only to violent conflict; the cumulative effect undermines all dimensions of food security, including availability, access, utilization and stability.[103]

These consequences of climate change for human wellbeing have developed and deepened because earlier opportunities to address them have not been taken.[104] The basic science and data showing that global warming was occurring and would result in climate change were essentially in place by 1979,[105] well before the IPCC was set up in 1988. Although the most recent overall report by the IPCC, AR6 in 2021, is particularly dramatic in its findings as well as unequivocal about the core science, previous Assessment Reports have drawn essentially the same picture. There have been some areas of doubt about details and, as it turns out, some of the estimates of how fast climate change would unfold have been understatements. The conclusions of the successive Assessment Reports have, however, repeatedly offered a scientific basis for action. However, even when the world has agreed on the need for action, as it did in the Paris Climate Agreement in December 2015, it has found it extraordinarily difficult to follow through.

These decades of inaction have had two further consequences. First, many changes due to GHG emissions can be expected to be irreversible for centuries or even millennia, especially in the ocean, ice sheets and global sea level. In short, global warming and climate change are creating a new world. Even if global GHG emissions are reduced, global warming and its climate impact will continue for decades. Even if global temperature rise is not just stopped but put into reverse, so the average temperature returns to 1850–1900 levels, the natural world may not return to its 19th century condition.[106]

Second, while there is still a chance to limit global warming to 1.5 °C above the pre-industrial level, and thus well below the 2 °C mark, the action required to achieve this becomes more radical and transformational with each year of delay. For the world to stay below 2 °C warming, with the long-term aim of gradually decreasing global average GHG concentration starting in the late 21st century, GHG emissions must halve by 2030 and be at net zero by 2050. To do this, there is no alternative but to completely phase out fossil fuel emissions—given the technologies for carbon capture are limited, this essentially means abandoning fossil fuels.[107]

The scale of the task is daunting, not least because of the enormous economic interests invested in fossil fuel production and use around the world. The social and economic dimensions of the task, and therefore its political ramifications, are profound. This only goes to underline the importance of understanding the links between these elements (see part 2 of this report), and appreciating that the scale of the necessary transformation will generate risks that will need to be anticipated and managed (see part 3).

1.2.4. Resources, resources

The era of the Great Acceleration since 1950 is characterized, as discussed above, by an extraordinary increase in economic output and, by many indicators, improvements in human wellbeing. While the human population has trebled during this period, the annual global extraction of raw materials has increased at twice the speed—sixfold.[108] Despite a distinct increase in

the use of raw materials from the 1850s onwards, for about a century it was broadly in line with population growth. Since around 1950, though, increasing use of raw materials has been driven primarily by rising incomes and consumption in the industrial world.[109]

Along with population growth, a key demographic trend of the current era is urbanization. Until the industrial revolution, the global population was overwhelmingly rural—according to various estimates relying on different definitions of 'urban', towns and cities were home to just 3–7 per cent of humanity when the world population passed the one billion mark in about 1810.[110] As the Great Acceleration started, the world's urban population was about 750 million people, some 30 per cent of the total.[111] Around 2007 the urban population surpassed 50 per cent of the world total—about 3.4 billion people out of 6.7 billion[112]—and on current projections this percentage will grow to about 70 per cent by 2050.[113] Much of the urban infrastructure required to accommodate this demographic trend has not yet been built, and if it is constructed using today's technologies, the consumption of raw materials by cities is expected to more than double by 2050.[114]

The relentlessness of this consumption of resources is unsustainable. One basic resource is water. Enormous amounts are needed to build cities, though agriculture continues to account for the majority of freshwater use (about 70 per cent of the total).[115] Over the past century, global water use has increased, according to various estimates, six-to-eight-fold.[116] Its use continues to grow by about one per cent a year and, without changes in current practices, will keep on growing due to population growth and urbanization as well as increased economic output and consumption. At the same time, the pesticides and chemical fertilizers that make increased food production possible are affecting both the soil and the water table.[117] The dangers lurking in the water are multiplied because most municipal wastewater in developing world cities goes untreated, creating significant public health risks.[118]

Combining this with the effects of climate change means that security of supply of water is increasingly aspirational for much of the world's population. The UN's definition of water security is cumbersome but instructive, emphasizing access to adequate quantities of water that is of acceptable quality for supporting human health and wellbeing, and preserving ecosystems.[119] Defined thus, every aspect of water security is endangered:

- About 4 billion people—representing just over half of the global population—experience severe water scarcity during at least one month of the year.[120]
- Just over 3 billion people—about 40 per cent of humanity—live in agricultural areas with high to very high levels of water shortages or scarcity.[121]
- About 2.3 billion people—just under 30 per cent of all of us—live in water-stressed countries, and 733 million live in countries where water stress is already critical.[122]

- There are 1.2 billion people—roughly one-sixth of the world population—who live in agricultural areas characterized by water scarcity.[123]
- In 2020, 771 million people lacked access to basic drinking water services.[124]

1.2.5. Tipping into the Anthropocene epoch

For more than a decade now, researchers have noted that the human impact on the biosphere is increasing the occurrence of 'tipping points'[125]—large, abrupt and persistent critical changes in ecosystems. These can be seen in diverse locations and at scales ranging from the local to the global, resulting in the loss of ecosystem services that have hitherto underpinned livelihoods, commerce and development.[126]

Exactly when future tipping points might be encountered is hard to predict. While climate science has made advances is this area, reflected in the IPCC's AR6, no clear dates or deadlines have yet emerged. The timing is obscure—not only as to when tipping points will be reached, but how long they will take, so to speak, to tip—because what is involved are the combined consequences of shifts in different ecosystems.[127] The idea of tipping points thus reflects the inter-connectedness that is a fundamental characteristic of the Earth system. Everything links to something else and, as a result, the system as a whole is relatively robust. Once damaged, however, the consequences unfold in cascades. Nature has proven to be a lot more durable than a house of cards but, if and when parts of it are fatally damaged, that may well be how collapses happen. Further, when tipping points are crossed, the change is likely to be irreversible.[128]

This directs attention towards 'tipping elements'—those parts of the Earth system that are particularly susceptible to tipping, such as melting sea ice and the Greenland and Antarctic ice sheets; changes in ocean and atmospheric circulation; and loss or alteration of critical flora, such as the large forests in the Amazon region and boreal forests in Russia and Canada.[129] Deforestation is closely linked to climate change, a significant consequence of which is melting ice. This gives weight to the warning from some research that if the global average temperature reaches 2 °C above the pre-industrial level, that might in the worst case be enough to cross a point of no return.[130]

Recognition of the breadth and depth of human influence on the biosphere, its aspects of irreversibility and relative newness in the history of humanity, let alone the planet, has led some scientists to regard it as the defining characteristic of a new epoch—the Anthropocene.[131] This succeeds the Holocene, the label given to the epoch of the past 12 millennia. The idea that the Anthropocene label is appropriate for this epoch was first proposed in a brief academic newsletter article in 2000,[132] and was eventually adopted by the International Union of Geological Sciences in 2016.[133] While there are multiple nuances in how the term is used, the common core meaning is

simply that human activity has become the major influence on the natural environment.[134]

The dating of the Anthropocene's onset continues to be discussed, along with the trigger event that brought it about. One line of thought favours the start of the industrial revolution—around 1800—while others opt for around 1945.[135] Though assigning a precise date may be a fruitless exercise, it seems logical to identify the approximate start date of the new epoch as sometime about 1945–1950—the dawn of the nuclear age, the plastic age and the Great Acceleration.

Many of the environmental events that lie ahead will be unprecedented.[136] This is a new world, or at least a new age, and as such is not yet fully understood. There is a possibility, even likelihood, that local events will have a widely dispersed and even global impact. For example, deforestation in the Brazilian Amazon region, by triggering changes in rainfall patterns, could affect maize yields in much of Latin America, with severe implications for food security.[137] Similarly, altering hydrological systems for agricultural purposes can have large, lasting and negative effects on the ecosystems necessary for agricultural productivity.[138] These knock-on effects are often thought of as reflecting systemic risk.[139] A combination of changes in the natural environment and human activity—agriculture, fishing, urbanization, industry—can have unexpected, interlocking effects that link geographically distant regions to each other.[140]

Abrupt and irreversible changes are, however, not limited to biophysical and ecological systems—social systems are also implicated.[141] Looking ahead, climate feedbacks of the kind that may be experienced after the 2 °C level of additional warming is passed could lead to heavy social stresses on, for example, people living in coastal and tropical regions.[142]

The Stockholm Resilience Centre has promoted the idea of 'planetary boundaries' to depict the scale of the risks being taken with the natural environment (see figure 1.2).[143] The nine boundaries are the limits on stratospheric ozone depletion; loss of biodiversity and biomass; the polluting effect of novel entities (e.g. chemicals, plastics); climate change; ocean acidification; freshwater use and changes in the global hydrological cycle; changes in land use; disruption to the cycles of nitrogen and phosphorus; and air pollution. Within these boundaries there is a 'safe operating space'; outside them are dangers we can glimpse but, because they are unprecedented, not fully grasp. In other words, the areas outside the boundaries of safety are where the Anthropocene's risks emerge and grow. As of 2021, five boundaries have been breached, three remain within the safe zone, and one has not yet been calculated.[144] Discussion continues about the concept of planetary boundaries, which may lead to the definitions and list of boundaries being refined. As an idea still in development, it has two significant benefits. First, it makes clear what we do not know—that is, what happens beyond the boundaries and, once they have been breached, how the different areas of damage will interact. Second, it offers a way of measuring the overall

Figure 1.2. Planetary boundaries

BII = Biodiversity Intactness Index; E/MSY = extinctions per million species-years; P = phosphorous cycle; N = nitrogen cycle; Novel entities = toxic and long-lived substances such as synthetic chemical pollutants, heavy metals, and radioactive materials.

Notes: The planetary boundaries concept looks at nine processes that are essential for environmental integrity. For each, it uses scientific evidence to assess whether the trend has gone so far as to cross the boundary of a 'safe operating space for humanity'. Crossing the estimated boundaries increases the risk of triggering large-scale abrupt or irreversible environmental changes.

Sources: This version is based on the original illustration designed by Azote for Stockholm Resilience Centre, based on analysis in Persson, L. et al., 'Outside the safe operating space of the planetary boundary for novel entities', *Environmental Science & Technology*, vol. 56, no. 3 (Feb. 2022); and Steffen, W. et al., 'Planetary boundaries: Guiding human development on a changing planet', *Science*, vol. 347, no. 6223 (Feb. 2015).

deterioration in the biosphere, or conversely, if corrective action is taken, the progress made in limiting or even restoring the damage that has been inflicted.

1.3. Peace, security and international politics

The international security horizon is every bit as concerning as the condition of the natural environment. While the timescale for the development of these two crises is different by an order of magnitude, their negative effects are nonetheless coinciding in our time. As this section shows, after an

improvement in international security in the 1990s following the end of the cold war, the years since 2010–11 have seen more armed conflicts, higher military spending, an expanding volume of international arms transfers and a crisis in nuclear arms control. There have been regional flashpoints and confrontation in every region except the Americas, as well as an increasingly sour tone in global geopolitics. These challenges are the standard concerns of security policy and strategic studies, traditionally placed in different categories of thought, official policy and action compared to the impact of environmental change discussed above. That distinction, however, is increasingly unsatisfactory in the light of today's realities.

There has long been recognition that the traditional security concept is too narrow. Even traditional security organizations have acknowledged as much, as the North Atlantic Treaty Organization (NATO) did in 1991, for example, with its 'new strategic concept', treating conflict prevention and the political management of crises as the core business of the future.[145] The decisive broadening of the agenda came in 1994 when the UN's Human Development Report introduced the human security concept, centred on the need to achieve 'security in the daily lives of the people'.[146] This has added human security—sometimes known as soft security—to the vocabulary, sometimes alongside and sometimes pitted against what is variously called state, national or hard security.

The human security and traditional security concepts are often treated as fundamentally different: one puts the people's needs ahead of the state's, and the other puts the state at the centre. This dichotomy, however, is not the whole story. Seen from one angle, the point of a state's security policy is to ensure the wellbeing of a country's citizens, thus contributing to their human security.[147] This relationship also works the other way round—issues of human security that do not feature in thinking about military preparations can nonetheless have traditional security consequences. The weakening of local ecosystems, which reduces food production and livelihood security, can lead to increased conflict over basic resources. For instance, while far from the whole explanation, pressures caused by drought and poor water management are an important element in how the wars in Syria and Yemen came about.[148]

The overlap between human and hard security is visible in other ways. Crime, for example, regularly accompanies civil armed conflict both as a precursor and an aftermath, and everything in between, as disease also often does. Moreover, as explored below, the scale of the Covid-19 pandemic has implications for both human and hard security. This suggests that neither the vocabulary of human security nor that of traditional security is telling the whole story, though both concepts address important parts of the whole. In war-torn, pandemic-ridden, cholera-attacked, water-insecure, poorly governed Yemen, for instance, the full range of threats to people's wellbeing and security need to be addressed. In such cases, a crisp distinction between human and traditional security acts as an obstacle to consistent and effective policy. It could lead, in the name of security, to actions that shore up some aspects of

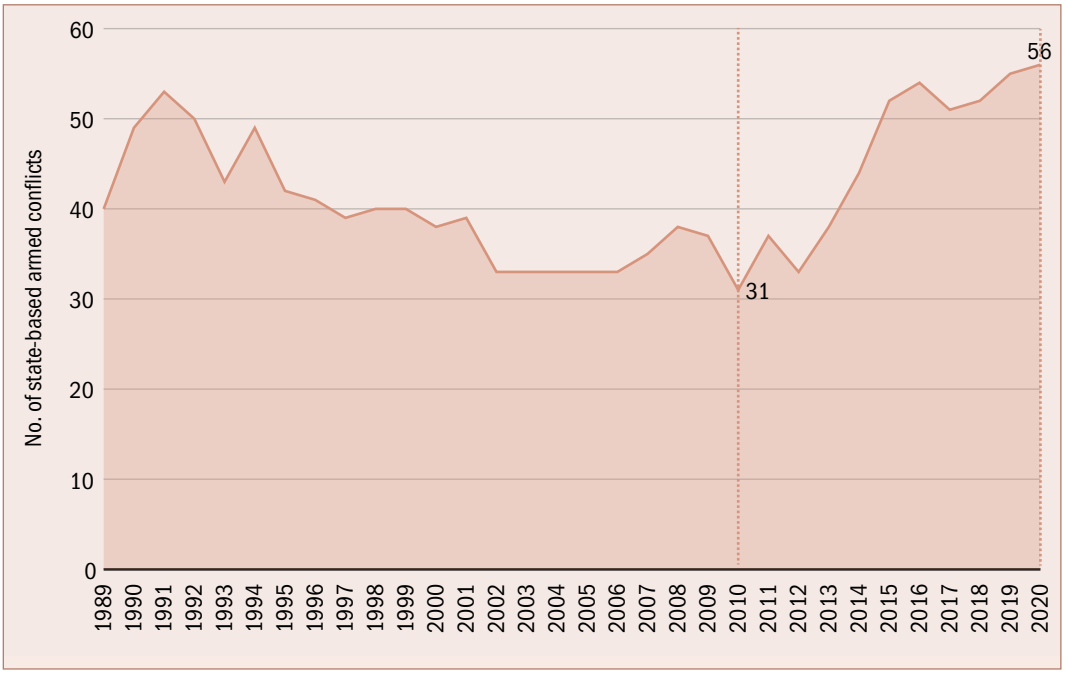

Figure 1.3. Number of state-based armed conflicts between 1989 and 2020

Sources: Uppsala Conflict Data Program; Pettersson, T. et al., 'Organized violence 1989–2020, with a special emphasis on Syria', *Journal of Peace Research* (July 2021); and Gleditsch, N. P. et al., 'Armed conflict 1946–2001: A new dataset', *Journal of Peace Research*, vol. 39, no. 5 (Sep. 2002).

governance while neglecting other critical areas, thereby weakening health services and obstructing sustainable hydro-policy.

There is one security space in which a multiplicity of different kinds of policies and actions contribute either to strengthening peaceful prospects or weakening them. This section explores that space. It begins by looking at the casualties of violent conflict including the natural environment, then the types of conflict, before looking at armaments, and then geopolitics, drivers of insecurity and the meaning of the concept of security in today's world.

1.3.1. Casualties of violent conflict

During the first decade of the 21st century, there was a good news story that mostly went untold: the world's zone of peace expanded. According to the Uppsala Conflict Data Program there were around 50 state-based armed conflicts in 1990 (see figure 1.3). This number rose over the course of the following half decade due to the wars of Yugoslavia's disintegration, the Soviet Union's break-up and conflicts in parts of sub-Saharan Africa. Following this, the number of armed conflicts each year began to fall, to around 30 in 2010.[149]

This 40 per cent decrease in the incidence of armed conflict was, however, barely reported at the time, the main exception being the 2005 and 2010 editions of the Human Security Report.[150] The reports pointed out that not only were there fewer armed conflicts in the years following 1995 but they were on average shorter and less lethal than in previous decades. They attributed this to the greater freedom of action enjoyed by the UN because

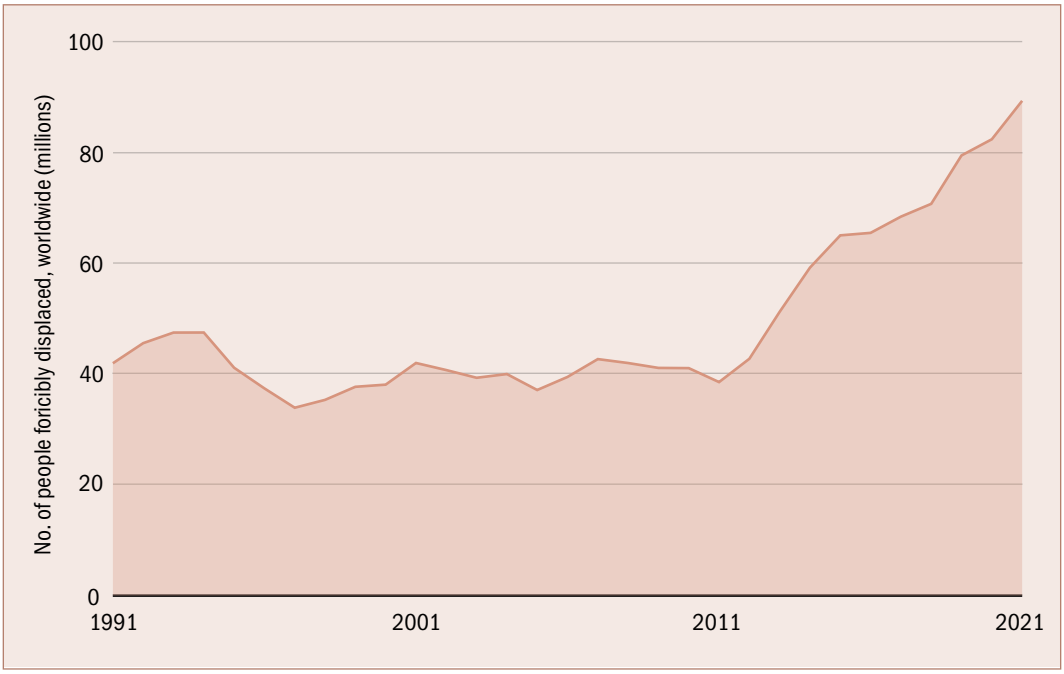

Figure 1.4. Total population forcibly displaced, worldwide

Source: United Nations High Commissioner for Refugees (UNHCR), 'UNHCR global trends 2020', 18 June 2021.

action by the Security Council was no longer inhibited by cold war relations between the USA and the Soviet Union. Unfortunately, this positive trend bottomed out around 2007 and since 2010 there has been a sharp annual surge in both the lethality and the annual number of armed conflicts, which was 56 in 2020—higher than the 1990 level.

Data on war deaths is full of uncertainties. As far as can be determined, war deaths approximately doubled in the second decade of the 21st century compared to the first, primarily due to warfare in Syria. Even so, the number is much lower over the past 20 years than for much of the period since the end of World War II.[151] The declining number of deaths per war reflects the changing motives and tactics of many fighting forces, which we return to below.

As figure 1.4 shows, the number of refugees and other people forcibly displaced by conflict, violence and persecution has been climbing sharply over the past decade. In 2021 there were 89.3 million forcibly displaced people—more than 1 per cent of the world's population[152]—compared to 41 million in 2010.[153] In other words, the second decade of this century saw a doubling of the number of people forced to flee their home and often their country for fear of violence and repression.

1.3.2. The environmental impact of violent conflict

The environmental impact of violent conflict varies greatly, depending on the scale, duration and form of combat (whether cities are attacked, for example).[154] When urban areas are bombed or hit by missile strikes or artillery, buildings are pulverized and large volumes of dust—containing a variety of materials such as cement, metals and industrial compounds—generated. This

dust is easily ingested and poses a severe health risk.[155] Attacks on oil facilities and chemical plants throw up lethal additions to air pollution and can also pollute freshwater and marine resources.[156]

In the rural setting, deforestation is a frequent consequence of armed conflict. Two common reasons for this are, first, communities need to use more local wood than normal for fuel as other supply sources dry up, and, second, fighting groups may contribute to over-logging for their own needs[157] or to sell for profit.[158] However, one of the best-known and most striking examples of deforestation in war is the use of Agent Orange by the USA to remove forest cover during the Vietnam War in the 1960s and 1970s.[159] The use of chemical herbicides in this way is now illegal under international humanitarian law,[160] one of a range of rules limiting military impacts on the natural environment during wartime that are part of customary international law.[161]

However, the regulation of actions that have a damaging effect on the natural environment—environmental governance—is another casualty of armed conflict. Implementation of the key agreements on limiting damage to the environment depends on the ability of states to ensure it is effective. Insecurity, instability and open armed conflict disrupt a state's capacity to respond to environmental challenges and the flouting of environmental regulations, all too often tempting them to deploy environmental destruction against their adversaries.[162] The erosion of both the capacity and commitment to protect the natural environment may linger even after the fighting is over. Reconstruction and recovery after armed conflict has many priorities, with the natural environment routinely placed low on the list.[163]

Weapons and other military equipment generate a war-legacy of environmental damage.[164] Landmines, cluster munitions and other explosive remnants of war restrict access to agricultural land and continue to pollute soil and groundwater even after they have been cleared. Naval wreckage, meanwhile, causes marine pollution. Beyond direct military destruction, there is the problem of the abandonment of military scrap. In addition, some weapons have particularly toxic components, such as depleted uranium, used in some shells and armour plating, with their effects persisting long after their use in combat in countries such as Iraq and Kosovo.[165]

Routine, non-war military activities also have an environmental impact, using large tracts of land for bases and for training purposes, as well as consuming vast quantities of raw materials and energy. The fuel consumption of the US military alone produces enough GHG emissions to mean that, were it a country, it would rank as the 47th biggest emitter.[166] Adding other major powers such as China and Russia into the equation, as well as including all GHG-emitting military activities, would produce a yet more striking statistic. However, it should be added that the US military has been a leading investor in clean energy since 2007.[167] Its NATO allies are moving in the same direction because renewable energy is cheaper, safer (since it reduces the need for long, vulnerable supply lines) and, therefore, more effective.[168]

Nuclear weapons testing has had a lasting impact on health, with an increase in the incidence and risk of many kinds of cancer, especially from the 504 atmospheric (above ground) test explosions that took place from 1945 (the first test, by the USA) to 1980 (the last in the atmosphere, by China).[169] The damaging effects of nuclear testing on health are local, regional and global, and have persisted for well over half a century. Recognition of nuclear testing's health hazards took it—literally—underground, in order that radioactivity released in the explosion would not get into the atmosphere. Leaks from underground tests have occurred, however, including two known incidents in 1969 and 1987 at the Soviet Novaya Zemlya sites in the Arctic Ocean and a US test in Nevada in 1970.[170] Major environmental risk persists in other forms. From 1948 to 1956 there were 67 atmospheric nuclear tests over two atolls—Bikini and Eniwetok—in the US Marshall Islands.[171] Radioactive debris from these explosions, almost 85 000 cubic metres, has been collected and stored in the Runit Dome. Although an official US assessment in 2020 found no immediate likelihood that the dome would collapse, and saw no measurable adverse effect on the environment from, for example, contaminated groundwater,[172] others are less sanguine.[173] One major concern is that sea-level surges or extreme weather, such as may ensue from climate change, could damage the dome, with catastrophic effects.[174]

1.3.3. Types of violent conflict

In many places, human security is further diminished because conflicts are fluid and chaotic. The number of armed groups active in some wars has exploded: in Syria over 1000 separate militias have been identified, and in Libya as many as 2000.[175] One estimate suggests more such groups have emerged since 2010 than in the previous eight decades combined.[176]

There are far more intra-state than inter-state wars, but there remains plenty of external engagement in internal wars. Foreign forces are involved in just over one-third of current armed conflicts, sometimes as direct combatants.[177] For example, four armed conflicts in the Middle East and North Africa—Iraq, Libya, Syria and Yemen—are fundamentally shaped by the involvement of foreign forces. Conflicts may also be internationalized through political, financial and technical support for one or more of the combatants, with examples including cases as different as Egypt, Iraq, the Israel–Palestine conflict and Nigeria.[178]

Just as the nature of contemporary violent conflict often flouts neat distinctions between the national and international, so it blurs the difference between political and criminal violence. In many cases, the activities of militias that started fighting for political reasons—to control government or territory—are overlaid by criminal violence. This may begin as a way of financing an insurgency but the means can take over the ends, with the consequence that an armed conflict becomes the first phase of a prolonged period of violence and chaos. The conflict and its aftermath create stakeholders with an interest in perpetuating violence. Criminal and political organizations often occupy

the same strategic and geographic space, sometimes contesting control of it and sometimes cooperating to exploit it through trafficking narcotics, people, weapons and contraband.[179] In these cases, the distinction between the criminal and the political may simply be a matter of arbitrary labelling.

The lethal potential of criminal violence is as great as that of some intra-state wars. In Mexico the number of killings linked to narcotics crime gangs has exceeded 100 000 over the course of a single decade.[180] This is not typical, however—the declining number of deaths per armed conflict noted in section 1.3.1 is probably due to the fact that it does not take much violence to intimidate local communities or the political establishment of a town, city or province. In many places, criminal gangs move on from intimidation to forming networks with holders of political power and managers of state institutions. This hollows out the state, leaving it incapable of defending the common good, regardless of leaders' intentions.[181] In such cases, the system of corruption, crime and violence is not a challenge to order—it *is* the order. Looting state resources becomes both the purpose and means of holding onto power, ultimately leading to a political culture that depends on, breeds and celebrates violence.[182] It is a pattern repeated in many parts of the world, taking over parts of or sometimes even the entirety of a country. It has been seen during war and/or in its aftermath in countries as varied as Afghanistan, Bosnia, Colombia, the Democratic Republic of the Congo (DRC), Lebanon, Libya, South Sudan and the United Kingdom (as seen in Northern Ireland). Governments are almost always part of the problem, with politicians and officials often responsible for the violence, which then becomes part of the political bargaining between elite groups.[183] The result is persistent low-level violence and instability, as can be seen in some eastern provinces of the DRC.[184]

Research on these ways of holding and using power suggests a need to rethink how peacebuilding and state building works (or fails) in such contexts. If peacebuilding focuses exclusively on war-related violence, it may overlook much of what is necessary to prevent the next war. This is one reason why narrow concepts of security are outmoded. The same research emphasizes the need for whole-of-society approaches to peacebuilding, working not only at the level of elites but at the grass roots. The process of recovering from prolonged violent conflict is complex, long and dangerous, but there are examples from locations as diverse as Colombia, Georgia, India, Sicily and the USA to show it is possible.[185] Some examples in the literature on environmental peacebuilding suggest that cooperation to defend the natural environment and re-nurture ecosystem services can be a way of overcoming social and political divisions and the propensity to violent conflict.[186] We return to environmental peacebuilding in part 4 of the Environment of Peace report.

1.3.4. Military spending and the arms trade

Increased military spending and major weapons transfers during the 2010s are evidence of a widespread and growing atmosphere of insecurity. In 2021

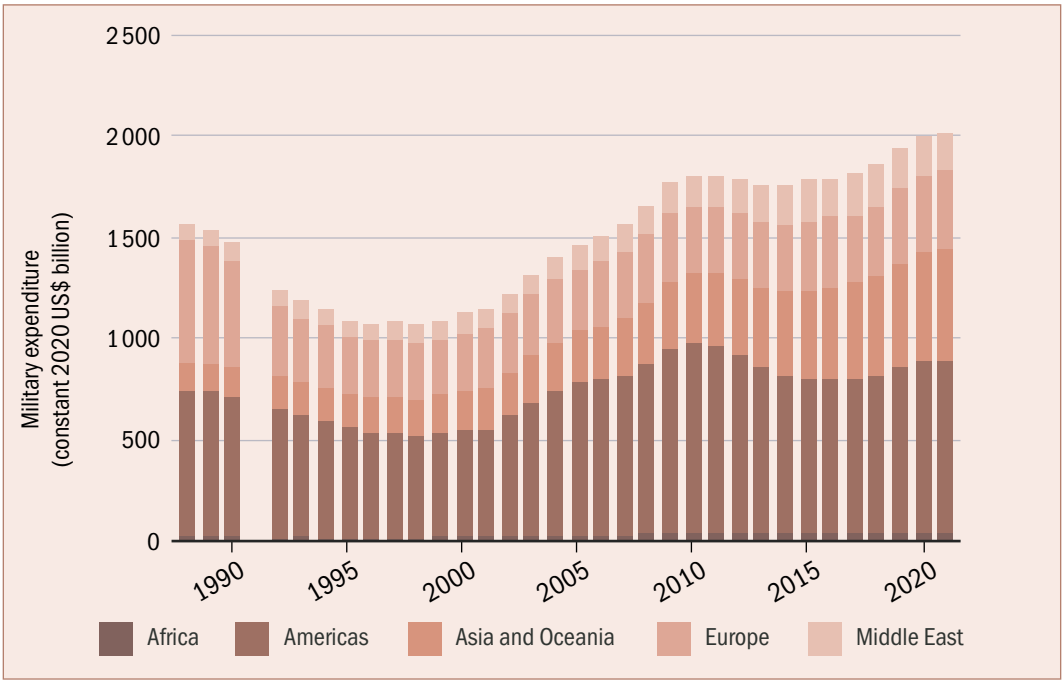

Figure 1.5. World military expenditure, by region, 1988–2021

Notes: To allow comparison over time, all values used in this figure are adjusted for inflation and expressed in constant (2020) US dollars. The absence of data for the Soviet Union in 1991 means that no total can be calculated for that year.

Source: SIPRI Military Expenditure Database, Apr. 2022.

world military spending surpassed $2 trillion—the highest level it has ever been (see figure 1.5).[187]

SIPRI's data shows that the end of the cold war in 1990 ushered in a decade of reduced military spending. However, from 1999 it picked up and, aside from the immediate wake of the 2008–2009 financial and economic crisis, it has risen steadily since. In 2020—the first year of the Covid-19 pandemic—military spending rose by just over 2 per cent.[188] The world's five biggest spenders in 2021 were, in order, the USA, China, India, the UK and Russia, which between them were responsible for just over 60 per cent of the global total.

Meanwhile, the global trade in major conventional weapons grew steadily from 2002 onwards, though it has stabilized and fallen slightly in the last few years (see figure 1.6).[189] The 2010s saw it at its highest level since 1990, though significantly lower than its peak in the 1980s.

The five largest arms exporters during the 2017–21 period were, in order, the USA, Russia, France, China and Germany. The USA's share of the global market is 39 per cent, Russia's is 19 per cent, while the share for the next three combined is 20 per cent—in other words, the top five exporters hold over three-quarters of the world market. Market concentration is much more marked on the supply side than the demand side. The five biggest arms importers in 2017–21 were, in order, India, Saudi Arabia, Egypt, Australia and China, which between them were jointly responsible for about 38 per cent of imports.

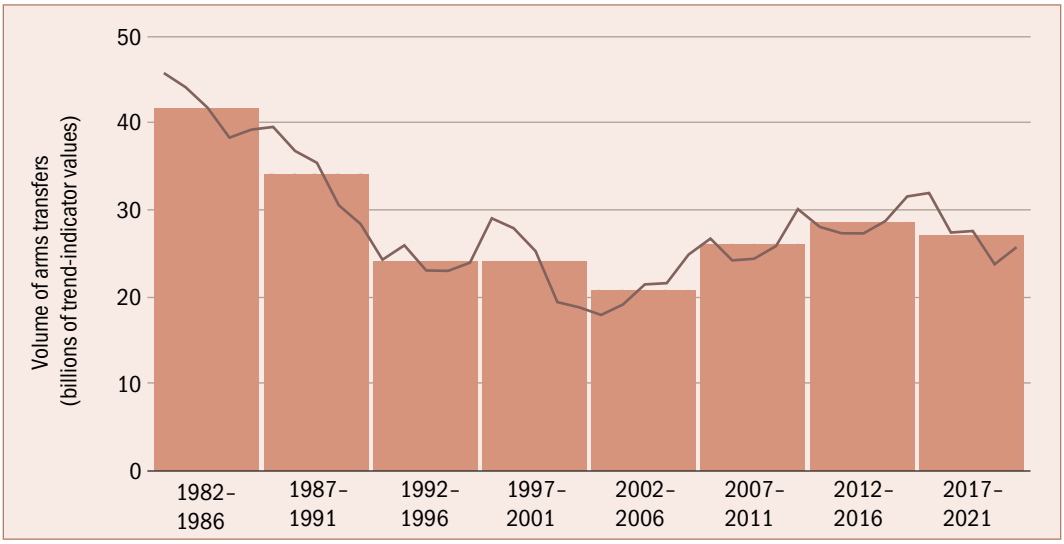

Figure 1.6. The trend in international transfers of major arms, 1982–2021

Notes: The bar graph shows the average annual volume of arms transfers for 5-year periods and the line graph shows the annual totals. The SIPRI trend-indicator value (TIV) is a measure of the volume of international transfers of major arms. The method used for the SIPRI TIV is described on the Arms Transfers Database web page.

Source: SIPRI Arms Transfers Database, Mar. 2022.

1.3.5. Weapons of mass destruction

Like the reduced number of armed conflicts from 1995 to 2010, the falling number of nuclear weapons has been an under-reported good news story. At its peak in the 1980s the global stockpile of nuclear warheads and bombs totalled some 70 000. In January 2022 SIPRI estimated the total to be some 12 705.[190] Though today's nuclear weapons are in many ways more capable than those built 30 years ago, the reduction is both large and significant. As shown in figure 1.7, the period when nuclear arsenal reductions were fastest was the 1990s.

There are signs, however, that nuclear reductions have stalled. Of the 12 705 warheads and bombs, just 3732 (about 30 per cent) are operationally deployed, which means they are on bombers, in missile siloes or in submarines ready for use. Almost all of these are owned by Russia and the USA. France and the UK are the other two countries with operationally deployed warheads, though in much smaller numbers, while none of China's warheads is operationally deployed.[191] In 2020 the number of operational warheads increased by 100—the first increase in a long time.[192] In addition, commercial satellite imagery in 2021 showed what appears to be construction of 300 new intercontinental ballistic missile siloes in northern China.[193] If so, this could signify a major increase in the overall size of China's arsenal by as much as 1000 warheads.

Bilateral arms control between Russia and the USA, which was responsible for almost all the reductions in the global nuclear stockpile, entered crisis followed by stasis during the 2010s.[194] While the extension of the 2010 Russian–US Treaty on Measures for the Further Reduction and Limitation of Strategic Offensive Arms (normally known as New START) in

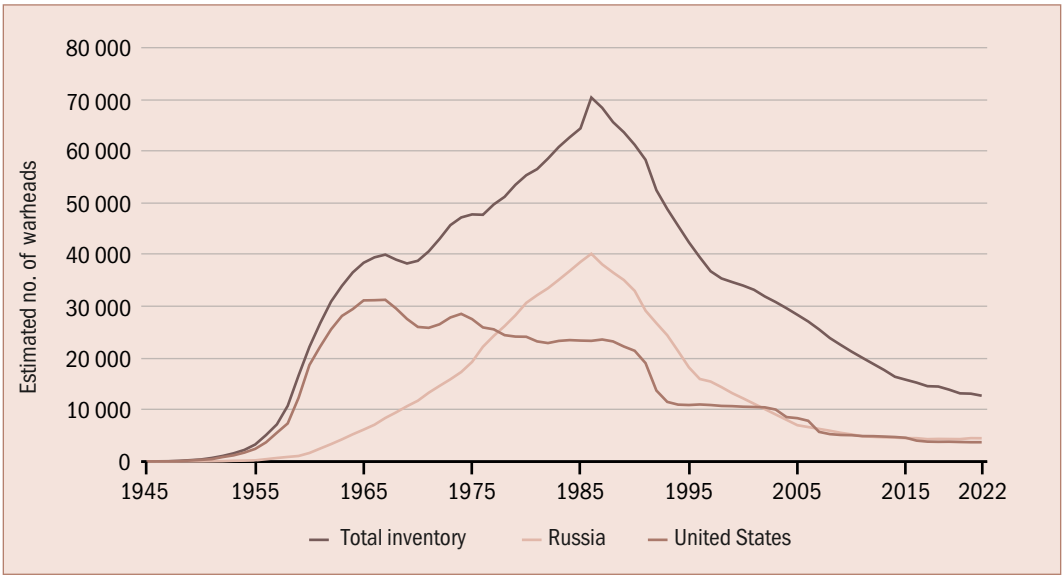

Figure 1.7. Estimated global nuclear warhead inventories, 1945–2022

Note: The total inventory of the nine countries possessing nuclear weapons (i.e. the United States, Russia, France, China, the United Kingdom, Pakistan, India, Israel and North Korea) includes stockpiled warheads plus those that are retired and awaiting dismantlement.

Source: Kristensen, H. M., Korda, M. and Norris, R., 'Status of world nuclear forces', Federation of American Scientists, 2 Mar. 2022.

February 2021—the one remaining bilateral nuclear arms control treaty between Russia and the USA—kept open the opportunity to breathe new life into the process, there are many obstacles to surmount in order to do so.[195]

Nine states own nuclear weapons. In order of going nuclear they are the USA (first nuclear test detonation in 1945), Russia (1949), the UK (1952), France (1960), China (1964), Israel (unknown—believed to own nuclear weapons by 1966), India (1974), Pakistan (1998) and North Korea (2006). The proliferation of nuclear weapons is generally regarded as one of the most serious risks in world politics. Although some question the good faith of governments in 'the nuclear club' who argue against further states joining it, a world with a multitude of nuclear-armed states is a forbidding prospect.

The Nuclear Non-Proliferation Treaty (NPT)—first signed in 1968 and entered into force in 1970—along with its associated safeguards administered by the International Atomic Energy Agency, is the world's primary instrument for preventing nuclear proliferation.[196] Around the time that it came into force, some 15 states had 'near nuclear' status.[197] At the time, six states possessed nuclear weapons. They have since been joined by three more.

When the Soviet Union collapsed, Belarus, Kazakhstan and Ukraine gave up the nuclear weapons they, so to speak, inherited from the Soviet Union. This was the only responsible decision since all three lacked the infrastructure needed to deploy and maintain nuclear weapons and keep them safe from theft and accident. South Africa abandoned its nuclear weapon development during the final years of the apartheid regime, while Iraq's nuclear weapon programme was dismantled under international supervision during the 1990s (as investigation following the 2003 Iraq war showed) and Libya's in 2003–2004.[198] Iran's development of nuclear technology has been controversial in

the West for many years. Despite the barrage of accusations against Iran, the country does not possess nuclear weapons and is a party to the NPT, meaning it has forsworn the option of developing, producing or owning them. It has never acknowledged having a programme to develop nuclear weapons, nor ever been proven to have one, although there are indications of a possible programme before 2003.[199] The Joint Comprehensive Plan of Action, often known simply as the Iran deal, blocked the country's path to developing nuclear weapons until at least 2030.[200] Under the administration of President Donald J. Trump, however, the USA announced in 2018 that it would pull out of its obligations under the deal, which it did the following year, despite clear evidence that Iran was fully implementing its obligations.[201] Since the US withdrawal, Iran has started to breach the limits on its nuclear activities. Negotiations on restoring the deal with full compliance in 2021 did not achieve their goal and continued into 2022,[202] and remain unresolved at the time of writing.

The existence of nuclear weapons, even in much smaller numbers than three or four decades ago, remains a source of extreme risk. The probability of deliberate nuclear war is low but is not and cannot be zero. At the beginning of 2022 the five permanent members of the UN Security Council—the P5 of China, France, Russia, the UK and the USA; all nuclear weapon states—tacitly acknowledged this in a unanimous statement worked out in an informal P5 group. Harking back to the epochal statement made by the Soviet and US leaders, Mikail Gorbachev and Ronald Reagan, upon meeting in Geneva in 1986,[203] it affirms that 'nuclear war cannot be won and must never be fought'.[204] Welcome as this acknowledgement of reality was, as was the support given to it by India as another of the states in possession of nuclear weapons,[205] it left some observers wondering about the justification for continuing with the nuclear modernization path on which all of the P5 are set.[206]

Further, there are risks of accident, including war by accident. For the period 1950–80 the USA officially acknowledges 32 of the most serious category of accidents—'Broken Arrow', which covers unexpected events when a nuclear weapon was accidentally launched, fired, detonated, stolen or lost, with six nuclear weapons permanently lost.[207] In addition, a declassified US Department of Defense document lists 65 other accidents and 716 incidents—many trivial—involving nuclear weapons in a single decade, 1957 to 1967.[208] While safety procedures may have improved since then and the number of warheads has diminished, it would take a major act of faith to think the risks of mishandling nuclear weapons have been eliminated. Neither the Soviet Union nor Russia has reported accidents with nuclear weapons, though there are reports of two nuclear weapons having been lost on the seabed in 1989 when a Soviet submarine sank.[209] Again, it would be an act of faith to assume there have been no other incidents.

As well as hardware accidents, there can be software accidents. The most famous incident, which arguably brought the world closer to

nuclear devastation than on any other occasion of which there is public knowledge, happened in September 1983. A Soviet Colonel, Stanislav Petrov, saw information on his computer screen that an American *Minuteman* intercontinental ballistic missile had been launched, targeting Moscow. He had moments to decide what to do. Feeling that if a nuclear strike were to be launched it would involve a massive onslaught rather than a single missile, he reported the incident as a system malfunction. When the computer identified further *Minuteman* missile launches, he stood by his scepticism and again reported a system malfunction.[210] The information was therefore not passed up the line to an authority who could have decided to retaliate against the non-existent attack. As September 1983 was a period of particular tension in US–Soviet relations, such a decision would have been quite likely, with catastrophic consequences.

Recent years have seen the use of chemical weapons (CW). The main violator of the norm against CW use has been the Syrian government, which has employed CW over the course of a decade of internal warfare. The first allegations came in December 2012, with further CW attacks taking place in 2013.[211] Following a Russian proposal, an unprecedented effort was made to achieve CW disarmament in the midst of war, and by June 2014 all CW that the Syrian government claimed it held were shipped out of the country.[212] Nonetheless, reports of CW use in Syria soon re-surfaced.[213] An independent commission established by the UN Human Rights Council confirmed at least 34 CW attacks conducted by the Syrian government from 2013 to the beginning of 2018, many using chlorine or sarin, a nerve agent,[214] while Human Rights Watch reported a total of 85 CW attacks in the same period, most by the government.[215]

CW have also been used as apparent instruments of political control, punishment and intimidation in cases such as the polonium poisoning of Russian defector Alexander Litvinenko in London in 2006;[216] the attempted novichok poisoning of Sergei Skripal, another Russian defector residing in the UK, and his daughter in 2018 (an incident that resulted in the death of an uninvolved British woman);[217] and the novichok poisoning of Russian opposition leader Alexei Navalny in 2020.[218]

Meanwhile, the forward march of technology continues, including artificial intelligence (AI). One area in which this is having an impact is the increasing feasibility of autonomous weapon systems.[219] It is now well within the bounds of technological possibility that weaponry capable of autonomously acquiring and striking targets will be deployed in defensive systems, and it is by no means impossible that autonomous weaponry will be deployed in an offensive mode and made available for use in fast-paced combat. There are also implications for strategic nuclear forces—developments in missile defence mean that, in crisis, an increasing mass of data would need to be handled with speed. To handle such tasks, AI would likely be used.[220]

Uncomfortable questions also emerge over cyber security.[221] It has become a cliché to say that, in the next war, the first attack will be in

cyberspace—however, the more uncomfortable thought is that the first attacks have already occurred. Protecting critical infrastructure such as health systems, public transport, energy generation and communications is a recognized priority for national security planning. Parts of this infrastructure, such as communications and financial services, can be severely disrupted by hacking; in others, cyberattacks can disrupt them for short periods without physical attack. Such concerns extend to military communications and information systems in light of what are sometimes called 'left of launch' cyber tactics—hacking into command and control systems for major weapons.[222]

1.3.6. Global geopolitics

Even before Russia's invasion of Ukraine in 2022, the past decade-and-a-half had witnessed a marked deterioration in international security.[223] The evidence lies in the material on peace, conflict and security issues already covered. By late 2021, the Russian military build-up on its borders with Ukraine and increased Chinese military activity around Taiwan underlined the unstable condition of global politics. In February 2022 Russia invaded Ukraine, the human impact of which has been immense. While casualty estimates are notoriously unreliable, evidence of the destruction of towns and cities could be seen on television screens and news media around the world, and seven million people became refugees from Ukraine in the first six months of fighting.[224]

The twin crises over Ukraine and Taiwan did not, however, come out of the blue. One component of the process of rising tensions and deepening confrontation that has intensified over the past decade has been the vicissitudes of arms control and disarmament. Whereas the 1990s saw a plethora of arms control, arms reduction and disarmament treaties, since the 2010s the arms control architecture has begun to crumble. The three great powers—China, Russia and the USA—are all enhancing their armed forces, as are the USA's allies in Europe and Northeast Asia. China has increased its annual military spending every year over the past quarter of a century.[225] Russia has several new strategic weapon systems under development, many of them dramatically unveiled by President Vladimir Putin at a public ceremony in March 2018.[226] The USA increased its own military spending during the Trump administration,[227] is carrying through long-term programmes to enhance and modernize its nuclear weapons and missile defence,[228] and has established the new US Space Force.[229] The military doctrines of both Russia and the USA declare a willingness to use nuclear weapons first in a conflict if fundamental national interests are at stake.[230] In the USA, the administration of Joe Biden announced its intention 'to reduce the role of nuclear weapons in our national security strategy'[231] and, in mid-2021, started a review of the country's nuclear posture.[232] This posture has, however, remained consistent across successive administrations since the start of the 1990s.[233] Amid the atmosphere set by the Ukraine war, it seems unlikely that US doctrine will change significantly in the near future.

In short, the willingness as the cold war ended to address nuclear and similar fears by cooperative arrangements has been replaced by a focus on maintaining military strength. There is only one bilateral Russia–US arms control agreement left: New START. Events have moved on a long way since the 1990s, when it seemed that a degree of Russian integration with the West was on offer. Long before the invasion of Ukraine, this was no longer regarded as a possibility on either side. A speech by President Putin at the 2007 Munich Security Conference made clear Russian objections to a European order that had been shaped by the West during a decade of Russian weakness.[234] Seemingly paying no heed to this, in April 2008, NATO officially welcomed the aspirations of both Georgia and Ukraine to join the alliance and stated that one day they would be members.[235] Four months later, Russian forces crossed into Georgia in response to a Georgian attack on Tskhinvali, capital of the breakaway province of South Ossetia—an attack that was itself described by a European Union (EU) inquiry as a disproportionate response to partisan attacks on Georgian targets.[236] In 2009, during his first year in office, President Barack Obama attempted to 'reset' relations between the USA and Russia.[237] The effort had little effect. Russia's 2014 annexation of Crimea and operations in eastern Ukraine marked a decisive moment in the deterioration of the relationship and of international security.

The Biden administration's emphasis on extending the New START agreement with Russia in its first weeks in office indicated a much greater commitment to arms control than was apparent in the Trump administration. Policy on arms control, however, is not the same as policy towards Russia. The Biden administration has been more critical than the Trump administration, with the US president responding affirmatively when asked if he regarded the Russian president as a killer, prompting a furious response from Russian media and diplomats.[238] While the more abrasive posture adopted by the Biden administration may in part be due to the evidence of Russian influence in the 2016 US presidential election,[239] it also reflects a deeper suspicion of Russian policy and motives—an attitude reciprocated by the Russian leadership.[240]

Relations between China and the USA deteriorated over approximately the same period, due to a combination of political competition, strategic confrontation and economic rivalry. China's economic growth during the past four decades has averaged close to 10 per cent annually.[241] Though growth was much slower in 2020, the first year of the Covid-19 pandemic, China's was the only major economy that grew *at all* that year.[242] Some analysts believe China's economy is already larger than the USA's by one measure and expect it to outstrip the USA by all measures during the 2020s. Others, however, suggest this will happen much later, if ever.[243] Since the international financial crisis of 2008–2009, China's economic strength has become the foundation for a more assertive international policy. As well as strengthening its armed forces, it has pressed its interests in the East and South China Seas; gained friends and allies in Africa using development assistance and investment; and launched a major transport infrastructure investment programme across Asia

in the Belt and Road Initiative.[244] Moreover, China has presented itself as a new champion of multilateralism, globalization, and of action to mitigate and adapt to climate change.[245] It has, in short, strengthened both its hard and soft power, as well as its political and commercial weight, in world affairs.[246]

In the USA the response has been a bipartisan consensus on opposition to China's rise that is reminiscent of the consensus that existed on the Soviet threat. One aspect of this response has been the 'trade war' initiated in 2018, which has resulted in China and the USA each imposing high trade tariffs on the other.[247] By the first quarter of 2021, the higher tariffs had become the new normal between the two countries.[248] Even so, and despite the resulting sour atmosphere, trade between the two countries continued to flourish.[249] Meanwhile, the trilateral security pact between Australia, the UK and the USA known as AUKUS, launched in September 2021, may be of limited near-term military significance but sends a clear political and strategic message of an alliance against China.[250] Together with its AUKUS allies—as well as others, including Canada, France, Germany, Japan and New Zealand—the USA has conducted 'freedom of navigation' operations in areas of the South China Sea that China, despite a 500-page judgement against it in July 2016 by the Permanent Court of Arbitration, continues to claim as part of its territorial waters.[251] In September 2018, in a dangerously close encounter, a US warship and a Chinese warship passed within 40 metres of each other.[252]

Whether this should be regarded as a rerun of the US–Soviet cold war with one change in the cast of characters is debatable and hotly debated. One line of thinking in the USA treats the confrontation between the two great powers as inevitable;[253] an alternative approach points to the economic and commercial links that tie China and the USA together in a way that was never true of the cold war rivals.[254]

Against this difficult background, the joint Chinese and US statement on enhancing climate action, issued at the November 2021 COP26 international conference on climate change in Glasgow, offered a welcome sign that both powers could nonetheless seek to cooperate on at least this global issue.[255] The two offered strong statements of intent rather than binding commitments. Nevertheless, their coming together over climate change raised the possibility of other areas of pragmatic cooperation where long-term interests are shared, such as health risks and loss of biodiversity. A virtual summit between President Xi Jinping and President Biden the same month was generally interpreted as easing tensions and stressing the value of cooperation, though it failed to identify further areas for action.[256] However, when Speaker of the US House of Representatives Nancy Pelosi made an official visit to Taiwan in August 2022, thereby giving a forthright statement of support for Taiwan's continuing autonomy[257]—a position with bipartisan backing, as a follow-up visit by members of the US Congress demonstrated[258]—China responded by suspending military and climate cooperation with the USA.[259] It seems likely that a mix of confrontation, competition and some areas of cooperation will continue to characterize Chinese–US relations in the coming decade. Much

depends on which aspects of the relationship receive the greatest attention and effort from the two governments.

1.3.7. Drivers of insecurity

Intensifying geopolitical rivalries and the accompanying political ambitions, clashes and crises are driving increased insecurity on a global scale. They also reduce the capacity for managing conflict and political rivalry on regional and national scales. In 2019 there were missile strikes, proxy attacks and challenges to freedom of navigation in the Persian Gulf, while armed clashes escalated to new levels between two nuclear-armed states, India and Pakistan, over Kashmir.[260] In 2020 war erupted in Ethiopia and open warfare returned to the South Caucasus with the escalation of conflict between Armenia and Azerbaijan.[261] The absence of international capacity when it came to cooperatively managing and mitigating these conflicts was striking. Only in the South Caucasus was there an effective intervention to limit the violence, carried out by Russia, acting alone and effectively ignoring the apparatus set up by the Organization for Security and Cooperation in Europe to respond cooperatively to the conflict.

The same deficiency was notable in the case of the Covid-19 pandemic. Despite intense scientific cooperation in the development of a vaccine between research teams in a number of countries with advanced scientific capacity—though not between all the countries where such capability exists—the distribution of the vaccine revealed severe limitations in the extent and generosity of cooperation. The WHO issued a clear warning about the severe health risk to all posed by 'vaccine nationalism'—a me-first approach to immunization.[262] UN Secretary-General António Guterres attacked it in the following terms: 'Vaccine nationalism and hoarding are putting us all at risk. This means more deaths. More shattered health systems. More economic misery. And a perfect environment for variants to take hold and spread.'[263] The economic consequences of vaccine nationalism would likely also be dire, including for countries that stocked up with more vaccine than they needed.[264] A study by the Rand Corporation estimated vaccine nationalism as potentially imposing a global economic cost of $1.2 trillion a year, while investing in equitable worldwide vaccine distribution offered a return on spending of 4.8 to 1 ($4.80 earned for every $1 spent).[265]

This deficiency of cooperation was evident even when it came to a straightforward humanitarian appeal. In an attempt to turn a health crisis into a peace opportunity, Secretary-General Guterres issued a global ceasefire call in March 2020.[266] There was significant support for this, including from some parties actively engaged in armed conflict.[267] International support, however, was hindered by an argument between China and the USA about whether a UN Security Council resolution endorsing the appeal should mention the WHO.[268] In the end, the impact was limited, with few ceasefires lasting beyond a month.[269]

However, geopolitical rivalry, regional instability and political ambitions are not the only drivers of insecurity. They play out against a background of longer-term factors that are shaped to a significant degree by the fact that we live in a hyper-connected world. There are two important aspects to this. One is what is often known as connectivity: the ways in which far-flung parts of the world are connected to each other by trade, travel, communication and information flows. While connectivity can and does have positive implications, it also acts as a transmission mechanism for risk,[270] linking issues and locations. The second aspect is how diverse issues and spheres (such as security, economics, environment, society, politics, health) are connected to each other. These linkages are as pertinent a source of risk to human societies, economies and polities as the various linkages in the biosphere, explored above in relation to the onset of the Anthropocene epoch. Tracking these linkages in and between the natural and security spheres may help in developing an understanding of the most fruitful targets for remedial action. In that spirit, it is worth thinking through connectedness in the background drivers of insecurity. Here we focus on vulnerabilities in trade, cyberspace, social inequalities, food insecurity and disease.

1.3.7.1. Trade

The world relies on the sea for transport of food and energy, as well as for communication. Each year, enough maize, wheat, rice and soybean are transported to feed approximately 2.8 billion people.[271] Over 80 per cent of world trade by volume goes by sea, accounting for over 70 per cent of global commerce by value.[272] In all, the global food trade has 14 transport chokepoints: 6 are in inland waterways and 8 are maritime. Among the key chokepoints, the Panama Canal and Strait of Malacca (including the Singapore Strait) are especially important for transporting grain, while over a quarter of global soybean exports go through the Strait of Malacca and a fifth of global wheat exports go through the Bosphorus and the Dardanelles on their way from Ukraine and Russia. So far this century, 13 of the 14 chokepoints have experienced some form of disruption, mainly due to violent conflict or extreme weather events, which are becoming more frequent under the impact of climate change.[273]

Each year, approximately 2 billion tonnes of crude oil are transported by sea.[274] The key chokepoint for oil is the Straits of Hormuz in the conflict-affected Gulf region—around one-third of the global crude oil seaborne supply goes through the Hormuz seaway, which consists of two lanes, each two miles wide (about 3.22 km), with a two-mile-wide safety gap between them. Other maritime chokepoints for energy transport are the Bab al-Mandeb between Yemen and Djibouti, and the Suez Canal. The March 2021 case of the cargo ship *Ever Given* offers a vivid demonstration of the potential fragilities and risks at play. The ship got stuck in the Suez Canal, reportedly because of a strong gust of wind, resulting in 12 per cent of global shipping being held up.[275] By the time the *Ever Given* was re-floated six days later, some 10 million

barrels of crude oil (1.3 million tonnes) were waiting at each end of the canal.[276]

The melting of Arctic Sea ice due to climate change has opened up a new sea route north of Siberia. In 2018, Chinese container ships used this route to travel from Shanghai to Hamburg, reducing the length of the voyage by some 6000 miles (almost 10 000 km) compared to going via the Suez Canal.[277] Russia is planning a new generation of large icebreakers to keep the sea clear for navigation and has stated it expects to have year-round commercial shipping going through the northern route in 2022 or 2023.[278] Russian forecasts of 80 million tonnes of goods by 2024 and 130 million by 2035 are, however, small compared to total trade volumes.[279] It seems unlikely the Northern Sea Route will ease the problem of chokepoints being disruptively sealed off in the near future. Worse, in today's geopolitical climate, it could develop into a new zone of contention, not least because as the ice melts access is opening up to natural resources, including a major oil and gas field on the continental shelf off Russia's Barents Sea coastline.[280]

Other modes of transport are also vulnerable to disruption, such as oil pipelines and energy complexes. A US fuel pipeline operator had to shut down operations after a ransomware cyber-attack, closing a pipeline carrying 45 per cent of the east coast's supply of diesel, petrol and jet fuel. The short-term effects included price increases, with some US states declaring emergencies, and reports that at least 3500 petrol stations had run dry.[281] Whatever the source of these disruptions, they reveal vulnerabilities and drive insecurity.

1.3.7.2. Cyberspace

The closing of the US pipeline also illustrates the vulnerability of critical infrastructure such as energy, transport, health and communication systems to cyber disruption. From Swedish supermarkets[282] to the Irish health service[283] to the hacking attack via software provider Solar Winds on hundreds of organizations including government agencies,[284] and more, we are persistently reminded that our increasing reliance on cyberspace generates growing vulnerabilities. In many countries, everyday transactions—such as salary payments, household purchases, travel arrangements, insurance, banking, and pension contributions and payments—are conducted online, with proof of identity likewise provided virtually. In addition, communications, public utilities (e.g. the electricity grid and water distribution) and the management of transport (e.g. urban and highway traffic and air traffic control) all depend on efficient functioning within cyberspace. As a general rule, the more sophisticated and extensive a country's online capabilities are, the more vulnerable it is to cyber intrusions.[285] In turn, the consequences of cyber-attacks are more damaging, the effects on individuals of cyber-crime are more destructive, and the security arrangements required become more elaborate. The pace at which software companies modify their products makes it hard for security measures to keep up.[286] As in the case of the biosphere, the choices

made in building modern societies are making for an increasingly precarious world.

The actual insecurity generated by cyber-dependence is not the only problem. Though much of what goes wrong in cyberspace is accidental, there is a persistent temptation to attribute problems to hostile action by criminals or governments. Cyberspace has physical locations—some in outer space in satellites, some in ground-based installations—and more than 90 per cent of all data travels at some point through ocean cables.[287] From collisions with space debris to the consequences of extreme weather, these physical embodiments of cyberspace face a range of hazards. Among them, the role of human error is significant.[288] There is now considerable concern about the false alerts generated by cyber security systems, with one estimate suggesting that 45 per cent of system downtime is unnecessary.[289] There is also concern about how to handle incidents whose causes are unknown, and how to manage public and political perceptions so as to avoid an escalatory response against a body, such as another government, which may not have been responsible—at least deliberately—for the disruptive incident.[290] Amid the current geopolitical context of rivalry and suspicion, the atmosphere created by an incident is often febrile. Managing the situation becomes harder in proportion to the level of hostility, conflict and mutual recrimination there is in international politics. The more peaceful the global context, the more straightforward a calm response will be.

1.3.7.3. Inequality

Countries are also made vulnerable by inequalities, both vertical (as between social classes) and horizontal (as between groups divided by race, ethnicity or gender), as well as between them. Inequality is not just a matter of income and wealth, though it often starts there; it is also about political voice, access to power, social inclusion, and access to basic services including health provision and education.

Inequalities of income (what we earn) and wealth (what we own) are both sharp. The global average of individual annual income is about $16 700;[291] however, 85 per cent of the world's population live on less, with around 65 per cent living on less than $10 a day and about 10 per cent in what is currently defined as extreme poverty—living on $1.90 or less a day.[292] The richest 10 per cent of the world's population earns just over half of the global income each year, while the poorest half of the population earns a mere 8.5 per cent of the total.[293] Wealth inequality is even more striking than income inequality: the poorest half of the global population owns just 2 per cent of all economic wealth, while the richest 10 per cent owns 76 per cent.[294]

This is a field where the data and its meaning are hotly contested. There appears to be general agreement that while economic inequality between countries has declined, it has increased within most countries.[295] Taking a broad view, since about the turn of the century, inequality between individuals within a country has become a more important component of global inequality

than inequality between countries.[296] Put differently, social class and gender now matter more than nationality as determinants of individual inequality.

Oxfam depicts the extraordinary state of individual inequality with the startling claim that 26 people between them own the same amount as the poorest 3.8 billion[297]—though this estimate includes a great deal of paper wealth (e.g. stocks and shares), whose value fluctuates up and down. Estimated in this way, the total wealth of the world's approximately 2000 billionaires amounted to just under $12 trillion in 2020, having grown by almost $4 trillion over the previous year.[298] By comparison, the global total of economic stimulus that governments put into their Covid-19 responses amounted to $10 trillion.[299] This reflects a trend over the past 40 years in which countries have become significantly richer, but their governments have become significantly poorer.[300] That is to say, there has been a general rise in accumulated private wealth, from 3–4.5 times the size of annual gross national income (GNI) in most rich countries in 1970 to 5–8 times the size of GNI today. Meanwhile, public wealth has declined in nearly all countries since the 1980s, the exceptions being oil-rich countries with large sovereign wealth funds, such as Norway.[301]

Globally, men own 50 per cent more than women, who are excluded from many jobs,[302] still earn less for comparable work in most places, form the majority of those at the bottom of the economic pile, and globally put in 12.5 billion hours of unpaid work as carers each day.[303] These economic markers of gender inequality are only part of the story. Across the world, laws control and restrict women's behaviour more than they do men's, and in many countries crimes against women are treated less seriously by police authorities and the judicial system than crimes against men.[304] The education of girls is fundamentally a question of fairness. It has also been held up as a strategic development priority[305] and a directly attributable cause of increased economic output.[306] However, other factors are also key if the education of girls is to lead to economic growth;[307] not least, there has to be an effective and responsive state. More generally, the under-recognition and disparagement of the productive work undertaken by women inevitably detracts from a country's resilience in the face of multiple challenges. In other words, unfairness exacerbates vulnerabilities.

There is much academic debate about whether and how inequality contributes to armed conflict.[308] Part of the problem is that there is no neat or comprehensive explanation of the role played by any such factor—inequality, poverty, access to land, climate change, governance—in conflict causality.[309] Violent conflict is never caused by just one factor. The real issue is whether and how individual factors interact to create a context conducive to armed conflict, within which groups and their leaders opt to pursue political ends with violent means.[310] From this perspective, the evidence is clear that inequality generates persistent conflict risk.

1.3.7.4. Hunger

Having fallen steadily since 2005, world hunger began increasing again in 2017.[311] In 2021, 193 million people were acutely food insecure, meaning they were unable to meet their food consumption requirements—an increase of nearly 40 million from the year before—and over 39 million faced food emergencies, suffering very high acute malnutrition.[312] Hundreds of millions more, though in less desperate straits, are permanently hungry and under-nourished, with modelling indicating that the number of under-nourished people in the world will reach nearly 670 million in 2030.[313]

Food waste is an important issue. Estimates vary due to different definitions and methodologies about which parts of the food chain are included in the analysis. The UN Food and Agriculture Organization calculates that, measured by value, 14 per cent of food produced globally is lost post-harvest before reaching the retail level. The UN Environmental Programme, meanwhile, estimates that 17 per cent of food available at the retail, food service and consumer level is wasted by being thrown away.[314] Improving supply chain efficiency will not, however, address the most significant part of the problem.

The main causes of the increase in world hunger are the consequences of armed conflict and the impact of climate change.[315] Though the Covid-19 pandemic negatively impacted global hunger statistics in 2020, violent conflict remained the primary driver of global hunger.[316] The effect, however, is not one way—hunger also drives violent conflict,[317] and lasting food insecurity in the wake of war serves to feed the next war.[318] Without resolving the problems of insecurity and climate change, it is unlikely sustained progress can be made in reducing world hunger. At the same time, if the problems of food insecurity go unresolved, countries will remain vulnerable to the maladies that hunger brings, including social upheaval, community fragmentation, psychological destabilization and low physiological immunity.[319]

1.3.7.5. Disease

For the most part, the relationship between health and violent conflict has been studied only by looking at the impact of conflicts on human health. From the treatment of wounds to the consequences of health infrastructure (e.g. clinics, hospitals, pharmacies) being destroyed or closed in the midst of violent conflict, the negative impact of war on health is a well-studied area.[320] Likewise, it is well known that war has spurred major advances in medicine, such as blood transfusions in World War I and the use of antibiotics in World War II.[321] While the possibility of disease as a threat to peace and security is a relatively recent notion and so not yet thoroughly researched, it has nonetheless entered high policy. In the USA, a National Intelligence Estimate on the link was issued as far back as January 2000.[322] In 2014, the Obama administration pushed for the creation of the Global Health Security Agenda (GHSA)[323]—a cooperative effort involving 44 governments at the outset and some 70 by 2020[324]—and

in 2016 assigned the task of coordinating the US role in the GHSA to the National Security Council.[325]

To understand how a pandemic may have negative impacts on peace and security, it is worth starting with Covid-19. Official data on the scale of the pandemic is unreliable due to, among other reasons, methodological shortcomings and the limited capacity of many national reporting systems. How much the result understates the full impact of Covid-19 is hard to pin down. Studies of excess mortality—how many more people died in a given period than is normal for a given country—suggest the true number of deaths from Covid-19 is significantly higher than the official count.[326] By the end of September 2022, the confirmed Covid-19 death toll was 6.55 million;[327] the WHO's estimate for deaths in 2020 and 2021 related to Covid-19, however, based on excess mortality, put the death toll at 14.9 million (in a range from 13.3 to 16.6 million).[328] Another study, based on a model that takes prevalence of the disease as well as excess mortality into account, estimated 23.2 million Covid-related deaths (in a range from 16.1 to 27.7 million).[329]

Given the global reach of the pandemic, an economic impact was inevitable. In 2020, economic output fell in all bar 20 countries, including all major national economies except China.[330] The pandemic also depressed wages in two-thirds of countries for which official data is available,[331] and is estimated to have driven approximately 120 million people into extreme poverty in the course of 2020, reversing three decades of progress in poverty reduction.[332] Initial estimates for 2021 indicated a continued, albeit smaller, spread of extreme poverty in the pandemic's second year.[333] These impacts tend to sharpen social inequality and thus deepen social vulnerability and risk of conflict.

At the same time, it is well established that consolidated democracies are internally more peaceful than autocracies, semi-democracies and transitional states.[334] Given that the condition of democracy is a significant factor in conflict causation, the deterioration in the quality of democracy in recent years, accelerated in 2020 and all too often justified as part of governmental responses to the pandemic, is of considerable concern.[335] Thus, through rising inequality and declining democratic quality, the pandemic forces itself into our thinking on prospects for peace, conflict and security.

The number of armed conflicts tends to increase some two to three years after a major economic disruption. Examples include the oil price shock of the early-to-mid-1970s, the Asian financial crisis of 1997 and the global economic crisis of 2008–2009.[336] The 2020 Covid-related economic downturn may have the same effect—historically, pandemics have been followed by periods of social unrest, political instability and heightened conflict.[337] Both the direct effects of disease and its social and economic repercussions, as well as deficient government responses to it, combine to contribute to the erosion of human wellbeing. This plays out against a socio-economic background that is conducive to rising levels of inequality, on a foundation in which ecosystem services decline because of environmental crisis.

We are living in an age of vulnerability.

1.3.8. The idea of security

The complex mix of challenges on today's security horizon suggests a need to think hard about what we mean by security—that is, the security of whom or what, against what threat?

Hans J. Morgenthau was an intellectual giant in the study of international politics in the 20th century. He was a leading figure in the realist school of international relations, which regards rivalry between states as inevitable and even right, because 'politics, like society in general, is governed by objective laws that have their roots in human nature'.[338] Central to these 'objective laws' is 'the concept of interest defined in terms of power'.[339] For Morgenthau, a political realist 'thinks of interest defined as power, as the economist thinks of interest defined as wealth'.[340] Thus, 'International politics, like all politics, is a struggle for power' in pursuit of the national interest.[341] This does not mean simply pursuing power by force—for Morgenthau, diplomacy was about persuasion and negotiation as well as power and pressure, and could entail concessions on non-vital issues.[342]

Here is to be found the intellectual justification for conducting geopolitics in a way that undermines the prospects for cooperation on the world's great security challenges. For Morgenthau, self-centred international behaviour is inevitable, realistic and natural—and therefore right. What mattered for Morgenthau was to understand that this is the nature of things and, given that reality, to get the greatest advantage possible, measured in terms of power. What we can see today, more clearly than was visible in the 1940s when Morgenthau wrote his *magnum opus*, because we can now see the damage inflicted on the biosphere since the Great Acceleration began (at around the time he was writing), is that that kind of international behaviour is self-defeating and destructive.

Morgenthau's thinking remains influential. Looking back from our current vantage point, however, it is clear that the core weakness in Morgenthau's theorizing of politics is his assertion that it is based on human nature. What he did not and perhaps could not recognize is our human connection with the natural environment—the biosphere of which we are a part. If that environment decays, interest based on power becomes a second order concern at best.

Politics and political relations must henceforth be conceptualized in relation to nature, not merely on a contestable interpretation of human nature. Recognizing that we face a planetary emergency means recognizing that state policy based on acquiring as much power as possible in the national interest is entirely outmoded, wasteful and counter-productive because it is damaging to the interests of the people who make up the country. This could be branded 'ecological realism' because preserving the biosphere is a core national, as well as human, interest.[343] Henceforth, national and international policies must be rethought in light of a concept of interest based on achieving balance in the biosphere. While rivalries and contestations will inevitably remain, security will not be achieved by pursuing them. Rather, facing the complex mix of security

issues currently presented in the Anthropocene, the critical element of security is cooperation.

It is that simple.

1.4. People and governance

The discussion thus far brings us inevitably to the question of governance. No environmental issue is purely an environmental issue. Concerns about the natural environment arise from a recognition that something has gone wrong in human interactions with it and, therefore, that this relationship must be governed differently if it is to be improved. Attempting to improve environmental governance, however, brings us face-to-face with the toxic geopolitics of the current period. This is one of the key linkages between the crisis in the environment and the bleakness of the international security horizon. As part 2 goes on to show, there are further linkages between environmental stress and conflict.

An important part of the discussion around the planetary emergency concerns how we govern both our relationship with nature and our international political relations. On both fronts, this entails action at multiple levels. Some of what is needed to restore ecosystem health and much of what is needed to build peace must be carried out in local communities, whether urban or rural. On the other hand, some of the action is of necessity national, regional and international, and almost all the more localized action requires national or international support and investment. Accordingly, this section focuses more on global than local governance.

The task today is threefold:

- To manage the consequences of climate, environmental and other challenges that have built up over time and that will unavoidably unfold over the coming years;
- To ensure that the changes made to address the drivers of environmental damage do not generate new risks of insecurity and injustice; and
- To ensure that steps taken to build peace and security are sensitive to the environment.

This can only be fulfilled through collective action at different scales (local, national, regional, global) and in different spheres—in local communities, in the machinery of government, in relations between governments, and in the economy and the business sector. The emphasis on collective action, in turn, means that a model of governance fit for purpose in the Anthropocene epoch must place adaptiveness and social inclusion at its core. This envisages good governance as an adaptive process of working together, whether in communities, on a national scale, in cross-border cooperation or in international partnership. For this to be possible, there must be a process

of negotiating a viable bargain between participants, balancing their interests in the most productive way. This is equally true for relations between states and for relations between community groups. Or looked at slightly differently, whatever the condition of international political relationships, they have to be good enough to permit potential adversaries to work together on the primary problems.

1.4.1. Deficiencies of global governance

The difficulty here is that international governance is not in a good condition. Its deficiency was visible on a world stage in COP26—the 26th Conference of Parties to the UN Framework Convention on Climate Change, held in Glasgow in November 2021. While governance deficiencies are probably less important than economic interests and inertia in explaining the lack of progress on addressing climate change thus far, without improved governance there is little chance of achieving the necessary changes in economic functioning. Though the concluding statement at COP26 was regarded by many as a step forward compared to previous statements of intent and policy, it fell considerably short of what was needed.[344] Positives included accelerating the process of making national commitments more ambitious.[345] Overall, however, global warming will continue:[346] even if all promises are fulfilled the rise in global average temperature will likely exceed the 1.5 °C limit set as the goal by the 2015 Paris Agreement.[347] Less optimistic assessments, based on current policies, show average warming will clearly exceed the 2 °C limit agreed as essential in Paris.[348] Strikingly, the President of COP26 apologized tearfully at the end of the conference for last-minute changes that watered down the conference statement's green commitments, replacing an undertaking to 'phase out' coal with an intent to 'phase down'.[349]

This is only one symptom among many of the flaws in global governance, despite the energy and effort invested and the gains achieved through agreements and international institutions. The WHO set up an independent panel to analyse its role in responding to Covid-19, with the subsequent report highlighting that most governments ignored warnings of a possible pandemic, were unprepared, and were slow to acknowledge the dangers of Covid-19 when it emerged.[350] Moreover, once the crisis was upon them, vaccine nationalism reared its head (see section 1.3.6).

Lack of effective cooperation and coordination allows many flaws in global governance to persist. While some of these may be created in error, others are clearly the result of deliberate action by the parties benefitting from them. For example, the absence of coordination creates loopholes through which large amounts of unpaid tax slip. It is estimated that the world loses $427 billion annually in direct tax revenues due to tax avoidance (which is legal) and evasion (which is not). Multinational corporations are responsible for 60 per cent of these lost taxes, wealthy individuals the remainder.[351]
A further reason underlying the lack of coordination is simply that state

sovereignty is an important value in international politics, permitting states to act independently of each other even when the state, as a unit, is not of a scale that is appropriate to the problem. This creates a fragmented governance framework, which, for example, makes it difficult to take care of the 64 per cent of the world's ocean surface that constitutes what is known as areas beyond national jurisdiction (ABNJ). ABNJ are a global commons increasingly affected by unsustainable and illegal fishing, pollution from shipping, and mineral extraction.[352] Institutions and agreements focused on ABNJ deal with individual issues, making it difficult to create new rules that address emerging and cross-cutting issues.[353]

The governance of outer space also reveals gaps. The current legal framework was largely developed in the 1960s and 1970s—the most recent multilateral treaty is the Moon Agreement, which was adopted by the UN General Assembly in 1979 and entered into force in 1984.[354] Taken together, these agreements do not regulate private actors, who have become increasingly important and active in space and lack any enforcement mechanisms.[355] Nor do they provide clarity over preventing or managing the militarization of outer space, or provide instruments for handling disputes.[356]

In sum, scanning the instruments and institutions of international governance reveals dated measures driven—or at least constrained—by a narrow conception of national interest among competing states, or by vested interests. These processes have little prospect of engaging affected communities, and lack sufficient responsiveness to today's realities and concerns. While it is not impossible for states to come together and cooperate in the sustainable management of ABNJ or other global commons, it is undoubtedly difficult, requiring the appetite and determination to arrive at joint, cooperative approaches and solutions.

1.4.2. Improving governance

According to the Commission on Global Governance, governance is 'the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated and cooperative action may be taken'.[357]

Since the earliest times, identifying, preparing for and responding to security risks has been among the primary functions of governance. In democratic political theory, though individuals and communities are diverse, the state should be directed by a sense of the common good—the overall, balanced interests of the whole citizenry. When the state is not thus directed, it is repressive.[358] When the state represents and serves as best it can the collective will of the people, the result is a shared 'conception of political justice' and institutions that citizens engage with and, as a general rule, trust.[359] All things being equal, global governance simply extends the principles of the common good, balanced interests and a shared conception of justice. Unfortunately, however, all things are not equal, which goes a long way to explaining global governance's deficiencies.

Two issues to consider here are incentives and social position. From a long-term and societal point of view, it is clear that the cost of inaction on climate change is much larger than the cost of action, while the cost of persisting with security policy based on narrow notions of national self-interest is greater than moving towards a security approach based on cooperation and sustainability. Impacts are felt at different temporal and spatial scales, however, and differentially by each social group, with those who have the power and resources to take action potentially disinclined to do so, misguidedly believing themselves immune to the costs of inaction. These are straightforwardly political issues, not just at the global level but in national and local politics too. Winning the arguments over these issues is part of the challenge of shifting to environmental sustainability and a secure peace.

There is effectively no choice other than to take up the challenge. Flaws in global governance are imperfections in an important and continuing enterprise. Entry into the Anthropocene epoch only emphasizes the importance of establishing a normative and regulatory framework capable of ending the harm inflicted on the natural environment by human action. At the same time, entry into the Anthropocene represents a fundamental contextual change—more of the same is simply not good enough. In relation to both the environment and security issues, we need transformative change.

Here we offer **nine areas for change** in pursuit of the urgent collective task of not only thinking differently—as Einstein declared was necessary about the onset of the nuclear age—but planning how to act differently. The nine concern data issues, inclusivity, legitimacy, dialogue, the need for coordination, the free rider syndrome, political trust, countering populism, and the problem of linearity.

Today's biosphere and security risks, as explored above, involve many uncertainties as to the timing and scale of impacts. At the most basic level, there are grounds for concern about flaws in the **data** reported by governments on which climate pledges and modelling are based.[360] This is not a problem of climate science but of whether national governments have the will and capacity to provide accurate data on GHG emissions. Leaving aside issues of deliberate distortion of data, there are significant challenges in knowledge acquisition, storage, management, dissemination and application. These affect all environmental issues, not just climate change.[361] New technologies capable of processing the huge amounts of data involved can help identify risks, including ones that have a low probability of occurring but a high impact if they do.[362] The era of big data offers previously unavailable opportunities to gather insights about the severity and exposure of climate hazards, as well as their interaction with political, economic and social variables.[363] These approaches hold great promise when it comes to informing planning and investment by governments, businesses and communities. However, it is important that such technologies are not seen as silver bullets but rather contributions to enhanced decision making.

One way of improving decision making is to emphasize mechanisms that involve working collectively, with broad and diverse participation. As the IPCC's 2022 report repeatedly emphasizes, **inclusivity** broadens the range of individuals or actors involved in assessing a set of risks, thereby increasing the sum and diversity of knowledge exerted on the problem. This in turn makes it more likely a creative solution will be found, and improves collective ownership of the outcome.[364] While four major actors—China, the EU, India and the USA—could, if they were able to reach agreement, start to reduce the more than 50 per cent of global GHG emissions they are jointly responsible for at present,[365] the chances of such an agreement being successfully implemented without the buy-in of a wide range of actors—from Indigenous people to major corporations—are extremely low.

Communities interact frequently and share a location or identity (e.g. neighbourhood, religious or kinship groups). They work through informal networks based on trust, reciprocity and social norms—what some call 'social capital'.[366] Communities generally have more knowledge about local circumstances than is available in a country's capital, let alone international organizations. They are therefore better placed than centralized planners to establish policy, plans and priorities,[367] and also have greater incentives and ability to influence local affairs.[368] Communities thus have an advantage in managing the risks they face in their localities (such as local violence or flooding) due to their proximity to the people affected and their ability to recognize, understand and resolve local tensions. However, risks often exist on a scale that local communities are not equipped to handle.

Reliance on personal interactions is both a strength of communities and a potential weakness. Communities are not necessarily fair or inclusive, and can be marked by strong inequalities in power and wealth. Who is included and who is excluded in decision making determines what policies are selected and how they are implemented.[369] Local communities may exclude vulnerable people (chronically ill, widowed), women, new entrants (migrants, refugees) or those who happen to be different (ethnic and other minorities) from fair access to local markets, community spaces, public service or political voice and power.[370] Exclusion exposes some groups to a greater likelihood and worse impact of environmental hazards, while generating grievances and potential conflict arising from resentment at unequal distributions of power and resources.[371] Thus, while the attractions of acting locally are great, there is a risk it becomes too narrow in both focus and participation. Avoiding these risks is a challenge we return to in part 4.

The core point here is that there are differences of position, allegiance and interest in all societies and communities. These differences produce competing claims, especially when addressing the complex interplay between different priorities over environmental and security risks. This competition can only be handled by institutions accepted as legitimate arbiters by all the competing groups. Ownership or control of an institution by one group will necessarily diminish the **legitimacy** of how claims are settled. This issue

of legitimacy is especially important in the context of an issue in which transformative—or even just far-reaching—change is envisaged, such as responding to climate change. Only by adopting an inclusive approach can it be ensured that differences between stakeholders in a community or society are moderated peacefully. This mindset also holds true for UN member states, often referred to—hopefully rather than accurately for the most part—as 'the international community'.

The emphasis on legitimacy and inclusivity means that effective governance must involve continuous **dialogue**. In producing a viable, negotiated compromise, it is vital that different groups' concerns are aired, understood and balanced against each other. In order to be effective rather than merely a public relations exercise, the process needs to involve government institutions, business, community groups and civil society.

Dialogue is also needed to develop a **coordinated** approach,[372] which constitutes a fundamental element in addressing Anthropocene challenges. Coordination is required between issues (e.g. climate, security, health, inequality, trade, cyber vulnerability), actors (e.g. governments, businesses, international agencies, cities), actions (e.g. analysis, forecasting, policy-making, financing, implementation), spaces (e.g. cyberspace, outer space, the oceans, the land) and scales (from the local to the global). All this goes well beyond the often articulated need to escape institutional and intellectual siloes, though that is not a bad starting point. Ultimately, it involves setting aside how these topics have been divided up in the past and ignoring who has got what piece of the action hitherto—in other words, a fresh start in figuring out what is most likely to enhance both security and the natural environment. Coordination, in short, is not simply a technical question of aligning actions on diverse issues, nor of effective implementation of agreed measures. Rather, coordination is also a process of negotiation, which is why dialogue is required to achieve it.

Dialogue-driven coordination that aims for legitimacy and inclusivity is also necessary when it comes to dealing with **the free rider problem**. The simplest definition of a free rider is someone who benefits from a collective action without paying; the free rider problem is that the efficient production of collective goods is jeopardized by the incentive not to pay for it.[373] If the input of every actor (e.g. governments, cities, corporate entities) is required to make something (e.g. climate action) successful, there is a chance everyone will contribute. However, if the withdrawal of an actor's contribution would make no discernible difference to the overall benefit, which the delinquent actor would continue to receive regardless, a rational actor might decide not to contribute. And then another. And perhaps more. Once a certain momentum of non-payment of dues has built up, the incentive not to bother may become too much to resist, at which point the whole effort collapses. This may be especially tempting when the benefit of the action lies well into the future but its costs are to be paid now. What free riders need to know is that the costs of inaction far outweigh the costs of action.

This underlines the importance of growing public and political awareness of the issues, an inspiring youth movement, more ambition for action from countries worldwide, and an increasing sense of urgency. For global governance to work, political engagement is crucial at the national and local scales, where ordinary citizens have the capacity to influence things and a sense of their own agency. However, sustained engagement by ordinary citizens requires a belief that things can be influenced to change, which in turn necessitates a degree of trust in at least some of the main public institutions. Widely expressed concerns about a generalized decline in **political trust** place this in doubt.[374] The evidence for this decline is a good deal less clear than many fear and, as far as democratic states are concerned, trust seems to flow as well as ebb.[375] There is little doubt, though, that, where it is possible to identify the problem through opinion surveys and people are free to express the distrust they feel, trust in many countries' public institutions cannot be taken for granted.

Distrust in institutions feeds dissatisfaction with the system of government and with the balances and compromises demanded by democracy. One of the current symptoms of this dissatisfaction is **populism**.[376] Of concern here is that populism is often associated with a nationalistic turn away from international cooperation, as seen in the USA, the UK and other countries in western Europe in recent years. In both liberal and illiberal states, populism tends to be anti-foreigner and especially anti-immigrant, and is often associated with a systematic rejection of expert knowledge and science.[377]

Countering populism is unlikely to be successful if the focus is on responding to populist arguments on their own terms. Instead, what is needed is an alternative that can be put forward as more appealing and urgent. From this perspective, it is important to bear in mind that resolving the environmental and security dimensions of the planetary emergency involves more than simply doing what is done today but a bit better. The climate crisis, other environmental crises and today's security challenges can only be successfully tackled by a radical change of course. The old diplomacy is no longer enough.[378] The old politics is no longer enough. The old economic trade-offs are no longer enough. And the old idea that you can simply make a policy to fix each of these problems is likewise no longer enough.

One way or another, working within current institutional and political realities, awareness has to grow that we are facing problems with a quite particular profile. These are not problems for which there are **linear** solutions. It is not a question of a single cause having a single effect. Rather, a multiplicity of causes—social, political, economic, natural, technical, human, military, contemporary, historical—interact to generate a multiplicity of effects in each domain. There are six characteristics to these non-linear problems:[379]

1 They are multi-dimensional;

2 They have multiple stakeholders;

3 They have multiple causes;

4 They have multiple symptoms;

5 They have multiple solutions; and

6 They are constantly evolving.

This simple list offers an overview of everything that has been argued, as well as all the evidence brought forward, both in this part and the rest of the report. Parts 2, 3 and 4 continue in the same vein of identifying problems and potential ways of addressing them in a mode that respects these six realities. Policies, institutional designs and practical initiatives for a global environment of peace will only work if they succeed in respecting them. The task ahead is different from classic problem solving. There are no boxes to tick, no moment when it will be possible to declare 'job done' and move onto the next issue. The way of working must be attuned to the challenges faced and the ways in which they interact; modified to meet different needs at different times in different places, while maintaining a clear overall direction. It is an approach to governance that emphasizes the importance of adaptiveness. If we can find a way to work like this, then it will be possible to introduce an environment of peace to the environmental crisis and interlocking security challenges of the Anthropocene.

ENDNOTES

1 United Nations, Report of the United Nations Conference on the Human Environment, Stockholm, 5–16 June 1972, A/CONF.48/14/Rev.1, 1973.

2 Brown, L. B., *Redefining National Security*, Worldwatch Paper no. 14 (Worldwatch Institute: Washington, DC, Oct. 1977).

3 Matthews, J. T., 'Redefining security', *Foreign Affairs*, vol. 68, no. 2 (1989).

4 Brown, N., 'Climate and conflict', *RUSI Journal*, vol. 135, no. 4 (Dec. 1990).

5 Krampe, F., 'Why United Nations peace operations cannot ignore climate change', 22 Feb. 2021.

6 Stanway, D., 'US climate envoy Kerry urges China to keep politics out of global warming', Reuters, 2 Sep. 2021; 'China warns US climate cooperation at risk over political tension', NBC News, 2 Sep. 2021; and Volcovici, V., 'US–China diplomatic breakdown clouds outlook for global climate progress', Reuters, 6 Aug. 2022.

7 UN Economic and Social Council Resolution 1346 (XLV), 30 July 1968.

8 United Nations, *Our Common Agenda: Report of the Secretary-General* (United Nations: New York, 2021), p. 12.

9 O'Brien, K., 'The return of the Enlightenment', *American Historical Review*, vol. 115, no. 5 (Dec. 2010).

10 Mace, G. M., Norris, K. and Fitter, A. H., 'Biodiversity and ecosystem services: A multilayered relationship', *Trends in Ecology & Evolution*, vol. 27, no. 1 (Jan. 2012); and Folke, C. et al., 'Social-ecological resilience and biosphere-based sustainability science', *Ecology & Society*, vol. 21, no. 3 (2016).

11 Díaz, S. et al., 'Assessing nature's contributions to people', *Science*, vol. 359, no. 6373 (2018); and Brondízio, E. S. et al. (eds), *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (IPBES: Bonn, May 2019).

12 Intergovernmental Panel on Climate Change (IPCC), 'Summary for policymakers', eds V. Masson-Delmotte et al. *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the IPCC Sixth Assessment Report (Cambridge University Press: Cambridge, UK/New York, USA, 2021).

13 Rockström, J. et al., 'We need biosphere stewardship that protects carbon sinks and builds resilience', *Proceedings of the National Academy of Sciences*, vol. 118, no. 38 (Sep. 2021).

14 Rockström et al. (note 13).

15 Steffen, W. et al., 'The Anthropocene: From global change to planetary stewardship', *Ambio*, vol. 40, no. 7 (Nov. 2011).

16 Rockström, J. et al., 'The unfolding water drama in the Anthropocene: Towards a resilience-based perspective on water for global sustainability', *Ecohydrology*, vol. 7, no. 5 (2014).

17 Wohlleben, P., *The Secret Network of Nature* (Vintage: London, 2018).

18 National Geographic Society, 'Biodiversity', 23 Aug. 2019.

19 Montanarella, L., Scholes, R. and Brainich, A. (eds), *The Assessment Report on Land Degradation and Restoration* (IPBES: Bonn, 2018); and Halpern, B. S. et al., 'Spatial and temporal changes in cumulative human impacts on the world's ocean', *Nature Communications, vol. 6*, no. 1 (July 2015).

20 UN Food and Agriculture Organization of the UN, *The State of the World's Forests 2022* (FAO: Rome, May 2022), p. xiii.

21 Steffen, W. et al., 'The trajectory of the Anthropocene: The Great Acceleration', *Anthropocene Review*, vol. 2, no. 1 (Apr. 2015).

22 Dasgupta, P., *The Economics of Biodiversity: The Dasgupta Review* (HM Treasury: London, 2021), p. 101.

23 Worldometer, 'Countries ranked by life expectancy', accessed 13 Nov. 2021.

24 Roser, M., Ortiz-Ospina, E. and Ritchie, H., 'Life expectancy', Our World in Data, Oct. 2019.

25 Moatsos, M., 'Global extreme poverty: Present and past since 1820', ed. Organisation for Economic Co-operation and Development (OECD), *How Was Life? Volume II: New Perspectives on Well-Being and Global Inequality since 1820* (OECD: Paris, 2021).

26 Moatsos (note 25).

27 Kolbert, E., *The Sixth Extinction: An Unnatural History* (Henry Holt & Company: New York, Feb. 2014).

28 Brondízio et al. (note 11), p. xvi; and Purvis, A. et al., 'Status and trends—Nature', eds E. S. Brondízio et al., *Global Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (IPBES: Bonn, 2019).

29 Bar-On, Y. M., Phillips, R. and Milo, R., 'The biomass distribution on Earth', *Proceedings of the National Academy of Sciences*, vol. 115, no. 25 (June 2018).

30 Grooten, M. and Almond, R. E. A. (eds), *Living Planet Report 2018: Aiming Higher* (WWF: Gland, 2018), p. 90.

31 Goulson, D., 'The insect apocalypse, and why it matters', *Current Biology*, vol. 29, no. 19 (Oct. 2019).

32 Hallmann, C. A. et al., 'More than 75 percent decline over 27 years in total flying insect biomass in protected areas', *PLOS One*, vol. 12, no. 10 (Oct. 2017).

33 Lister, B. C. and Garcia, A., 'Climate-driven declines in arthropod abundance restructure a rainforest food web', *Proceedings of the National Academy of Sciences*, vol. 115, no. 44 (Oct. 2018).

34 Forister, M. L., Pelton, E. M. and Black, S. H., 'Declines in insect abundance and diversity: We know enough to act now', *Conservation Science and Practice*, vol. 1, no. 8 (Aug. 2019).

35 Montgomery, G. A. et al., 'Is the insect apocalypse upon us? How to find out', *Biological Conservation*, vol. 241 (Jan. 2020).

36 Smil, V., *Harvesting the Biosphere: What We Have Taken from Nature* (MIT Press: Cambridge, MA, 2013); and Bar-On, Phillips and Milo (note 29).

37 Noriega, J. A. et al., 'Research trends in ecosystem services provided by insects', *Basic and Applied Ecology*, vol. 26 (Feb. 2018).

38 Marco, M. Di et al., 'Sustainable development must account for pandemic risk', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 117, no. 8 (2020); Jones, K. E. et al., 'Global trends in emerging infectious diseases', *Nature*, vol. 451, no. 7181 (2008); Myers, S. S. and Patz, J. A., 'Emerging threats to human health from global environmental change', *Annual Review of Environment and Resources*, vol. 34 (2009); and Semenza, J. C., 'Cascading risks of waterborne diseases from climate change', *Nature Immunology*, vol. 21, no. 5 (May 2020).

39 Frumkin, H. and Haines, A., 'Global environmental change and noncommunicable disease risks', *Annual Review of Public Health*, vol. 40, no. 1 (Apr. 2019).

40 Ahmad, N. A. et al., 'Air pollution effects on adult mortality rate in developing countries', *Environmental Science and Pollution Research*, vol. 28, no. 7 (Feb. 2021).

41 OECD, *Geographic Variations in Health Care: What Do We Know and What Can Be Done to Improve Health System Performance?* (OECD: Paris, 2014).

42 Persson, L. et al., 'Outside the safe operating space of the planetary boundary for novel entities', *Environmental Science & Technology*, vol. 56, no. 3 (Feb. 2022).

43 Kaza, S. et al., *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (World Bank: Washington, DC, 2018).

44 World Bank, 'Trends in solid waste management', accessed 23 Aug. 2021.

45 Geyer, R., Jambeck, J. R. and Law, K. L., 'Production, use, and fate of all plastics ever made', *Science Advances*, vol. 3, no. 7 (July 2017).

46 Chamas, A. et al., 'Degradation rates of plastics in the environment', *ACS Sustainable Chemistry & Engineering*, vol. 8, no. 9 (Mar. 2020); WWF Australia, 'The lifecycle of plastics', 2 July 2021; and Giacovelli, C., *Single-Use Plastics: A Roadmap for Sustainability* (UNEP: Nairobi, 2018).

47 Cox, K. D. et al, 'Human consumption of microplastics', *Environmental Science & Technology*, vol. 53, no. 12 (June 2019).

48 Ragusa, A. et al, 'Plasticenta: First evidence of microplastics in human placenta', *Environment International*, vol. 146 (Jan. 2021); and Ragusa, A. et al, 'Raman microspectroscopy detection and characterisation of microplastics in human breastmilk', *Polymers*, vol. 14 (June).

49 European Commission Directorate-General for Research and Innovation, *Environmental and Health Risks of Microplastics Pollution* (European Commission: Brussels, Apr. 2019).

50 Lebreton, L. et al., 'Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic', *Scientific Reports*, vol. 8, no. 1 (Dec. 2018).

51 UN Environment Programme (UNEP), *Towards a Pollution-Free Planet: Background Report* (UNEP: Nairobi, 2017), p. 28.

52 UNEP (note 51), p. 27.

53 Smith, D. L., Dushoff, J. and Jr, J. G. M., 'Agricultural antibiotics and human health', *PLOS Medicine*, vol. 2, no. 8 (July 2005); Chang, Q. et al., 'Antibiotics in agriculture and the risk to human health: How worried should we be?', *Evolutionary Applications*, vol. 8, no. 3 (2015); and Manyi-Loh, C. et al., 'Antibiotic use in agriculture and its consequential resistance in environmental sources: Potential public health implications', *Molecules*, vol. 23, no. 4 (Apr. 2018).

54 UNEP (note 51).

55 Health Effects Institute, *State of Global Air 2020: A Special Report on Global Exposure to Air Pollution and Its Health Impacts* (Health Effects Institute: Boston, 2020).

56 Ritchie, H. and Roser, M., 'Air pollution', Our World in Data, 2021; Ritchie, H. and Roser, M., 'Indoor air pollution', Our World in Data, 2019; and UNEP (note 51), pp. 15–16.

57 Institute for Health Metrics and Evaluation (IHME), University of Washington, 'GBD compare', data as of 2019, accessed 23 Aug. 2021.

58 Schraufnagel, D. E. et al., 'Air pollution and noncommunicable diseases: A review by the Forum of International Respiratory Societies' Environmental Committee. Part 1: The damaging effects of air pollution', *Chest*, vol. 155, no. 2 (Feb. 2019).

59 Newbury, J. B. et al., 'Association between air pollution exposure and mental health service use among individuals with first presentations of psychotic and mood disorders: Retrospective cohort study', *British Journal of Psychiatry* (19 Aug. 2021).

60 Bekkar, B. et al., 'Association of air pollution and heat exposure with preterm birth, low birth weight, and stillbirth in the USA Systematic Review', *JAMA Network Open*, vol. 3, no. 6 (June 2020).

61 Wesselink, A. and Wellenius, G. A., 'Impacts of climate change on reproductive, perinatal and paediatric health', *Pediatric and Perinatal Epidemiology*, vol. 36, no. 1 (Jan. 2022).

62 Carey, I. M. et al., 'Are noise and air pollution related to the incidence of dementia? A cohort study in London, England', *BMJ Open*, vol. 8, no. 9 (Sep. 2018).

63 FAO, *Healthy Soils are the Basis for Healthy Food Production* (FAO: Rome, 2015), p. 1.

64 Rodríguez-Eugenio, N., McLaughlin, M. and Pennock, D., *Soil Pollution: A Hidden Reality* (FAO: Rome, 2018), p. vi.

65 FAO, *Status of the World's Soil Resources: Main Report* (FAO: Rome, 2015), p. xix.

66 Montanarella, Scholes and Brainich (note 19), p. 18.

67 UNEP, *Healthy Environment, Healthy People* (UNEP: Nairobi, 2016), p. 22.

68 Brondízio et al. (note 11), p. xiv.

69 Díaz, S. et al., 'Pervasive human-driven decline of life on Earth points to the need for transformative change', *Science*, vol. 366, no. 6471 (13 Dec. 2019); Wilkinson, D. A. et al., 'Habitat fragmentation, biodiversity loss and the risk of novel infectious disease emergence', *Journal of the Royal Society Interface*, vol. 15, no. 149 (2018); and Jones, K. E. et al., 'Global trends in emerging infectious diseases', *Nature*, vol. 451, no. 7181 (Feb. 2008).

70 Watts, N. et al., 'Health and climate change: Policy responses to protect public health', *The Lancet*, vol. 386, no. 10006 (Nov. 2015).

71 Ryan, S. J. et al., 'Warming temperatures could expose more than 1.3 billion new people to Zika virus risk by 2050', *Global Change Biology*, vol. 27, no. 1 (Jan. 2021).

72 NASA, Goddard Institute for Space Studies, 'Global land–ocean temperature index', accessed 30 Aug. 2022.

73 IPCC (note 12).

74 Arias, P. A. et al., 'Technical summary', eds V. Masson-Delmotte et al. *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the IPCC Sixth Assessment Report (Cambridge University Press: Cambridge, UK/New York, USA, 2021), pp. 39–40.

75 Arias et al. (note 74), p. 44. The IPCC defines confidence levels in terms of the amount, consistency, quality and types of evidence supporting its conclusions, as well as the degree of agreement between different streams of evidence. 'High confidence' reflects high agreement between multiple, independent and consistent lines of high-quality evidence.

76 IPCC (note 12). Note that referring to 1850–1900 as 'pre-industrial' may seem anomalous to readers familiar with how advanced industrialization was by then (albeit in Europe and North America, rather than worldwide). The reason for using this period as a baseline for comparison is because it is the first in which sufficiently comprehensive records exist to estimate global surface temperatures.

77 Eyring, V. et al., 'Human influence on the climate system', eds V. Masson-Delmotte et al. *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the IPCC Sixth Assessment Report (Cambridge University Press: Cambridge, UK/New York, USA, 2021).

78 Chen, D. et al., 'Framing, context, and methods', eds V. Masson-Delmotte et al. *Climate Change 2021: The Physical Science Basis*, Contribution of Working Group I to the IPCC Sixth Assessment Report (Cambridge University Press: Cambridge, UK/New York, USA, 2021).

79 Chemke, R., Ming, Y. and Yuval, J., 'The intensification of winter mid-latitude storm tracks in the southern hemisphere', *Nature Climate Change*, vol. 12, no. 6 (June 2022).

80 Fountain, H., 'It rained at the summit of Greenland. That's never happened before', *New York Times*, 20 Aug. 2021; and Milman, O., 'Greenland: Enough ice melted on single day to cover Florida in two inches of water', *The Guardian*, 30 July 2021.

81 Hausfather, Z., 'Analysis: When might the world exceed 1.5C and 2C of global warming?', Carbon Brief, 4 Dec. 2020; and United Nations, Paris Agreement, Treaties-XXVII.7.dm, adopted 12 Dec. 2015, entered into force 4 Nov. 2016.

82 Arias et al. (note 74), p. 94.

83 Ciavarella, A. et al., 'Prolonged Siberian heat of 2020 almost impossible without human influence', *Climatic Change*, vol. 166, nos 1–2 (May 2021); and Philip, S. Y. et al., 'Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021', World Weather Attribution, 7 July 2021.

84 For an expression of scepticism about the climate change impact on drought in the Horn of Africa see van Oldenborgh, G. J. et al., 'Rapid analysis of drought in Somalia, 2016', World Weather Attribution, 30 Mar. 2017; while for a contrary view see Tierney, J. E., Ummenhofer, C. C. and deMenocal, P. B., 'Past and future rainfall in the Horn of Africa', *Science Advances*, vol. 1, no. 9 (Oct. 2015).

85 Han, X. et al., 'Attribution of the extreme drought in the Horn of Africa during short-rains of 2016 and long-rains of 2017', *Water*, vol. 14, no. 3 (Jan. 2022).

86 Tellman, B. et al., 'Satellite imaging reveals increased proportion of population exposed to floods', *Nature*, vol. 596, no. 7870 (4 Aug. 2021).

87 Mallapaty, S., 'Why are Pakistan's floods so extreme this year?', *Nature*, 2 Sep. 2022.

88 Tan, C., 'China warns of "stronger flood" as Three Gorges Dam faces swell', *Nikkei Asia*, 17 July 2020.

89 Ni, V. and Davidson, H., 'Death toll rises and thousands flee homes as floods hit China', *The Guardian*, 21 July 2021.

90 Celis, N., 'Half of China hit by drought in worst heatwave on record', Phys.org News, 25 Aug. 2022; BBC News, 'Europe's drought the worst in 500 years—report', 23 Aug. 2022; and Toreti, A. et al., *Drought in Europe: August 2022* (EU Publications Office: Luxembourg, Aug. 2022).

91 Jones, M. W. et al., 'Climate change increases the risk of wildfires', ScienceBrief Review, Jan. 2020; and Dunne, D., 'Explainer: How climate change is affecting wildfires around the world', Carbon Brief, 14 July 2020.

92 Lin, N. et al., 'Physically based assessment of hurricane surge threat under climate change', *Nature Climate Change*, vol. 2, no. 6 (June 2012).

93 Magnan, A. K. et al., 'Integrative cross-chapter box on low-lying islands and coasts', eds H.-O. Pörtner et al., *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (Cambridge University Press: Cambridge, UK/New York, USA, 2019).

94 Watts, N. et al., 'The Lancet Countdown: Tracking progress on health and climate change', *The Lancet*, vol. 389, no. 10074 (2017).

95 Robine, J.-M. et al., 'Death toll exceeded 70,000 in Europe during the summer of 2003', *Comptes Rendus Biologies*, vol. 331, no. 2 (Feb. 2008).

96 Im, E.-S., Pal, J. S. and Eltahir, E. A. B., 'Deadly heat waves projected in the densely populated agricultural regions of South Asia', *Science Advances*, vol. 3, no. 8 (Aug. 2017); and Wehner, M. et al., 'The deadly combination of heat and humidity in India and Pakistan in summer 2015', *Bulletin of the American Meteorological Society*, vol. 97, no. 12 (Dec. 2016).

97 Vecellio, D. J. et al., 'Evaluating the 35°C wet-bulb temperature adaptability threshold for young, healthy subjects (PSU HEAT Project)', *Journal of Applied Physiology*, vol. 132, no. 2 (Feb. 2022).

98 Raymond, C., Matthews, T. and Horton, R. M., 'The emergence of heat and humidity too severe for human tolerance', *Science Advances*, vol. 6, no. 19 (May 2020).

99 Campbell-Lendrum, D. and Wheeler, N., *COP24 Special Report: Health & Climate Change* (WHO: Geneva, 2018).

100 Wesselink and Wellenius (note 61).

101 Rocklöv, J. and Dubrow, R., 'Climate change: An enduring challenge for vector-borne disease prevention and control', *Nature Immunology*, vol. 21, no. 5 (May 2020); and Watts et al. (note 94).

102 Romanelli, C. et al., *Connecting Global Priorities: Biodiversity and Human Health. A State of Knowledge Review* (CBD Secretariat/WHO: Montreal/Geneva, 2015).

103 FAO et al., *The State of Food Security and Nutrition in the World 2021: Transforming Food Systems for Food Security, Improved Nutrition and Affordable Healthy Diets for All* (FAO/IFAD/UNICEF/WFP/WHO: Rome, 2021).

104 Weart, S. R., *The Discovery of Global Warming*, revised edn (Harvard University Press: Cambridge, 2008); Rich, N., *Losing Earth: The Decade We Could Have Stopped Climate Change* (Picador: London, 2019); and Bell, A., 'Sixty years of climate change warnings: The signs that were missed (and ignored)', *The Guardian*, 5 July 2021.

105 Ad Hoc Study Group on Carbon Dioxide and Climate, *Carbon Dioxide and Climate: A Scientific Assessment* (National Academy of Sciences: Washington, DC, 1979); and Weart (note 104).

106 IPCC (note 12), p. 80.

107 Welsby, D. et al., 'Unextractable fossil fuels in a 1.5°C world', *Nature*, vol. 597, no. 7875 (Sep. 2021).

108 Krausmann, F. et al., 'From resource extraction to outflows of wastes and emissions: The socioeconomic metabolism of the global economy, 1900–2015', *Global Environmental Change*, vol. 52 (Sep. 2018).

109 Krausmann, F. et al., 'Material flow accounting: Measuring global material use for sustainable development', *Annual Review of Environment and Resources*, vol. 42, no. 1 (Oct. 2017), p. 656.

110 Grauman, J. V., 'Orders of magnitude of the world's urban population in history', UN Department of Economic and Social Affairs (UNDESA), *Population Bulletin of the United Nations no. 8—1976* (UNDESA: New York, 1977); and Goldewijk, K. K., Beusen, A. and Janssen, P., 'Long-term dynamic modelling of global population and built-up area in a spatially explicit way: HYDE 3.1', *The Holocene*, vol. 20, no. 4 (2010).

111 UNDESA, Population Division, 'World urbanization prospects: The 2018 revision', accessed 25 Feb. 2021.

112 UNDESA (note 111).

113 UN Economic and Social Council, 'Some facts on urbanization', Fact Sheet, May 2014.

114 Swilling, M. et al., *The Weight of Cities: Resource Requirements of Future Urbanization* (UNEP: Nairobi, 2018), p. 41.

115 FAO, 'Water use', AQUASTAT—FAO's Global Information System on Water and Agriculture; and World Bank, 'Water in agriculture', 8 May 2020.

116 UN Educational, Scientific and Cultural Organization (UNESCO), *The United Nations World Water Development Report 2020: Water and Climate Change* (UNESCO: Paris, Mar. 2020); and Wada, Y. et al., 'Modelling global water use for the 21st century: The Water Futures and Solutions (WFaS) initiative and its approaches', *Geoscientific Model Development*, vol. 9, no. 1 (Jan. 2016).

117 Mateo-Sagasta, J. et al., *Water Pollution from Agriculture: A Global Review—Executive Summary* (FAO/IWMI: Rome/Colombo, 2017), p. 3.

118 Kookana, R. S. et al., 'Urbanisation and emerging economies: Issues and potential solutions for water and food security', *Science of The Total Environment*, vol. 732, no. 139057 (Aug. 2020).

119 Bigas, H., *Water Security and the Global Water Agenda: A UN-Water Analytical Brief* (UNU-INWEH: Hamilton, ON, Oct. 2013), p. 1.

120 Mekonnen, M. M. and Hoekstra, A. Y., 'Four billion people facing severe water scarcity', *Science Advances*, vol. 2, no. 2 (Feb. 2016).

121 FAO, *The State of Food and Agriculture 2020: Overcoming Water Challenges in Agriculture* (FAO: Rome, 2020), p. 25.

122 UN-Water, *Summary Progress Update 2021: SDG 6—Water and Sanitation for All* (UN-Water: Geneva, July 2021), p. 7.

123 FAO (note 121), p. v.

124 UN-Water (note 122), p. 9.

125 Biggs, O. et al., 'Regime shifts', eds A. Hastings and L. J. Gross, *Encyclopedia of Theoretical Ecology* (University of California Press: Berkeley, CA, 2012); Scheffer, M. et al., 'Catastrophic shifts in ecosystems', *Nature*, vol. 413, no. 6856 (Oct. 2001); and Hughes, T. P. et al., 'Multiscale regime shifts and planetary boundaries', *Trends in Ecology & Evolution*, vol. 28, no. 7 (June 2013).

[126] Rocha, J. et al., 'Marine regime shifts: Drivers and impacts on ecosystems services', *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 370, no. 1659 (Jan. 2015); and Rocha, J. C. et al., 'Cascading regime shifts within and across scales', *Science*, vol. 362, no. 6421 (Dec. 2018).

[127] Wunderling, N. et al., 'Interacting tipping elements increase risk of climate domino effects under global warming', *Earth System Dynamics*, vol. 12, no. 2 (June 2021).

[128] Arias et al. (note 74), p. 80.

[129] Lenton, T. M. et al., 'Climate tipping points—too risky to bet against', *Nature*, 27 Nov. 2019.

[130] Steffen, W. et al., 'Trajectories of the earth system in the Anthropocene', *Proceedings of the National Academy of Sciences*, vol. 115, no. 33 (Aug. 2018).

[131] Steffen, W., Crutzen, P. J. and McNeill, J. R., 'The Anthropocene: Are humans now overwhelming the great forces of nature', *AMBIO: A Journal of the Human Environment*, vol. 36, no. 8 (Dec. 2007).

[132] Crutzen, P. J. and Stoermer, E. F., 'The "Anthropocene"', *IGBP Global Change Newsletter*, vol. 41 (May 2000).

[133] Subcommission on Quaternary Stratigraphy, Anthropocene Working Group, 'What is the Anthropocene? Current definition and status', 21 May 2019; and Carrington, D., 'The Anthropocene epoch: Scientists declare dawn of human-influenced age', *The Guardian*, 29 Aug. 2016.

[134] Malhi, Y., 'The concept of the Anthropocene', *Annual Review of Environment and Resources*, vol. 42, no. 1 (Oct. 2017).

[135] Subcommission on Quaternary Stratigraphy (note 133); and Carrington (note 133).

[136] Steffen et al. (note 130); and Hamilton, C., *Defiant Earth: The Fate of Humans in the Anthropocene* (Polity Press: Oxford, 2017).

[137] Spera, S. A., Winter, J. M. and Partridge, T. F., 'Brazilian maize yields negatively affected by climate after land clearing', *Nature Sustainability*, vol. 3, no. 10 (Oct. 2020).

[138] Gordon, L. J., Peterson, G. D. and Bennett, E. M., 'Agricultural modifications of hydrological flows create ecological surprises', *Trends in Ecology & Evolution*, vol. 23, no. 4 (Apr. 2008).

[139] Helbing, D., 'Globally networked risks and how to respond', *Nature*, vol. 497, no. 7447 (May 2013); Centeno, M. A. et al., 'The emergence of global systemic risk', *Annual Review of Sociology*, vol. 41, no. 1 (Aug. 2015); and Galaz, V. et al., 'Institutional and political leadership dimensions of cascading ecological crises', *Public Administration*, vol. 89, no. 2 (June 2011).

[140] Keys, P. W. et al., 'Anthropocene risk', *Nature Sustainability*, vol. 2, no. 8 (Aug. 2019).

[141] Milkoreit, M. et al., 'Defining tipping points for social-ecological systems scholarship—an interdisciplinary literature review', *Environmental Research Letters*, vol. 13, no. 3 (Mar. 2018); and Otto, I. M. et al., 'Social tipping dynamics for stabilizing Earth's climate by 2050', *Proceedings of the National Academy of Sciences*, vol. 117, no. 5 (Feb.2020).

[142] Xu, C. et al., 'Future of the human climate niche', *Proceedings of the National Academy of Sciences*, vol. 117, no. 21 (May 2020).

[143] Stockholm Resilience Centre, 'The nine planetary boundaries', accessed 31 Aug. 2021. The planetary boundary concept was first presented in 2009 and subsequently updated in 2015. See Rockström, J. et al., 'Planetary boundaries: Exploring the safe operating space for humanity', *Ecology & Society*, vol. 14, no. 2 (2009); and Steffen, W. et al., 'Planetary boundaries: Guiding human development on a changing planet', *Science*, vol. 347, no. 6223 (Feb. 2015).

[144] Persson et al. (note 42).

[145] North Atlantic Treaty Organization (NATO), 'The Alliance's New Strategic Concept (1991), agreed by the heads of state and government participating in the meeting of the North Atlantic Council', 7–8 Nov. 1991.

[146] UN Development Programme, *Human Development Report 1994* (Oxford University Press: New York, 1994).

[147] Lodgaard, S., 'Human security: Concept and operation', eds M. Muller and B. de Gaay Fortmann, *From Warfare to Welfare: Human Security in a Southern African Context* (Royal Van Gorcum: Assen, 2004).

[148] See e.g. Daoudy, M., 'Rethinking the climate–conflict nexus: A human–environmental–climate security approach', *Global Environmental Politics*, vol. 21, no. 3 (Aug. 2021); Smith, D. and Krampe, F., 'Climate-related security risks in the Middle East', eds A. Jägerskog, M. Schulz and A. Swain, *Routledge Handbook on Middle East Security*, 1st edn (Routledge: London, 2019); and Schaar, J., 'A confluence of crises: On water, climate and security in the Middle East and North Africa', SIPRI Insights on Peace and Security no. 2019/4, July 2019.

[149] Data from the Uppsala Conflict Data Program (UCDP), UCDP Conflict Encyclopedia (UCDP Database), Department of Peace and Conflict Research, Uppsala University, accessed 26 June 2021.

[150] Human Security Centre, *Human Security Report 2005: War and Peace in the 21st Century* (Oxford University Press: New York, 2005); and Human Security Report Project (HSRP), Simon Fraser University, *Human Security Report 2009/2010: The Causes of Peace and the Shrinking Costs of War* (Oxford University Press: New York, 2011).

[151] See e.g. Roser, M., 'War and peace', Our World in Data, 2016. Note that some of the more 'optimistic' assessments showing declining numbers of people killed in war omit the 1994 Rwandan genocide and similar genocidal attacks in other countries, and also appear to choose the lowest available estimates for the death toll in e.g. the Iran–Iraq War, 1980–88, and the second Sudanese civil war, 1983–2005. See Des Forges, A., *'Leave None to Tell the Story': Genocide in Rwanda* (Human Rights Watch: New York, Mar. 1999); Encyclopaedia Britannica, 'Iran–Iraq war', 15 Oct. 2021; and US Committee for Refugees and Immigrants, '1.9 million dead from Sudan's civil war; more than 70 000 deaths in 1998, report estimates', ReliefWeb, 10 Dec. 1998.

[152] UN High Commissioner for Refugees (UNHCR), 'Figures at a glance', 2022.

[153] UNHCR, *Global Trends: Forced Displacement in 2020* (UNHCR: Copenhagen, June 2021), p. 6.

[154] Weir, D., 'How does war damage the environment?', Conflict and Environment Observatory, 4 June 2020.

[155] Garrity, A., 'Conflict rubble: A ubiquitous and under-studied toxic remnant of war', Conflict and Environment Observatory, 10 July 2014.

[156] Weir, D., 'Collateral damage estimates and the acceptability of attacks on industrial sites', Conflict and Environment Observatory, 3 July 2015.

[157] Weir (note 156).

[158] Anwari, R. and Siddique, A., 'Illegal logging boosts Taliban, IS revenues in Eastern Afghanistan', Gandhara, 5 Oct. 2017; Aldaghbashy, A., 'Yemen's forests another casualty of war amid fuel crisis', SciDev.Net, 9 May 2019; and Davis, M., 'Forests and conflict in Cambodia', *International Forestry Review*, vol. 7, no. 2 (2005).

[159] Westing, A., *Ecological Consequences of the Second Indochina War* (Almqvist & Wiksell International: Stockholm, 1976).

[160] International Committee of the Red Cross (ICRC), Customary International Humanitarian Law (IHL) database, 'Practice relating to rule 76: Herbicides', accessed 17 Jan. 2022.

[161] ICRC, *Guidelines on the Protection of the Natural Environment in Armed Conflict* (ICRC: Geneva, 2020).

[162] International Law and Policy Institute (ILPI), *Protection of the Natural Environment in Armed Conflict: An Empirical Study* (ILPI: Oslo, 2014).

[163] Weir (note 156).

[164] Weir (note 156).

[165] UNEP, *Desk Study on the Environment in Iraq* (UNEP: Geneva, 2003); UNEP and UN Centre for Human Settlements (UNCHS), *The Kosovo Conflict: Consequences for the Environment & Human Settlements* (UNEP/UNCHS: Nairobi, 1999).

[166] Belcher, O. et al., 'Hidden carbon costs of the "everywhere war": Logistics, geopolitical ecology, and the carbon boot-print of the US military', *Transactions of the Institute of British Geographers*, vol. 45, no. 1 (Mar. 2020).

[167] Gardner, T., 'US military marches forward on green energy, despite Trump', Reuters, 1 Mar. 2017.

[168] Stoltenberg, J., 'NATO must combat climate change', NATO, 27 Sep. 2020; and Kanunnikova, T., 'How green energy makes the military stronger', *Asia Times*, 13 Oct. 2020.

[169] Simon, S., Bouville, A. and Land, C., 'Fallout from nuclear weapons tests and cancer risks', *American Scientist*, vol. 94, no. 1 (Jan. 2006).

[170] United States Atomic Energy Commission (USAEC), *Baneberry Summary Report* (USAEC: Washington, DC, May 1971) and Khalturin, V. I. et al., 'A review of nuclear testing by the Soviet Union at Novaya Zemlya, 1955–1990', *Science and Global Security*, vol. 13, nos 1–2 (2005).

[171] Atomic Heritage Foundation, 'Marshall Islands', accessed 18 Jan. 2022.

[172] US Department of Energy, 'Report on the status of the Runit Dome in the Marshall Islands', Report to Congress, June 2020.

[173] Rust, S., 'US says leaking nuclear waste dome is safe; Marshall Islands leaders don't believe it', *Los Angeles Times*, 1 July 2020.

[174] Jose, C., Wall, K. and Hinzel, J. H., 'This dome in the Pacific houses tons of radioactive waste–and it's leaking', *The Guardian*, 3 July 2015.

[175] World Bank and United Nations, *Pathways for Peace: Inclusive Approaches to Preventing Violent Conflict* (World Bank Group: Washington, DC, 2018); McQuinn, B., 'Global trends: Armed-group proliferation—origins and consequences', ed. International Institute for Strategic Studies, *The Armed Conflict Survey 2020* (Routledge: Abingdon, 2020); and BBC News, 'Guide to key Libyan militias', 11 Jan. 2016.

[176] McQuinn (note 175).

[177] Sollenberg, M. and Melander, E., 'Patterns of organized violence, 2007–16', *SIPRI Yearbook 2017: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2017).

[178] Davis, I., 'Tracking armed conflicts and peace processes', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021); and Davis, I. and Fazil, S., 'Armed conflict and peace processes in the Middle East and North Africa', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021).

[179] de Boer, J. and Bosetti, L., *The Crime–Conflict Nexus: Assessing the Threat and Developing Solutions* (UNU-CPR: New York, May 2017).

[180] Beittel, J. S., *Mexico: Organized Crime and Drug Trafficking Organizations*, Congressional Research Service (CRS) Report for Congress R41576 (US Congress, CRS: Washington, DC, 28 July 2020), p. 6.

[181] Banfield, J., *Crime and Conflict: The New Challenge for Peacebuilding* (International Alert: London, July 2014).

[182] Kleinfeld, R., *A Savage Order: How the World's Deadliest Countries Can Forge a Path to Security* (Knopf Doubleday: New York, 2018).

[183] de Waal, A., *The Real Politics of the Horn of Africa: Money, War and the Business of Power* (Polity Press: Cambridge, 2015); and de Waal, A., 'Introduction to the political marketplace for policymakers', Justice and Security Research Programme Policy Brief no. 1, Mar. 2016.

[184] Bouvy, A. and Lange, M., *Ending the Deadlock: Towards a New Vision of Peace in Eastern DRC* (International Alert: London, 2012).

[185] Kleinfeld (note 182); and Banfield (note 181).

186 Döring, S., 'Come rain, or come wells: How access to groundwater affects communal violence', *Political Geography*, vol. 76 (Jan. 2020); Ide, T., 'Does environmental peacemaking between states work? Insights on cooperative environmental agreements and reconciliation in international rivalries', *Journal of Peace Research*, vol. 55, no. 3 (May 2018); Krampe, F., 'Empowering peace: Service provision and state legitimacy in Nepal's peace-building process', *Conflict, Security & Development*, vol. 16, no. 1 (Mar. 2016); Krampe, F., Hegazi, F. and VanDeveer, S. D., 'Sustaining peace through better resource governance: Three potential mechanisms for environmental peacebuilding', *World Development*, vol. 144 (Aug. 2021); Bogale, A. and Korf, B., 'To share or not to share? (Non-) violence, scarcity and resource access in Somali Region, Ethiopia', *Journal of Development Studies*, vol. 43, no. 4 (May 2007); Taher, T. et al., 'Local groundwater governance in Yemen: Building on traditions and enabling communities to craft new rules', *Hydrogeology Journal*, vol. 20, no. 6 (Sep. 2012); Ide, T., Palmer, L. R. and Barnett, J., 'Environmental peacebuilding from below: Customary approaches in Timor-Leste', *International Affairs*, vol. 97, no. 1 (Jan. 2021); Burt, M. and Keiru, B. J., 'Strengthening post-conflict peacebuilding through community water-resource management: Case studies from Democratic Republic of Congo, Afghanistan and Liberia', *Water International*, vol. 36, no. 2 (Mar. 2011); and Johnson, M. F., Rodríguez, L. and Quijano-Hoyos, M., 'Intrastate environmental peacebuilding: A review of the literature', *World Development*, vol. 137 (2021).

187 Lopes da Silva, D. et al., 'Trends in world military expenditure, 2021', SIPRI Fact Sheet, Apr. 2022.

188 Lopes da Silva, D., Tian, N. and Marksteiner, A., 'Trends in world military expenditure, 2020', SIPRI Fact Sheet, Apr. 2021; Tian, N., Lopes da Silva, D. and Marksteiner, A., 'Global developments in military expenditure, 2020', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021).

189 Wezeman, P. D., Kuimova, A. and Wezeman, S. T., 'Trends in international arms transfers, 2020', SIPRI Fact Sheet, Mar. 2021; and Wezeman, S. T. et al., 'Developments in arms transfers, 2016–20', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021).

190 Kristensen, H. M. and Korda, M., 'World nuclear forces', *SIPRI Yearbook 2022: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2022), pp. 341–42.

191 Note that 5708 nuclear warheads are in storage and need to be transported and/or loaded onto their delivery systems (such as bombers and missiles) to be ready for use; in addition, 3265 warheads have been 'retired' and are waiting to be dismantled; see *SIPRI Yearbook 2022: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2022), chapter 10 and table 10.1, p. 342.

192 Kristensen and Korda (note 190), pp. 333–34.

193 Kristensen and Korda (note 190), p. 385.

194 Smith, D., 'Introduction: International stability and human security in 2019', *SIPRI Yearbook 2020: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2020), pp. 10–16.

195 Smith (note 194), pp. 6–9.

196 UN Office for Disarmament Affairs, 'Treaty on the Non-Proliferation of Nuclear Weapons (NPT)', accessed 6 Sep. 2021.

197 Hirdman,S., 'The near-nuclear countries and the Non-Proliferation Treaty', *World Armaments and Disarmament: SIPRI Yearbook 1972* (Almqvist & Wiksell: Stockholm, 1972).

198 Friedman, U., 'Why one president gave up his country's nukes', The Atlantic, 9 Sep. 2017; Atomic Heritage Foundation, 'South African nuclear program', 15 Aug. 2018; Special Advisor to the Director of Central Intelligence on Iraq's Weapons of Mass Destruction (WMD), *Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD, with Addendums (Duelfer Report)* (GPO: Washington, DC, sep. 2004); and Hart, J. and Kile, S. N., 'Libya's renunciation of nuclear, biological and chemical weapons and ballistic missiles', *SIPRI Yearbook 2005: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2005).

199 Kerr, P. K., *Iran's Nuclear Program: Status*, Congressional Research Service (CRS) Report for Congress RL34544 (US Congress, CRS: Washington, DC, 1 Apr. 2019).

200 Rauf, T., 'Implementation of the Joint Comprehensive Plan of Action in Iran', *SIPRI Yearbook 2017: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2017).

201 International Atomic Energy Agency, 'Verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)', 24 May 2018.

202 Abadi, C., 'The Iran nuclear deal's long year of negotiations and uncertainty', *Foreign Policy*, 24 Dec. 2021; Lynch, C., 'A last-ditch effort to save the Iran deal', *Foreign Policy*, 28 Dec. 2022; 'Iran says nuclear agreement can be reached if US sanctions lifted', Al Jazeera, 6 Jan. 2022; and Fassihi, F. and Jakes, L., 'Trading threats, the US and Iran inch closer to a nuclear pact', *New York Times*, 12 Jan. 2022.

203 Reagan, R., 'Joint Soviet–United States Statement on the Summit Meeting in Geneva', American Presidency Project, 21 Nov. 1985.

204 French Ministry for Europe and Foreign Affairs, 'Joint Statement of the Leaders of the Five Nuclear-Weapon States on Preventing Nuclear War and Avoiding Arms Races', 3 Jan. 2022.

205 Indian Ministry of External Affairs, 'Official Spokesperson's response to a media query regarding the Joint Statement on Preventing Nuclear War and Avoiding Arms Races', 7 Jan. 2022.

206 Davis Gibbons, R., 'Five nuclear weapon states vow to prevent nuclear war while modernizing arsenals', Bulletin of the Atomic Scientists, 17 Jan. 2022.

207 US Department of Defense, 'Narrative summaries of accidents involving US nuclear weapons 1950–1980', Apr. 1981; accessed via 'Broken arrows: How many nuclear accidents have we had?', PBS.

[208] US Department of Defense, Defense Atomic Support Agency, 'Accidents and incidents involving nuclear weapons (U)', 15 Oct. 1967.

[209] Council on Foreign Relations, 'Loose nukes', 1 Jan. 2006; and Scollon, M. and Greer, S., 'Komsomolets wreck site reveals high radiation levels 30 years after Soviet sub sinks', Radio Free Europe/Radio Liberty, 11 July 2019.

[210] Morris, I., *War! What Is It Good for? Conflict and the Progress of Civilization from Primates to Robots* (Farrar, Straus and Giroux: New York, 2015); Hoffman, D., '"I had a funny feeling in my gut"', *Washington Post*, 10 Feb. 1999; and Chan, S., 'Stanislav Petrov, Soviet officer who helped avert nuclear war, is dead at 77', *New York Times*, 18 Sep. 2017.

[211] Arms Control Association, 'Timeline of Syrian chemical weapons activity, 2012–2021', May 2021.

[212] Organisation for the Prohibition of Chemical Weapons (OPCW)–UN Joint Mission, 'Closure of OPCW–UN Joint Mission', accessed 6 Sep. 2021; see also Makdisi, K. and Pison Hindawi, C., 'The Syrian chemical weapons disarmament process in context: Narratives of coercion, consent, and everything in between', *Third World Quarterly*, vol. 38, no. 8 (2017).

[213] Arms Control Association (note 211).

[214] UN Human Rights Council, 'Press statement on the alleged use of chemical weapons in eastern Ghouta', Press release, 13 Apr. 2018; and Almukhtar, S., 'Most chemical attacks in Syria get little attention. Here are 34 confirmed cases', *New York Times*, 13 Apr. 2018.

[215] Human Rights Watch, 'Syria: A year on, chemical weapons attacks persist', 4 Apr. 2018.

[216] Owen, R., *The Litvinenko Inquiry: Report into the Death of Alexander Litvinenko* (British Government: London, 2016).

[217] Zanders, J., 'Novichok between opinion and fact—Part 1: Deconstruction of the Russian denial', The Trench, 10 Apr. 2018; and OPCW, 'Summary of the report on activities carried out in support of a request for technical assistance by the United Kingdom of Great Britain and Northern Ireland (technical assistance visit tav/02/18)', S/1612/2018, 12 Apr. 2018.

[218] Steindl, D. et al., 'Novichok nerve agent poisoning', *The Lancet*, vol. 397, no. 10270 (Jan. 2021); and OPCW, 'Summary of the report on activities carried out in support of a request for technical assistance by Germany (technical assistance visit – tav/01/20)', S/1906/2020, 6 Oct. 2020.

[219] Boulanin, V. and Verbruggen, M., *Mapping the Development of Autonomy in Weapon Systems* (SIPRI: Stockholm, Nov. 2017).

[220] Boulanin, V. et al., *Artificial Intelligence, Strategic Stability and Nuclear Risk* (SIPRI: Stockholm, June 2020).

[221] Sanger, D. E., *The Perfect Weapon: War, Sabotage, and Fear in the Cyber Age* (Crown Publishers: New York, 2018); and Kaplan, F. M., *Dark Territory: The Secret History of Cyber War* (Simon & Schuster: New York, 2017).

[222] Lewis, P. and Unal, B., 'The destabilizing danger of cyberattacks on missile systems', Chatham House, 2 July 2019.

[223] Smith (note 194); and Bulletin of the Atomic Scientists, 'At doom's doorstep: It is 100 seconds to midnight', 20 Jan. 2022.

[224] UNHCR, 'Ukraine refugee situation', Operational Data Portal, 2022.

[225] Lopes da Silva, Tian and Marksteiner (note 188).

[226] TASS Russian News Agency, 'Russia to develop first prototype of next-generation strategic bomber by early 2020s', 13 Apr. 2017; and Putin, V., 'Presidential Address to the Federal Assembly', 1 Mar. 2018.

[227] Lopes da Silva, Tian and Marksteiner (note 188), pp. 246–48.

[228] Kristensen, H. M. and Korda, M., 'United States nuclear forces', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021); and Kristensen, H. M., 'US nuclear forces', *SIPRI Yearbook 2019: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2019).

[229] Smith, D., 'Introduction: International stability and human security in 2018', *SIPRI Yearbook 2019: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2019), pp. 8–9; and Porras, D., 'Creeping towards an arms race in outer space', *SIPRI Yearbook 2020: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2020), pp. 515–16.

[230] On Russian military doctrine see Russian President, 'Military doctrine of the Russian Federation [in Russian]', 5 Feb. 2010 (also available in English); and Russian President, 'Meeting of the Valdai International Discussion Club', 18 Oct. 2018. On US military doctrine see US Department of Defense (DOD), *Nuclear Posture Review* (US DOD: Arlington, VA, Feb. 2018).

[231] White House, *Interim National Security Strategic Guidance* (White House: Washington, DC, Mar. 2021).

[232] Reif, K., 'Biden administration begins nuclear posture review', *Arms Control Today*, Sep. 2021.

[233] Smith (note 229), pp. 6–8.

[234] Putin, V., 'Speech and the following discussion at the Munich Conference on Security Policy', Munich Conference on Security Policy, 10 Feb. 2007.

[235] NATO, 'NATO decisions on open-door policy', NATO News, 3 Apr. 2008.

[236] Independent International Fact-finding Mission on the Conflict in Georgia, *Report: Volume I* (European Court of Human Rights: Rome, Sep. 2009).

[237] Zygar, M., 'The Russian reset that never was', *Foreign Policy*, 9 Dec. 2016; and Pifer, S., 'US–Russia relations in the Obama era: From reset to refreeze?', ed. Institute for Peace Research and Security Policy at the University of Hamburg (IFSH), *OSCE Yearbook 2014* (Nomos Verlagsgesellschaft: Baden-Baden, 2015).

238 Gessen, M., 'How Biden rattled Putin', *New Yorker*, 19 Mar. 2021; Chernova, A., Ullah, Z. and Picheta, R., 'Russia reacts angrily after Biden calls Putin a "killer"', CNN, 18 Mar. 2021; and Troianovski, A., 'Russia erupts in fury over Biden's calling Putin a killer', *New York Times*, 18 Mar. 2021.

239 Mueller III, R. S., *Report on the Investigation into Russian Interference in the 2016 Presidential Election. Volume I of II* (US Department of Justice: Washington, DC, Mar. 2019); and Mueller III, R. S., *Report on the Investigation into Russian Interference in the 2016 Presidential Election. Volume II of II* (US Department of Justice: Washington, DC, Mar. 2019).

240 Greene, S., 'How to speak with Moscow when there's nothing to talk about', *Moscow Times*, 23 Apr. 2021; Al Jazeera, 'Following Biden–Putin talks, Russia calls on US to heed demands', 31 Dec. 2021; and Borger, J., 'Ukraine crisis: Tense talks between US and Russia open in Geneva', *The Guardian*, 10 Jan. 2022.

241 Hirst, T., 'A brief history of China's economic growth', World Economic Forum, 30 July 2015.

242 Jones, L., Palumbo, D. and Brown, D., 'Coronavirus: How the pandemic has changed the world economy', BBC News, 24 Jan. 2021.

243 Farley, R., 'Can China's economy overtake the United States?', *The Diplomat*, 23 July 2021; and Zhu, E. and Orlik, T., 'When will China rule the world? Maybe never', Bloomberg, 5 July 2021.

244 Ghiasy, R. and Zhou, J., *The Silk Road Economic Belt: Considering Security Implications and EU–China Cooperation Prospects* (SIPRI/Friedrich Ebert Stiftung: Stockholm, 2017); Ghiasy, R., Su, F. and Saalman, L., *The 21st Century Maritime Silk Road: Security Implications and Ways Forward for the European Union* (SIPRI/Friedrich Ebert Stiftung: Stockholm, 2018); and Lew, J. J. et al., *China's Belt and Road: Implications for the United States* (Council on Foreign Relations: Washington, DC, Apr. 2021).

245 Anderlini, J., Feng, W. and Mitchell, T., 'Xi Jinping delivers robust defence of globalisation at Davos', *Financial Times*, 7 Jan. 2017; Smith, A., 'China's Xi lectures Trump on globalization and climate change', NBC News, 17 Jan. 2017; and Hilton, I., 'China: Contradictions in climate leadership', The Interpreter, 11 Dec. 2017.

246 Mahbubani, K., *Has China Won? The Chinese Challenge to American Primacy* (Public Affairs: New York, 2020).

247 Wong, D. and Koty, A. C., 'The US–China trade war: A timeline', China Briefing, 25 Aug. 2020.

248 Bown, C. P., 'US–China trade war tariffs: An up-to-date chart', Peterson Institute for International Economics, 16 Mar. 2021.

249 Gordon, N., 'For all the "decoupling" rhetoric, US–China trade is booming', *Fortune*, 23 July 2021.

250 Wintour, P., 'What is the Aukus alliance and what are its implications?', *The Guardian*, 16 Sep. 2021.

251 Permanent Court of Arbitration, 'Case 2013-19: The South China Sea Arbitration (The Republic of Philippines v. The People's Republic of China)', 12 June 2016; and Holmes, O. and Phillips, T., 'South China Sea dispute: What you need to know about The Hague court ruling', *The Guardian*, 12 July 2016.

252 Browne, R. and Starr, B., 'US sails warships through Taiwan Strait amid tensions with China', CNN, 23 Oct. 2018.

253 Mearsheimer, J. J., 'The inevitable rivalry: America, China, and the tragedy of great-power politics', *Foreign Affairs*, vol. 100, no. 6 (Dec. 2021).

254 Brands, H. and Gaddis, J. L., 'The new Cold War: America, China, and the echoes of history', *Foreign Affairs*, vol. 100, no. 6 (Dec. 2021).

255 US Department of State, 'US–China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s', Press release, 10 Nov. 2021.

256 Lubold, G., Leary, A. and Wei, L., 'Biden, Xi cool down hostilities in virtual meeting', *Wall Street Journal*, 16 Nov. 2021; and *New York Times,* 'Biden and Xi pledge more cooperation, but offer no breakthroughs', 15 Nov. 2021.

257 Pelosi, N., 'Nancy Pelosi: Why I'm leading a congressional delegation to Taiwan', *Washington Post*, 2 Aug. 2022.

258 Lai, J. and Moritsugu, K., 'More US lawmakers visit Taiwan 12 days after Pelosi trip', AP News, 14 Aug. 2022.

259 Knickmeyer, E., Miller, Z. and Rising, D., 'China cuts off vital US contacts over Pelosi Taiwan visit', AP News, 5 Aug. 2022.

260 Smith (note 194), pp. 5–10.

261 Davis, I., 'The interstate armed conflict between Armenia and Azerbaijan', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021); and Davis, I., 'Armed conflict and peace processes in East Africa', *SIPRI Yearbook 2021: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2021).

262 Eaton, L., 'Covid-19: WHO warns against "vaccine nationalism" or face further virus mutations', *BMJ*, vol. 372, no. 292 (Feb. 2021).

263 United Nations, 'Vaccine nationalism, hoarding putting us all at risk, Secretary-General tells World Health Summit, warning COVID-19 will not be last global pandemic', Press Release SG/SM/20986, 24 Oct. 2021.

264 Kretchmer, H., 'Vaccine nationalism—and how it could affect us all', World Economic Forum, The Davos Agenda, 6 Jan. 2021.

265 Hafner, M. et al., *COVID-19 and the Cost of Vaccine Nationalism* (RAND Corporation: Santa Monica, CA, USA, 2020).

266 United Nations, Secretary-General, 'Secretary-General's appeal for Global Ceasefire', 23 Mar. 2020.

267 United Nations, 'Update on the Secretary-General's appeal for a Global Ceasefire', 2 Apr. 2020.

268 Gowan, R., 'What's happened to the UN Secretary-General's COVID-19 ceasefire call?', International Crisis Group, 16 June 2020. UN Security Council Resolution 2532 supporting the call for a ceasefire was finally passed on 1 July 2020.

269 See Davis (note 178), table 2.3.

[270] For analysis examining different structures of risk occurrence and risk transmission see part 2, section 2.5 of this report.

[271] Bailey, R. and Wellesley, L., *Chokepoints and Vulnerabilities in Global Food Trade* (Chatham House: London, 2017), p. iv.

[272] UN Conference on Trade and Development (UNCTAD), *Review of Maritime Transport 2017* (United Nations: Geneva/New York, 2017), p. x; UNCTAD, *Review of Maritime Transport 2021* (United Nations: Geneva/New York, 2021); and OECD, 'Ocean shipping and shipbuilding', [n.d.].

[273] Bailey and Wellesley (note 271), pp. iv–v.

[274] BP, *Statistical Review of World Energy 2021* (BP plc: London, 2021), p. 32; and Statista, 'Transport volume of crude oil in global seaborne trade from 2010 to 2020 (in million metric tons)', accessed 4 Sep. 2021.

[275] Ha, K. O. et al., 'How a desert wind blew $10 billion of global trade off course', Bloomberg, 27 Mar. 2021.

[276] McCarthy, N., 'Global oil shipments depend on major chokepoints', Statista, 25 Mar. 2021.

[277] Jones, B. D., *To Rule the Waves* (Scribner: New York, 2021), p. 25.

[278] Danilov, P. B., 'Russia is planning for year-round shipping on the Northern Sea route by 2022 or 2023', *High North News*, 12 Oct. 2021.

[279] Staalesen, A., 'A step closer to year-round shipments on Northern Sea Route', Barents Observer, 18 Jan. 2021.

[280] Jones (note 277), p. 25.

[281] Russon, M.-A., 'US fuel pipeline hackers "didn't mean to create problems"', BBC News, 10 May 2021; and BBC News, 'Colonial Pipeline: US fuel firm resumes service after cyber-attack', 12 May 2021.

[282] Tidy, J., 'Swedish Coop supermarkets shut due to US ransomware cyber-attack', BBC News, 3 July 2021.

[283] Perlroth, N. and Satariano, A., 'Irish hospitals are latest to be hit by ransomware attacks', *New York Times*, 20 May 2021.

[284] Center for Strategic and International Studies, 'Significant cyber incidents', Timeline since 2006.

[285] Wilson, S., 'The pandemic, the acceleration of digital transformation and the impact on cyber security', *Computer Fraud & Security*, vol. 2020, no. 12 (Dec. 2020), p. 13.

[286] Chatterjee, S. and Thekdi, S., 'An iterative learning and inference approach to managing dynamic cyber vulnerabilities of complex systems', *Reliability Engineering & System Safety*, vol. 193 (Jan. 2020), pp. 1–2; and Bolbot, V. et al., 'Vulnerabilities and safety assurance methods in Cyber-Physical Systems: A comprehensive review', *Reliability Engineering & System Safety*, vol. 182 (Feb. 2019), pp. 179–80.

[287] Jones (note 277), p. 49.

[288] Wilson (note 285), p. 13; and Chatterjee and Thekdi (note 286), pp. 1–2.

[289] Vigliarolo, B., 'The number of false positive security alerts is staggering. Here's what you can do to reduce yours', TechRepublic, 16 July 2021.

[290] Turell, J., Su, F. and Boulanin, V., *Cyber-Incident Management: Identifying and Dealing with the Risk of Escalation*, SIPRI Policy Paper no. 55 (SIPRI: Stockholm, Sep. 2020).

[291] Chancel, L. et al., *World Inequality Report 2022* (World Inequality Lab: Paris, Mar. 2022).

[292] Roser, M. and Ortiz-Ospina, E., 'Global extreme poverty', Our World in Data, 2019.

[293] Chancel et al. (note 291), p. 10.

[294] Chancel et al. (note 291), p. 10.

[295] International Monetary Fund (IMF), *Fiscal Monitor October 2017: Tackling Inequality* (IMF: Washington, DC, 2017).

[296] Chancel et al. (note 291), p. 68.

[297] Lawson, M. et al., *Public Good or Private Wealth?* (Oxfam: Oxford, Jan. 2019).

[298] Berkhout, E. et al., *The Inequality Virus: Bringing Together a World Torn Apart by Coronavirus through a Fair, Just and Sustainable Economy* (Oxfam: Oxford, Jan. 2021), p. 12.

[299] McKinsey & Company, 'Total stimulus for the COVID-19 crisis already triple that for the entire 2008–09 recession', 11 June 2020.

[300] Chancel et al. (note 291), p. 78.

[301] Chancel et al. (note 291).

[302] IMF (note 295).

[303] Coffey, C. et al., *Time to Care: Unpaid and Underpaid Care Work and the Global Inequality Crisis* (Oxfam: Oxford, Jan. 2020).

[304] Seager, J., *The Women's Atlas* (Myriad Editions: Oxford, 2018).

[305] World Bank, 'Girls' education', 8 Mar. 2021.

[306] Elks, S., 'How investing in girls' education could return billions in GDP', World Economic Forum, 28 Oct. 2020.

[307] Porter, S. A., 'Girls' education, development and social change: "Seeding, strengthening and linking" (Global Fund for Women)', *Policy Futures in Education*, vol. 14, no. 5 (June 2016).

[308] See e.g. Bahgat, K. et al., *Inequality and Armed Conflict: Evidence and Data* (Peace Research Institute Oslo: Oslo, Apr. 2017).

[309] For a useful survey of contending concepts that emphasizes the importance of multicausality, see Herbert, S., *Conflict Analysis: Topic Guide* (GSDRC, University of Birmingham: Birmingham, May 2017).

[310] See e.g. Bartusevičius, H., 'The inequality–conflict nexus re-examined: income, education and popular rebellions', *Journal of Peace Research*, vol. 51, no. 1 (Jan. 2014).

[311] FAO et al., *The State of Food Security and Nutrition in the World 2022* (FAO: Rome, July 2022), p. 13.

[312] Global Network Against Food Crises (GNAFC) and Food Security Information Network (FCIN), *2022 Global Report on Food Crises: Joint Analysis for Better Decisions* (FCIN, Rome: 2022), p. 6.

[313] FAO et al. (note 311), p. 10.

[314] English, A. et al., *The State of Food and Agriculture 2019: Moving Forward on Food Loss and Waste Reduction* (FAO: Rome, 2019), p. xiiii; and Forbes, H., Quested, T. and O'Connor, C., *Food Waste Index Report 2021* (UNEP: Nairobi, 2021), p. 20.

[315] GNAFC and FCIN (note 312).

[316] World Food Program USA, 'Nearly 60% of the world's hungriest people live in just a few countries. Why?', 11 Mar. 2022.

[317] GNAFC and FCIN, *2021 Global Report on Food Crises: Joint Analysis for Better Decisions* (FCIN: Rome, 2021); Holleman, C. F. et al., *Sowing the Seeds of Peace for Food Security: Disentangling the Nexus between Conflict, Food, Security and Peace*, FAO Agricultural Development Economics Technical Study no. 2 (FAO: Rome, 2017); Martin-Shields, C. P. and Stojetz, W., 'Food security and conflict: Empirical challenges and future opportunities for research and policy making on food security and conflict', *World Development*, vol. 119 (July 2019); and FAO et al. (note 103).

[318] Messer, E. and Cohen, M. J., 'Conflict, food insecurity and globalization', *Food, Culture & Society*, vol. 10, no. 2 (July 2007).

[319] Salaam-Blyther, T. and Hanrahan, C. E., 'The impact of food insecurity and hunger on global health: Issues for congress', Congressional Research Service (CRS) Report for Congress R40127 (US Congress, CRS: Washington, DC, Jan. 2009), pp. 3–9.

[320] Levy, B. and Sidel, V., 'Collective violence: War', eds R. Detels et al., *Oxford Textbook of Global Public Health*, 6th edn (Oxford University Press: Oxford, 2015).

[321] Larner, M., Peto, J. and Monem, N., *War and Medicine* (Black Dog: London, 2008); and Ekins, A. and Stewart, E., *War Wounds: Medicine and the Trauma of Conflict* (Exisle Publishing: Wollombi, 2015).

[322] National Intelligence Council (NIC), *The Global Infectious Disease Threat and Its Implications for the United States* (NIC: Jan. 2000).

[323] Rice, S., 'Why global health security is an emergency', White House, 4 Dec. 2014.

[324] Global Health Security Agenda (GHSA), 'The 6th GHSA Ministerial Meeting', Nov. 2020.

[325] US Government, 'Executive Order 13747—Advancing the global health security agenda to achieve a world safe and secure from infectious disease threats', 4 Nov. 2016.

[326] IHME, University of Washington, 'Estimation of excess mortality due to COVID-19', 13 May 2021.

[327] Our World in Data, 'Excess mortality during COVID-19', accessed 8 Oct. 2022.

[328] World Health Organization (WHO), '14.9 million excess deaths associated with the COVID-19 pandemic in 2020 and 2021', 5 May 2022.

[329] *The Economist*, 'The pandemic's true death toll', 21 Sep. 2022.

[330] Jones, Palumbo and Brown (note 242).

[331] International Labour Organization (ILO), *Global Wage Report 2020–21: Wages and Minimum Wages in the Time of COVID-19* (ILO: Geneva, Dec. 2020).

[332] Lakner, C. et al., 'Updated estimates of the impact of COVID-19 on global poverty: Looking back at 2020 and the outlook for 2021', World Bank Blogs, 11 Jan. 2021; and Beaumont, P., 'Decades of progress on extreme poverty now in reverse due to Covid', *The Guardian*, 3 Feb. 2021.

[333] Lakner et al. (note 332).

[334] For a two-decade old literature review supporting this conclusion, see e.g. Söderberg, M. and Ohlson, T., *Democratisation and Armed Conflicts* (SIDA: Stockholm, 2003); for a more recent review with the same conclusion, see Hegre, H., 'Democracy and armed conflict', *Journal of Peace Research*, vol. 51, no. 2 (Jan. 2014).

[335] *The Economist*, 'Global democracy has a very bad year: The pandemic caused an unprecedented rollback of democratic freedoms in 2020', 2 Feb. 2021; and Alizada, N. et al., *Autocratization Turns Viral: Democracy Report 2021* (University of Gothenburg: Gothenburg, Mar. 2021).

[336] See the conflict trends recorded by the UCDP Conflict Encyclopedia (note 149).

[337] Censolo, R. and Morelli, M., 'COVID-19 and the potential consequences for social stability', *Peace Economics, Peace Science and Public Policy*, vol. 26, no. 3 (Sep. 2020); and Jedwab, R. et al., 'Epidemics, pandemics, and social conflict: Lessons from the past and possible scenarios for COVID-19', *World Development*, vol. 147 (Nov. 2021).

[338] Morgenthau, H. J., *Politics Among Nations: The Struggle for Power and Peace*, 4th edn (Alfred A. Knopf: New York, 1966), p. 4.

[339] Morgenthau (note 338), p. 5.

[340] Morgenthau (note 338), p. 11.

[341] Morgenthau (note 338), p. 25.

[342] Morgenthau (note 338), pp. 431, 441.

[343] Patrick, S. M., 'The case for ecological realism', *World Politics Review*, 20 July 2020; and Patrick, S. M., 'The US is waking up to climate change's security implications', *World Politics Review*, 8 Nov. 2021.

[344] Åberg, A. et al., *COP26: What Happened, What Does This Mean, and What Happens Next?* (Chatham House: London, Nov. 2021), p. 1; and *New York Times*, '6 takeaways from the UN climate conference', 13 Nov. 2021.

[345] Hoicka, C. et al., 'COP26: Experts react to the UN climate summit and Glasgow Pact', The Conversation, 13 Nov. 2021.

[346] Climate Action Tracker, *Warming Projections Global Update* (New Climate Institute/Climate Analytics: Cologne/Berlin; Nov. 2021); and Hausfather, Z. and Forster, P., 'Analysis: Do COP26 promises keep global warming below 2C?', Carbon Brief, 10 Nov. 2021.

[347] Climate Action Tracker (note 346).

[348] Climate Action Tracker, 'The CAT Thermometer', Nov. 2021.

[349] Reuters, '"Deeply sorry": UK's Sharma offers apology for last-minute changes to climate deal', 13 Nov. 2021.

[350] Independent Panel for Pandemic Preparedness & Response, *COVID-19: Make it the Last Pandemic* (Independent Panel for Pandemic Preparedness & Response: Geneva, May 2021), pp. 15, 29–31, 38.

[351] Brown, M. et al., *The State of Tax Justice 2020: Tax Justice in the Time of COVID-19* (Tax Justice Network: Chesham, Nov. 2020), pp. 12–14.

[352] Ringbom, H. and Henriksen, T., *Governance Challenges, Gaps and Management Opportunities in Areas beyond National Jurisdiction* (GEF STAP: Washington, DC, 2017), p. 9.

[353] Ringbom and Henriksen (note 352), pp. 87–88, 90–91.

[354] UN Office for Outer Space Affairs, 'Agreement Governing the Activities of States on the Moon and Other Celestial Bodies', accessed 25 Nov. 2021.

[355] Broom, D., 'As private satellites increase in number, what are the risks of the commercialization of space?', World Economic Forum, 12 Jan. 2022; Johnson, K., *Key Governance Issues in Space* (CSIS: Washington, DC, Sep. 2020); Atkins, K., 'The commercialisation of outer space', *International Corporate Rescue*, vol. 19, no. 3 (2022); and Hertzfeld, H. R., Weeden, B. and Johnson, C. D., 'Outer space: Ungoverned or lacking effective governance?: New approaches to managing human activities in space', *SAIS Review of International Affairs*, vol. 36, no. 2 (2016), p. 16.

[356] Rajagopalan, R. P., 'The Outer Space Treaty', Council on Foreign Relations, 23 Feb. 2021; Raju, N., 'Diluted disarmament in space: Towards a culture for responsible behaviour', SIPRI Commentary, 17 Nov. 2020; and Lewis, P., 'Create a global code of conduct for outer space', Chatham House, 12 June 2019.

[357] Commission on Global Governance, *Our Global Neighborhood: The Report of the Commission on Global Governance* (Oxford University Press: Oxford, 1995), p. 3.

[358] Fawcett, E., *Liberalism: The Life of an Idea*, 2nd edn (Princeton University Press: Princeton, NJ, 2018), pp. 3–4.

[359] Rawls, J., *Political Liberalism* (Columbia University Press: New York, 1996), pp. 35, 48, 85.

[360] Mooney, C. et al., 'Countries' climate pledges built on flawed data, Post investigation finds', *Washington Post*, 7 Nov. 2021.

[361] Mastrángelo, M. E. et al., 'Key knowledge gaps to achieve global sustainability goals', *Nature Sustainability*, vol. 2, no. 12 (Dec. 2019); and Wu, S., Wei, Y. and Wang, X., 'Structural gaps of water resources knowledge in global river basins', *Hydrology and Earth System Sciences*, vol. 25, no. 10 (Oct. 2021).

[362] World Bank, *World Development Report 2014: Risk and Opportunity—Managing Risk for Development* (World Bank: Washington, DC, Oct. 2013).

[363] Ford, J. D. et al., 'Opinion: Big data has big potential for applications to climate change adaptation', *Proceedings of the National Academy of Sciences*, vol. 113, no. 39 (Sep. 2016).

[364] Pörtner, H.-O. et al. (eds), *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Working Group II Contribution to the IPCC Sixth Assessment Report (Cambridge University Press: Cambridge, UK/ New York, USA, Feb. 2022) pp. 22–35.

[365] Worldometer, 'CO_2 emissions by country'.

[366] Putnam, R. D., *Bowling Alone: The Collapse and Revival of American Community* (Simon & Schuster: London, 2000).

[367] Rauken, T., Mydske, P. K. and Winsvold, M., 'Mainstreaming climate change adaptation at the local level', *Local Environment*, vol. 20, no. 4 (Apr. 2015); and Agrawal, A., *The Role of Local Institutions in Adaptation to Climate Change* (World Bank: Washington, DC, Mar. 2008).

[368] Agrawal (note 367), p. 8.

[369] Rothstein, B., 'Good governance', ed. D. Levi-Faur, *The Oxford Handbook of Governance* (Oxford University Press: Oxford, 2012).

[370] World Bank, *Inclusion Matters: The Foundation for Shared Prosperity* (World Bank: Washington, DC, Nov. 2013).

[371] World Bank and United Nations (note 175); Opotow, S. and Weiss, L., 'New ways of thinking about environmentalism: Denial and the process of moral exclusion in environmental conflict', *Journal of Social Issues*, vol. 56, no. 3 (Jan. 2000); Germann, M. and Sambanis, N., 'Political exclusion, lost autonomy, and escalating conflict over self-determination', *International Organization*, vol. 75, no. 1 (2021); and Asal, V. et al., 'Political exclusion, oil, and ethnic armed conflict', *Journal of Conflict Resolution*, vol. 60, no. 8 (Dec. 2016).

[372] See also discussions of 'adaptive governance' in part 2 section, 2.6.3 and in part 4, section 4.5.2.3 of this report.

[373] Hardin, R., 'The free rider problem', Stanford Encyclopedia of Philosophy, 13 Oct. 2020.

[374] Perry, J., 'Trust in public institutions: Trends and implications for economic security', UNDESA, 20 June 2021.

[375] van der Meer, T. W. G., 'Political trust and the "crisis of democracy"', *Oxford Research Encyclopedia of Politics* (Oxford University Press: Oxford, Jan. 2017).

[376] Berman, S., 'Populism is a symptom rather than a cause: Democratic disconnect, the decline of the center-left, and the rise of populism in Western Europe', *Polity*, vol. 51, no. 4 (Oct. 2019).

[377] Lepore, J., 'A new Americanism: Why a nation needs a national story', *Foreign Affairs*, vol. 98, no. 2 (Apr. 2019); Copelovitch, M. and Pevehouse, J. C. W., 'International organizations in a new era of populist nationalism', *Review of International Organizations*, vol. 14, no. 2 (June 2019); and Bieber, F., 'Is nationalism on the rise? Assessing global trends', *Ethnopolitics*, vol. 17, no. 5 (Oct. 2018).

[378] Kampfner, J., 'Climate politics: Why the old diplomacy no longer works', Chatham House, 13 Oct. 2021; Patrick, 'The case for ecological realism' (note 343); and Patrick, 'The US is waking up to climate change's security implications' (note 343).

[379] Watkins, A. and Wilber, K., *Wicked & Wise: How to Solve the World's Toughest Problems* (Urbane Publications: Chatham, 2015), p. 16.

International Expert Panel

Margot Wallström (Chair), former Minister for Foreign Affairs, Sweden, European Commissioner for the Environment and UN Special Representative on Sexual Violence in Conflict

Jörg Balsiger, Director, Institute and Hub for Environmental Governance and Territorial Development at the University of Geneva

Helen Clark, former Prime Minister of New Zealand and Administrator of UN Development Programme

Ilwad Elman, Chief Operating Officer, Elman Peace, Somalia

Chibeze Ezekiel, National Sustainable Development Goals (SDGs) Champion for Ghana and Coordinator, Strategic Youth Network for Development

Arunabha Ghosh, Chief Executive Officer, Council on Energy, Environment and Water, India

Hindou Ibrahim, SDG advocate and environmental activist, Chad

Ma Jun, Director, Institute of Public and Environmental Affairs, China

Johan Rockström, Co-director, Potsdam Institute for Climate Impact Research

Aiyaz Sayed-Khaiyum, Attorney-General, Minister for Economy, Civil Service and Communications, and Minister Responsible for Climate Change, Fiji

Dan Smith, Director, SIPRI

Isabel Studer, Founding Director, Sostenibilidad Global, Mexico

Ulf Sverdrup, Director, Norwegian Institute of International Affairs

With thanks to the Environment of Peace Youth Expert Panel, our peer reviewers, and SIPRI's Climate Change and Risk Programme, Operations Department, Outreach Department and Soapbox.

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ENVIRONMENT OF PEACE

sipri

Stockholm International Peace Research Institute
Signalistgatan 9
SE-169 72 Solna, Sweden
Telephone: +46 8 655 97 00
sipri@sipri.org
www.sipri.org

environmentofpeace.org