CHAPTER

2

Unprecedented—the scope, scale and speed of human pressures on the planet

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The Anthropocene is ushering in new sets of complex, interconnected and universal predicaments. Social and ecological systems are ever more tightly coupled, within which inequalities form dangerous feedback loops. Systems thinking is in, siloed thinking out.

How does the Anthropocene impact human development, today and in the future?

This chapter shows that the Covid-19 pandemic has hit human development hard. Climate change is already dragging on economies, especially in developing countries. Hunger is rising, after decades of progress. Natural hazards are getting worse and threaten especially the more vulnerable, including women, ethnic groups and children.

Looking beneath the environment and sustainability: Human activity driving dangerous planetary change

The 21st century has seen a plethora of assessments and reports documenting multiple and worsening climate and ecological crises. Often seen as separate from one another, they mobilize public and policy attention to differing degrees. They are supported by distinct communities of advocates and civil society organizations. And they are sometimes presented as vindications of warnings made long ago about environmental degradation and climate change.

These challenges can be seen as manifestations of a more fundamental and integrated process of planetary change driven by human activity—leading to calls to designate our times as a new geological epoch: the Anthropocene. This chapter argues that we are confronting a fundamentally new set of challenges that cannot be seen simply as a continuation of past concerns about the environment and sustainability. This new reality compels reimagining the human development journey. And the case can be best made by laying out the evidence and describing the debates surrounding the Anthropocene concept.

The changes now unfolding reflect human pressures that are planetary (not just local) in scope, at a scale that is overwhelming the biosphere's regenerative ability and that has been unleashed with unprecedented speed.[1] The risk is that "[s]ociety may be lulled into a false sense of security by smooth projections of global change. Our synthesis of present knowledge suggests that a variety of tipping elements could reach their critical point within this century [...]."[2] The more that societies realize the implications of these changes, the more collectively self-aware they will be that we are shaping the future of the Earth system. This awareness corresponds to a completely new stage,[3] one in which the trajectory of the planet is clearly influenced by human agency and thus cannot be predicted using only biogeophysical processes.[4] Moreover, ecological challenges are often framed as a problem of the future, but the processes that need to be transformed are problems of today.[5] So the chapter marshals evidence to argue that the repercussions of the Anthropocene are already affecting human development prospects in the short run and in the long run—generating inequalities and social imbalances.

This evidence can feed into reasoned deliberations about both the challenges and the possibilities by reaching beyond researchers and policymakers dealing with the environment. As Amartya Sen notes, "There has been a serious failure in communicating the results of scientific analysis and in involving the general public in informed ethical reasoning."[6] Surely, the failure to act on this evidence has been aided by narrow interests that fear losing in this dialogue and public debate and that often mischaracterize the processes of scientific deliberation in ways that dilute the validity of results.[7] This impoverishes the debate on possible ways to confront the challenges of the Anthropocene.[8] And it can lead to a single-minded focus on a narrow set of high-profile issues that leaves the broader and far more consequential deep-seated determinants of those challenges in the background.[9]

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Societies today have the ability to act on this evidence like never before—and to make choices that take us away from potentially catastrophic paths. In doing so, it is important to go beyond panaceas, as Elinor Ostrom argues,[10] given that "configuring new spaces may require transformative changes in social norms, behaviours, governance and management."[11] And only by understanding the complexity of interactions between societies and ecosystems can we account for the unprecedented changes of the Anthropocene.

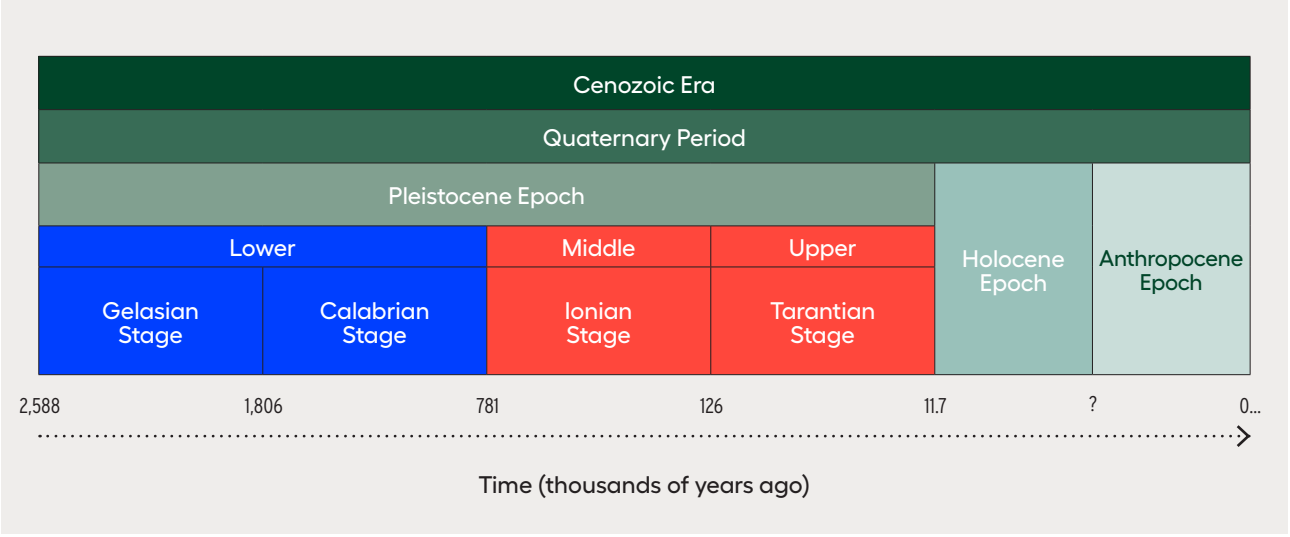
Enter the Anthropocene

"[T]he world is a complex, nonlinear system, in which the living and non-living components are tightly coupled [... with] important tipping points."[12]

Timothy M. Lenton

The story of the planet over time is told in the Geological Time Scale (figure 2.1). It records distinct periods in the Earth's history over timescales spanning thousands to millions of years, differentiated by characteristics ranging from climate to the emergence of life and stages in its evolution.[13] Earth system scientists

Figure 2.1 How the Anthropocene would fit in the Geological Time Scale corresponding to the Quaternary Period



Source: Malhi 2017.

introduced the term Anthropocene at the turn of the 21st century (spotlight 2.1). They confronted a range of observations of recent changes to the planet that contrasted with the paleoenvironmental record of the Holocene (which is estimated to have started about 11,700 years ago) and indicated that the planet was operating in a no analogue state—that is, without precedent in the history of the planet.[14]

The Anthropocene is not yet formally established as a new geological epoch, but several geologists and Earth system scientists propose dating its beginning to the mid-20th century[15] with the growth in new anthropogenic materials as part of the evidence behind their proposal.[16] That would correspond to the Great Acceleration of human pressures on the planet that have the potential to leave a geological imprint (figure 2.2).

"The Anthropocene is not yet formally established as a new geological epoch, but several geologists and Earth system scientists propose dating its beginning to the mid-20th century.

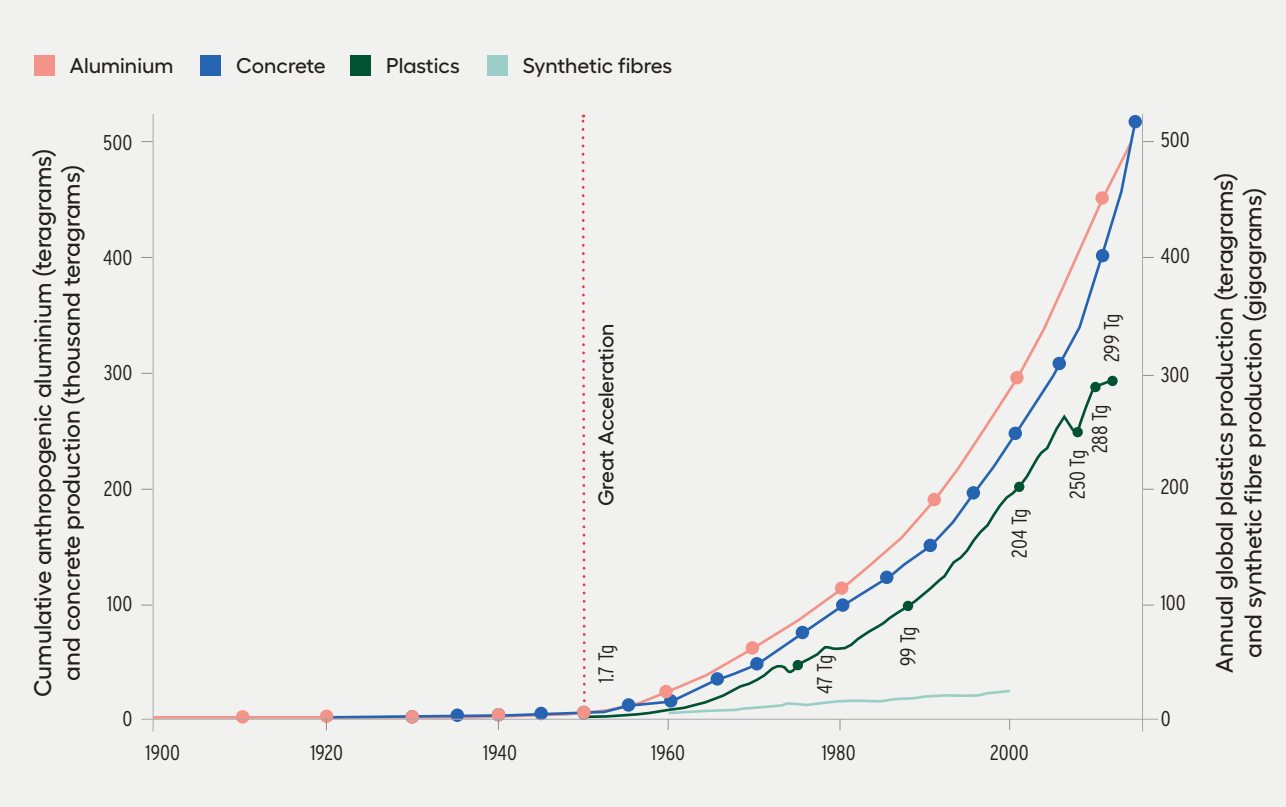
While the Anthropocene remains contested and subject to multiple interpretations, "the core concept that the term is trying to capture is that human activity is having a dominating presence on multiple aspects of the natural world and the functioning of the Earth system, and that this has consequences for how we view and interact with the natural world—and perceive our place in it."[17] This reflects the use of the term in this Report.

Drawing on interdisciplinary evidence and analysis, Earth systems science, geology and ecology characterize the Anthropocene from distinct perspectives (table 2.1). Each brings something different, showing that considering diverse perspectives and approaches reveals the complexity and reach of the concept.[18]

Learning from Earth system science: Something new under the sun

Human societies have always been tightly linked to local environmental conditions, and many of the mechanisms at those scales are well understood.[19] These links have become less tight and more indirect as societies have modernized, urbanized and shifted their reliance from local ecosystems to more distant ones for food, water and energy (chapter 3).[20] But the notion that humans are now a dominant force in altering Earth system processes with likely detrimental impacts on human development is novel and brings whole new dimensions to the longstanding discussions of the interactions between people and nature. A key insight from Earth system science is that life and geophysical systems have interacted almost since life emerged on Earth[21]—and that these interactions

Figure 2.2 Dating the beginning of the Anthropocene to the mid-20th century would correspond to the Great Acceleration of human pressures on the planet that have the potential to leave a geological imprint



Source: Waters and others 2016.

Table 2.1 Perspectives from the natural sciences on the Anthropocene

Field	Focus	Evidence	Approaches and metrics
Earth system science	Planetary functions	Moving outside the range of variability of the Holocene → Climate change → Biogeochemical cycles disrupted (especially nitrogen and phosphorus) → Ocean acidification → Land use change → Biodiversity loss	→ Earth system tipping points and tipping elements → Planetary boundaries
Geology	Earth history	Identifying a contemporary change that is significant and detectable over Earth history timescales → Abundance of new materials of pure anthropogenic origin (aluminium, concrete, plastics) → Presence of radionuclides linked to atmospheric nuclear weapons testing	
Ecology	Biosphere	Altering the diversity, distribution, abundance and interactions of life on Earth → Conversion of ecosystems into agricultural or urban anthromes → Increasing species extinction rates → Habitat losses, overharvesting → Invasive species, global harmonization of flora and fauna	→ Biophysical reserve accounting (such as ecological footprint) → Human appropriation of net primary productivity → Rates of species extinction → Ecosystem services, nature's contributions to people

Source: Human Development Report Office based on Malhi (2017) and other sources in the text.

are now magnified by the dominant role of human activities.

> "An important characteristic of the climate system during the Holocene is the tight link between the whole web of life on the planet and in the atmosphere, regulating the carbon cycle.

Over the past 2.6 million years the planet's temperature has oscillated sharply, leading to alternating warmer and colder periods. But the Holocene has been both warmer and more stable in temperature. The climate system has also been more stable, despite massive hydrological variability that has had radical implications at the regional scale. For instance, the Sahara has not always been the dry desert we see today, and the Amazon had to confront severe droughts earlier in the Holocene.[22] In fact, an important characteristic of the climate system during the Holocene is the tight link between the whole web of life on the planet and in the atmosphere, regulating the carbon cycle. For instance, about a fifth of annual average precipitation falling on land is linked to plant-regulated water cycles, with many places now receiving half the precipitation from this type of cycle that they received before.[23]

A main focus of the Earth system community is to understand the parameters under which disruptions to planetary processes result in changes that could push some of these processes or the entire planet outside the range of variability that has characterized the Holocene. Evidence is drawn, for instance, from the analysis of climate change, alterations of biogeochemical cycles and ocean acidification. Analytical approaches emerging from the field include identifying tipping points, critical thresholds when small additional human-induced pressures can move a system to an entirely new state. A tipping point for the entire Earth system is difficult to establish—and may not even exist.[24] But several analyses of large-scale elements of the Earth system suggest tipping elements for parts of the Earth system—for example, the Greenland ice sheet and forest biomes such as the Amazon and boreal forests.[25] Something hopeful is emerging from the identification of tipping points. Though dangerous and harmful ones are to be avoided or reversed, the same dynamics can be harnessed to turn small interventions into large impacts (such as a small conservation effort in the Apo Island in the Philippines, which resulted in a major restoration of marine life).[26]

A prominent framework to summarize how changes in the Earth system and the biosphere underpin human prosperity in fundamental ways is the planetary boundaries approach. In 2009 Johan Rockström and colleagues identified what they denoted a safe operating space for humanity.[27] This space is defined by several Earth system boundaries that, if transgressed, could undermine life-supporting conditions on our planet. This notion, refined over the years, remains one of the most influential framings for the challenges of the Anthropocene (box 2.1). Though the framework was designed explicitly for the global level only, there have been attempts to apply it at lower scales,[28] even though that is neither encouraged nor supported by the original proponents.[29] Still, the changes in the Earth system were not created by a homogeneous humanity, as can be clearly seen by the fact phosphorus and nitrogen (linked essentially to the use of fertilizers in agriculture) have breached the thresholds in several places around the world but remain far from levels of concern in many others.[30]

Understanding geological and ecological change

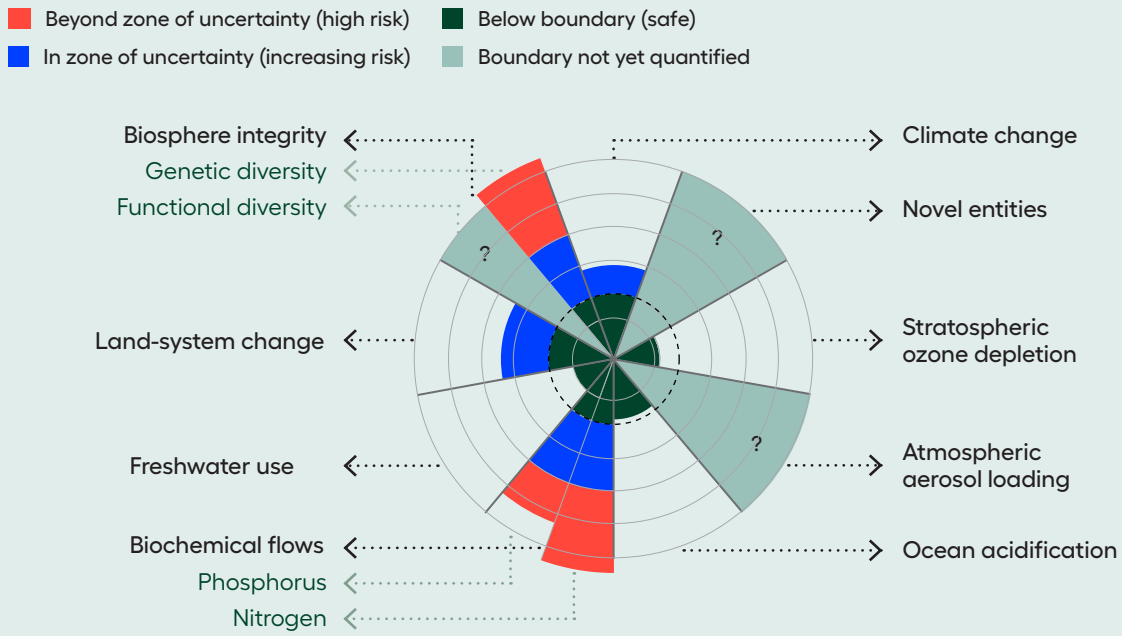
To specify the Anthropocene as a new geological epoch, geologists must identify a contemporary human-induced change that is significant and detectable over the timescales of Earth's history.[31] Mining, landfills, construction and urbanization have resulted in the greatest expansion of new minerals that do not exist in the natural world as rocks (in the geological sense of having the potential for long-term persistence).[32] Pure elemental aluminium is one of these materials, and as much as 98 percent of the aluminium on Earth has been produced since 1950. Another is plastics, whose current annual production equals the global human biomass.[33] The disruptions of the global biogeochemical cycles of carbon and nitrogen also leave detectable signals visible in ice cores, reflecting rapid increases in the concentrations of carbon dioxide and methane. A unique and globally dispersed geological signature corresponds to the

Box 2.1 The planetary boundaries framework

Earth system boundaries delineate a safe operating space for humanity (see figure). They quantify human-caused environmental changes that risk destabilizing the long-term dynamics of the Earth system. The framework proposes nine boundaries—limits to what the Earth system can support while maintaining the life-supporting functions of the Holocene—conducive for human development.

Climate change and biodiversity integrity loss are tightly coupled core boundaries, and human activities are currently pushing both of them into a high-risk zone. If humanity breaches planetary boundaries too far or for too long, it may disrupt planetary life support systems, with substantial risks for human life as we know it.

Nine planetary boundaries



Note: The dotted area represents the safe operating space. The greater the human-caused perturbation, the greater the risk of large-scale abrupt and irreversible Earth system changes.
Source: Rockström and others 2009b; Steffen and others 2015.

The planetary boundaries framework has gained considerable attention and criticism since its inception in 2009. Some of the critiques parallel older debates about the limits to growth. But as Rockström and colleagues argue, limits to growth address neither the importance of ecosystems nor the possibility for abrupt nonlinear changes in the Earth system.[1] Other lines of criticism focus on the difficulties of defining global boundaries and the nonlinear dynamics for Earth system phenomena with such complex local and multiscale drivers, such as freshwater, biodiversity loss and land use change.[2]

The irreducible biophysical and social uncertainties associated with boundaries and global thresholds also spark debates about whether such framings can really motivate effective political action.[3] It has been argued that a focus on thresholds can lead to fatalism, unnecessary precaution and even perverse incentives that could contribute to their transgression. The international media and political debates about planetary boundaries in the runup to and during the United Nations Conference on Sustainable Development in June 2012 (Rio+20) vividly illustrate the interplay of scientific uncertainty about Earth system processes, differences in values and political conflict.[4]

Knowledge about various aspects of this safe operating space has increased rapidly over the past decade, including its applications for policymaking and business. Some of these scientific advances are related to single boundaries (including freshwater, biodiversity and nutrients) and to interactions between them.[5]

Notes
1. Rockström and others 2009b. **2.** Bass 2009; Blomqvist and others 2013; Molden 2009; Rockström and others 2018. **3.** Biermann 2012; Biermann and Kim 2020; Galaz 2014; Galaz and others 2012; Lewis 2012. **4.** Galaz 2014. **5.** Gerten and others 2013; Kahiluoto and others 2015; Lade and others 2020; Mace and others 2014; Nash and others 2017.
Source: Galaz, Collste and Moore 2020.

radioactive fallout from atmospheric nuclear weapons tested in the mid-20th century.

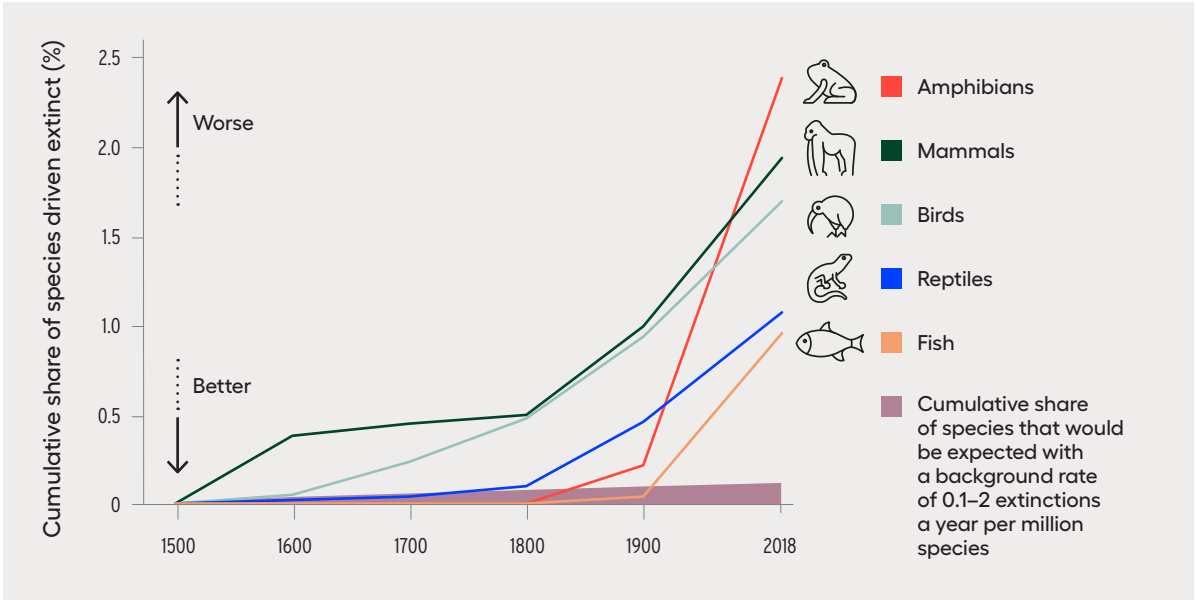
Geologists also consider changes in flora and fauna, both extinctions and the mixing of species across previously isolated continents and islands. Changes in periods in the geological timescale are often linked to sudden changes in the fossil record. While difficult to use as a marker for the Anthropocene with the precision of radionuclides, the magnitude and scale of the changes by humans to life on Earth may be the most enduring and obvious over the long term.

While Earth system science emphasizes the role of the biosphere on planetary functions and geologists look for markers, ecologists and sustainability scientists provide additional insights on human pressures by considering other fundamental changes to the diversity of life on the planet. The Anthropocene biosphere corresponds to a third and fundamentally new stage in the evolution of life on Earth.[34] The first was dominated by simple single-cell microbial organisms—from approximately 3.5 billion to 650 million years ago. In the second stage complex multicellular life emerged, becoming widespread and diverse after the Cambrian explosion 540 million years ago. Four characteristics make the Anthropocene biosphere unlike anything that has ever existed on the planet:

- Homogenization of flora and fauna through deliberate or accidental transfer of species across the globe.
- One species (humans) consuming 25–40 percent of land net primary productivity (that is, the biomass and energy made available by plants to all life on Earth).[35]
- Human-directed evolution of plants and animals, marginalizing natural biomes—something unprecedented in the last 2.4 billion years.[36]
- Increasing impact of new technologies as the biosphere interacts with the technosphere.[37]

In the Anthropocene biosphere, humans and livestock that is bred for human consumption outweigh all vertebrates combined (excluding fish), the mass of humans is an order of magnitude higher than that of all wild mammals and the biomass of domesticated poultry (dominated by chicken) is about three times that of all wild birds.[38] Rates of species extinction are estimated to be hundreds or thousands of times higher than background rates—that is, the rates that would be expected without human interference (figure 2.3).[39] Some argue that we are undergoing the sixth mass extinction in the planet's history.[40] Over the past 450 million years there were five mass extinctions, wiping out 70–95 percent of all species. It

Figure 2.3 Rates of species extinction are estimated to be hundreds or thousands of times higher than background rates



Note: Extinctions since 1500 for vertebrate groups. Rates for reptiles and fish have not been assessed for all species. See also Ceballos and others (2015).
Source: Díaz and others 2019b.

took millions of years for life to recover to the level of diversity before the extinction event. All five mass extinctions were due to natural causes, but the fact that humans may be driving a sixth raises profound ethical questions. And as a species disappears—a permanent loss—the ability of nature to provide some of its contributions on which we depend is also eroded.[41]

As much as three-quarters of the biosphere has been transformed into anthropogenic biomes—or anthromes.[42] Human societies have evolved to shape the ecology across that planet, with an impact that mirrors that of the climate, and are resetting evolutionary paths across the biosphere that will unfold, and have legacies, for hundreds of millions of years.[43]

Bringing the Anthro into the Anthropocene

But there is more to the Anthropocene than the accumulation of physical evidence of human activity's unprecedented impacts on the planet. That evidence is uncontested. And being aware of the scale and speed at which humans are changing the planet is crucial. The Anthropocene represents an unprecedented convergence of the timescales of human lives with those of historical, evolutionary and geological processes (spotlight 2.2).[44] The concept has also become a focal point of debate about how societies have evolved in their interaction with nature and how that evolution has shaped what we are today—and can inform what to envision going forward.[45]

Along with the physical evidence this added dimension of the Anthropocene is essential to framing a new human development narrative. It places people's interactions with nature in historical, social and economic contexts, informed by insights from the natural sciences.[46] This is reflected in new fields such as the climate-economy literature[47] and in the resurgence of interest in environmental history.[48]

Historical analysis places the current moment of the Anthropocene in perspective[49] but also shows how much of human history has been influenced by occurrences in the natural world. In the words of historian Kristina Sessa, "The idea that objects, animals, and other non-human entities (volcanoes, oak trees and solar radiation, for instance) shape the development of human affairs, that they possess historical agency in some form, has forced scholars to rethink some of their basic assumptions about government, power, and culture."[50]

"Human societies have evolved to shape the ecology across that planet, with an impact that mirrors that of the climate, and are resetting evolutionary paths across the biosphere that will unfold, and have legacies, for hundreds of millions of years.

But the interaction between people and nature has changed over time—and in dramatic ways during some major transitions (chapter 1). So the interaction runs in the other direction, too. The description of human activity's impact on the biosphere might suggest that the large-scale conversion of wildlands for human use is recent, but the Earth's latest transformation continues a process unfolding over time.[51] For instance, recent evidence suggests that rather than a geographic expansion of anthromes into uninhabited wildlands, the human impact on the biosphere can be described as an increasingly intensive use of land with already noticeable human impacts.[52] Even though some of this evidence remains contested,[53] it has led to the hypothesis that these early land use changes, starting at small scales thousands of years ago but unfolding over time to the global scale, drove substantial changes in greenhouse gas emissions and temperatures comparable to, and even higher, than in industrial times[54]—and that the Anthropocene should be used only as an informal term.

This historical perspective is also important to ensure that humans' impact on nature is not seen as a direct cause of modernity, industrialization or capitalism but as something more deeply embedded in our evolution and interaction with the natural world. Social, cultural and economic processes have enhanced environmental productivity by transforming ecosystems to meet human needs and wants.[55] While the scale of these transformations is unprecedented, having reached the entire planet, the underlying social and economic mechanisms remain relevant.[56]

For instance, the economic specialization and exchange that emerged deep in human history made it possible for most subsistence needs to be met with little direct interaction with ecosystems, in processes that eventually evolved to today's global supply chains. This has implications for both

overexploitation of natural resources and violations of human rights (chapter 3), but the point to emphasize is the socioeconomic nature of the underlying processes. Looking at romantic notions of returning to some prior balance with nature or seeing the evolution of the human population as dependent on fixed environmental limits, as ecology does with other species, does not account for the fact that human pressures on the environment are defined by sociocultural processes.[57]

Thus, many argue that rather than looking at the Anthropocene as a precisely dated geological period, it would be better to consider it a process, or a continuous Holocene/Anthropocene, in order to understand the long (and ongoing) transition of the dialectical relationship between cultural, political and economic systems and the natural world.[58] Others reject the notion altogether, criticizing a narrative that lumps humanity together without attending to either existing inequalities or historical asymmetries in power and overexploitation of resources.[59] One common line of criticism is that the notion of the Anthropocene, especially the more science-based formulations such as planetary boundaries, do not strike at the heart of the problem, which is seen as capitalist modes of production as well as longstanding historical legacies of colonization.[60] Although Edward Barbier documents that the environmental record of centrally planned and collectivized economies has been no better than that of capitalist ones.[61]

Some of these differences in perspective reflect differences between the social sciences and the humanities, on the one hand, and the natural sciences, on the other.[62] The humanities see society and the economy as complex systems, with nature at best a contextual backdrop or something that can be analytically separated from societies, even if they are physically interdependent (box 2.2). The natural sciences

Box 2.2 Complexity in social and natural systems

The world has always been complex, but in recent decades our cumulative knowledge, tools and thinking about it have evolved to explicitly recognize that complexity. In the natural sciences—and more recently in the social sciences—people have realized that patterns that seem random on the surface may have a complex structure, resulting in surprising, abrupt shifts and cascades of change that are not easily recognizable or fully predictable, posing challenges for governance.[1]

One definition of complex (adaptive) systems is that they are "composed of multiple individual elements that interact with each other yet whose aggregate properties or behaviour is not predictable from the elements themselves."[2] The interactions of these elements (also known as agents)—be they people, animals, countries or molecules—often lead to results not directly predictable from the intentions or actions of any single agent. These results are known as emergent properties of the complex system.

The term emergence was coined in 1875 by G. H. Lewes, a British psychologist and philosopher, to describe phenomena that cannot be described or predicted by studying their underlying components. In other words the aggregate pattern is more than the sum of its parts.[3] In this view of the world, order and structured patterns can arise without any conscious design or any particular designer.[4]

The social sciences, especially economics, have not always looked at the world through the lens of complexity, often preferring top-down, equilibrium-based models rather than the bottom-up, agent-based models used in complexity research.[5] This analytical gap was pointed out in the aftermath of the global financial crisis, as economists and policymakers had been basing their models on past trends, assuming the economy evolves in a linear way.[6]

In reality, however, even Earth science models that include environmental dynamics in a complex way often represent the socioeconomic (human) world as a simple process of macroeconomic optimization.[7] As a result, many important features of complexity—such as interactions and feedback among human and ecological systems, economic and social networks, and even human agency—are left out.[8]

Part of the reason is that the dominant social narrative underlying such models is the same as in the standard economic models just described. But in reality human society is linked through many networks,

(continued)

Box 2.2 Complexity in social and natural systems *(continued)*

not just trade and information but also politics and infrastructure. Human behaviour—shaped by norms and values—causes changes in the functioning of the Earth system, which in turn has feedback effects on human norms, values and behaviours.

If we study the natural world and human world separately, ignoring the loops both within and between them—we risk missing emergent phenomena such as critical tipping points. One way to enrich our understanding of this human–nature interaction is to move beyond the assumption that human agency is concerned only with cost-optimization. Goals and desirable outcomes differ among people and groups, and those differences often result in conflict. Just having lots of money does not make you (or your neighbours) necessarily better off. A recent study found that neighbours of lottery winners were more likely to go bankrupt, mainly since the neighbours attempt to emulate the winner's lavish lifestyle and go too far.[9]

Such models are especially relevant for studying socioecological systems that link human behaviour and environmental dynamics. One study applied fuzzy cognitive mapping and agent-based modelling to simulate alternative policy options in a water-scarce farming community.[10] Another study looked at factors that affect the behaviour of people charging their electric vehicles. The agent-based model for the question analysed policy interventions, including smart automated charging, financial incentives and information campaigns. The model also included insight on psychological drivers of behaviour that is environmentally friendly.[11] Agent-based models are sometimes combined with social network analysis—as with, for example, a recent study on information sharing among conservation rangers patrolling hunting communities.[12]

The way forward involves a more socially differentiated representation of agency, going deeper into social and socioeconomic networks and accounting for the complexity of coevolutionary dynamics.[13] The models can include such phenomena as segregation, social learning, value changes and group dynamics.[14]

Notes

1. Galaz 2019. **2.** Wilensky and Rand 2015, p. 6. **3.** Wilensky and Rand 2015. **4.** Reynolds 1987; Stonedahl and Wilensky 2010. A classic example of complexity in the natural world is the flying pattern of some bird flocks. Thinking in a simple linear way would lead people who see geese flying in a V-formation to conclude that there is a leader bird (either the biggest one or the mother bird), and all other birds follow its direction. However, the reality is both simpler and more complex. Every bird in the flock just follows three basic directional rules (while maintaining the same speed). First, every bird aligns its flight direction to match that of nearby birds. Second, every bird separates when it is too close to other birds to avoid hitting them. And third, cohesion means birds move towards other birds nearby. If there is a conflict between the rules, separation overrides the other two, to avoid collisions. Another example involves the dynamic interactions of prey (sheep) and predator (wolves) populations (Dublin and Lotka 1925; Volterra 1926) with each other and with the environment (such as grass for the sheep to eat; Wilensky and Reisman 2006). A sustainable outcome depends not only on the sheep or the wolves but also on their interactions. If the wolves are too powerful and eat all the sheep, they will starve to death. Likewise, if the sheep multiply too fast, they will eat all the grass (before it has a chance to regenerate) and die. A similar pattern has been observed with lynx (predator) and snowshoe hare (prey) in Alaska (United States) and Canada, where the population of the lynx rises and falls with that of the hares (with a time lag of 1–2 years; US Department of the Interior 2017). **5.** Arthur 1999; Crépin and Folke 2015. **6.** Farmer and Foley 2009. **7.** Something that sustainability science seeks to consider more systematically (Clark and Harley 2020). **8.** Donges and others 2017b. **9.** Agarwal, Mikhed and Scholnick 2016. **10.** Mehryar and others 2020. **11.** Van Der Kam and others 2019. **12.** Dobson and others 2019. **13.** Donges and others 2017a; Nyborg and others 2016 ; Verburg and others 2016. **14.** Auer and others 2015; Schleussner and others 2016.

take the reverse perspective, with natural systems as interdependent and complex and human agency described in aggregate terms as causing generalized impacts or disturbances.[63] Others oppose conceptualizing the Anthropocene as a process because they view the concept's power as signifying a rupture with the past, thus indicating a contemporary state of the world that urgently needs fundamental changes at the risk of catastrophic consequences for nature.[64]

Where does this leave us? With the notion that the Anthropocene is something novel in two ways. First, "the Anthropocene is an encapsulation of the concept that modern human activity is large relative to planetary processes, and therefore that human social, economic, and political decisions have become entangled in a web of planetary feedbacks. This global planetary entanglement is something new in human history and Earth history."[65] Second, the Anthropocene is a catalyst for systematic thinking about the interdependence of people and nature, including the Earth system. It is informed by a diversity of disciplines, going beyond linear and simplified narratives

of progress, and invites framing the options that face us today as more than a choice between impending catastrophe or an easy decoupling of economic activity from planetary pressures.

> "The Anthropocene is a catalyst for systematic thinking about the interdependence of people and nature, including the Earth system.

One implication of this understanding of the relationship between people and nature is the recent reframing of the conceptual approach of ecosystems as providers of services[66] to acknowledge nature's contributions to people.[67] This reframing also presents anthropogenic drivers of changes in nature as being embedded in institutions and governance systems. It recognizes the intrinsic value of preserving nature.

The remainder of this chapter brings the "Anthro into the Anthropocene" into even sharper relief, highlighting how dangerous planetary change already affects people's lived reality. It shows how different social groups and geographies are being affected and are likely to be affected in the future. Some of these differences are across countries, but most are across groups that are not separated by national borders. And most are expressed in an intersection of multiple characteristics that compound inequalities and differences in empowerment.

Anthropocene risks and human development

The Anthropocene implies enormous uncertainty for people and societies. Similarities to previous records provide some information on what is coming.[68] But unlike during other geological periods, the human factor—the one that took us to this point—will continue to be determinant.

Thus, the risks are not only greater; they are also different. The notion of risks faced by people is changing, as the risks reflect a new complex interrelation of planetary changes and social imbalances. Some scientists have proposed the notion of Anthropocene risk to reflect the new factors at play:[69] a new baseline of hazards (set of potential events), more complex exposure patterns resulting from the interconnection of the effects of social and planetary systems in different locations of Earth (telecoupling; see chapter 6) and new ways to predict and perceive, with limited knowledge about the events and their probabilities.

Yet amid this uncertainty it is possible to discern some new trends. First, the Anthropocene is starting to have deep development impacts, disturbing societies at large and threatening development reversals. Second, these trends are expected to intensify over the rest of the century, even under moderate to high climate mitigation. Developing countries are expected to absorb the bulk of the human costs, exacerbating already destabilizing dynamics, as chapter 3 explains.

Unprecedented planetary change, unprecedented shocks on human development

Shocks emanating from disturbances in life systems and climate change are affecting people and changing societies. The Covid-19 pandemic has shown how the effects of large-scale shocks emerge out of ecological systems under pressure from social activities.[70] These shocks are affecting the main components of human development with unprecedented magnitude, synchronicity and global reach. Simulations of the pandemic's real-time impact suggest that during 2020, all the capabilities accounted for in the Human Development Index were severely affected (figure 2.4).[71]

However, even before the Covid-19 pandemic, systemic risk had been on the rise, often overshadowed by average progress in economic development and poverty reduction. There are indications on several fronts.[72]

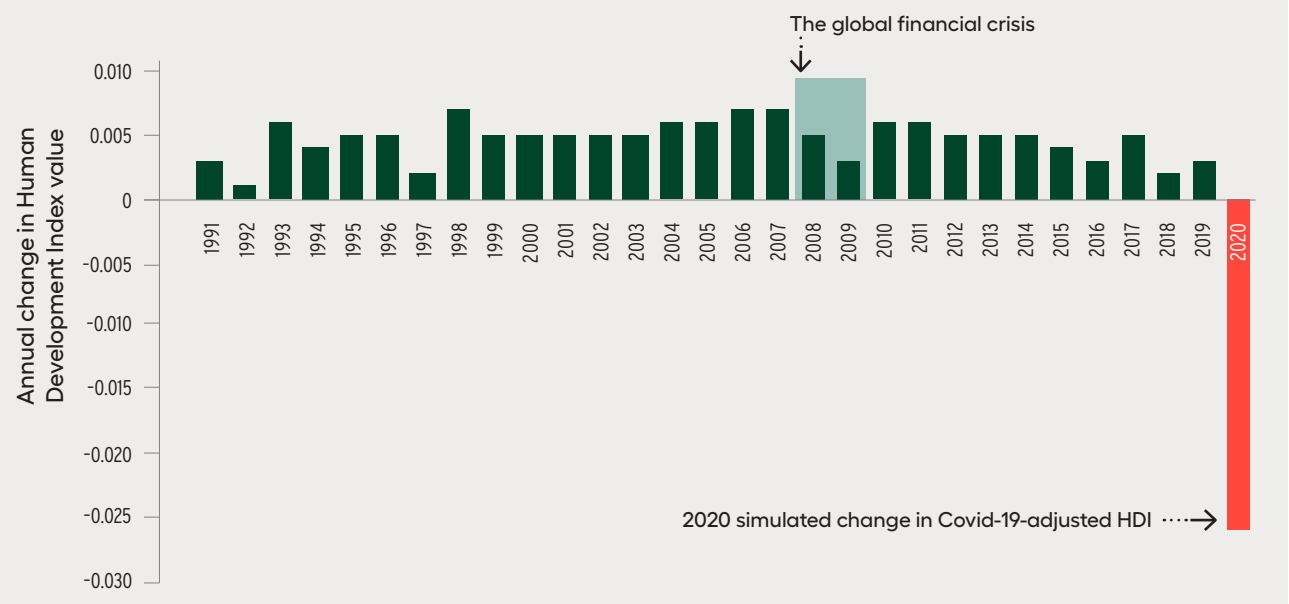
Climate change is weakening economic progress and increasing inequality

There is evidence that economic development has already been systematically affected by climate change. In most countries GDP per capita is lower today than in the counterfactual without climate change—particularly in lower income countries, where it is estimated to be 17–31 percent lower. Overall, cross-country income inequality is estimated to be 25 percent higher because of climate change.[73]

Increasing hunger

After two decades of progress the number of people affected by hunger (undernourished people) has been

Figure 2.4 The Covid-19 pandemic's unprecedented shock to human development

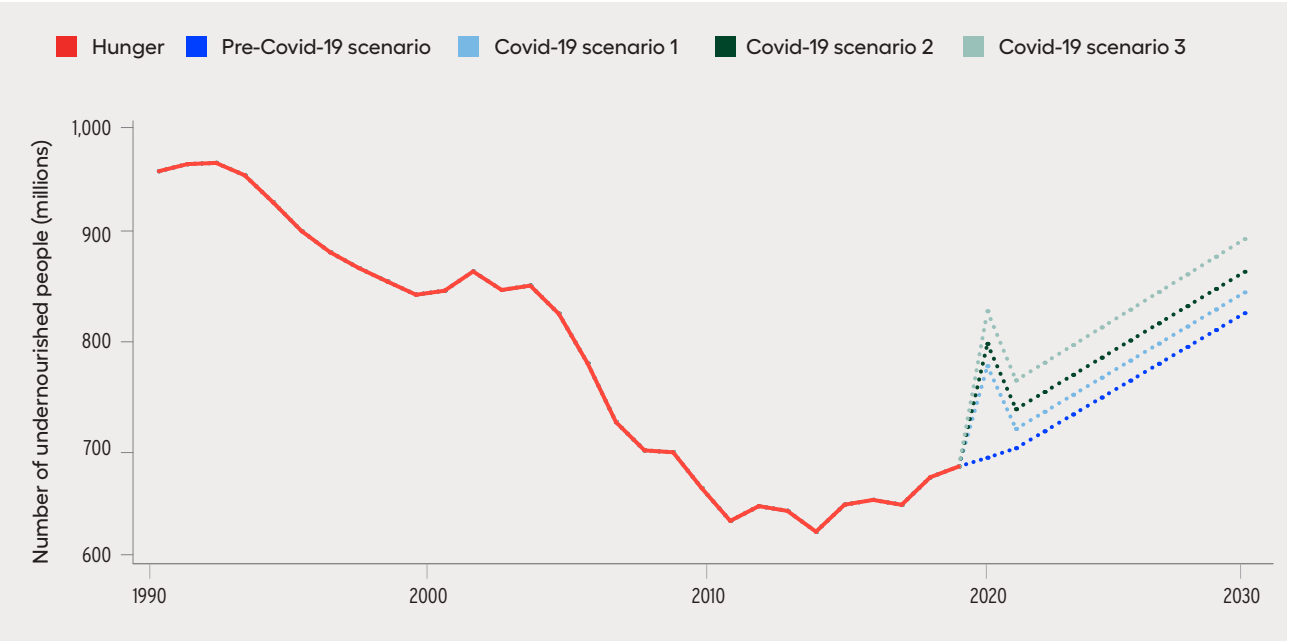


Source: Updated version of figure 3 in UNDP (2020b).

increasing since its low of 628 million in 2014. In 2019 the number was 688 million, up 60 million in only five years. Estimates for 2020 (including the effect of the Covid-19 pandemic) range from 780 million to 829 million (figure 2.5). By 2030, 900 million people could be undernourished. This trend is touching a large share of the global population: In 2019, 2 billion people were moderately or severely food insecure, 367 million more than in 2014.

The inflection point in the trajectory of progress in food security is due to multiple factors: stagnant or deteriorating economic conditions, weak positions in global value chains and large inequalities in the distribution of income, assets and resources. But

Figure 2.5 Hunger is on the rise



Source: Adapted from FAO and others (2020), using data for 1991–2001 from FAO (2020b) and UNDESA (2015).

anthropogenic shocks appear to be the newest driver: "increasing frequency of extreme weather events, altered environmental conditions, and the associated spread of pests and diseases over the last 15 years are factors that contribute to vicious cycles of poverty and hunger, particularly when exacerbated by fragile institutions, conflict, violence and widespread displacement of populations."[74]

Increasing impacts of natural hazards

During the relative stability of the Holocene, humans have learned to understand the forces of nature. To some extent, development progress is premised on delinking development from the shocks emanating from nature—which is reflected in the decline in people suffering from natural disasters over the 20th century. This resilience to uncertain but recurrent natural hazards has allowed for the reduction of inequalities in human development vulnerability.[75] But this is changing in the Anthropocene.

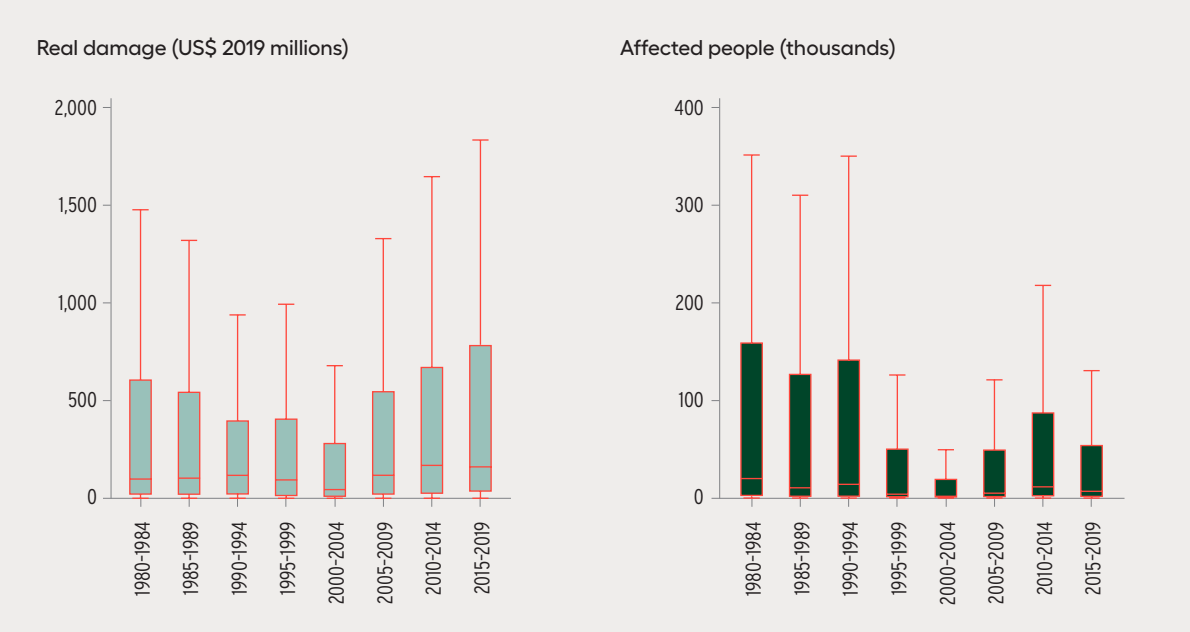
Recent scientific reports suggest that the effects of natural hazards have been increasing since the turn of the millennium.[76] Recorded damage and the number of affected people (including deaths, injured and homeless) suggest an inflection point (figure 2.6). Most of the increased economic cost has been in developed countries (with the increase in the top quartile of damage reflecting new and unusually costly hazards), but most of the increase in human costs (people affected) has been in developing countries.

Irreversible, growing and regressive effects

The human development effects of climate change —measured as days of extreme temperatures below 0 degree Celsius and above 35 degrees Celsius—are expected to be heterogeneous, with a greater burden for developing countries.

In a scenario without mitigation, by 2100 the number of days a year with extreme temperatures is expected to increase by 100 in low human development countries, 66 in medium human development countries and 37 in high human development countries (median values). In very high human development countries the number is expected to fall by 16—driven by a reduction in extreme cold days greater than the increase in extreme hot days (figure 2.7).

Figure 2.6 The effects of natural hazards appear to be increasing



Note: Natural hazards excluding geophysical and extraterrestrial events. Each box plots the middle 50 percent of the distribution; the central line is the median. Outside the box, the extreme lines are the approximate minimum and maximum of the distribution. Outliers are not shown.
Source: Human Development Report Office based on data from the Centre for Research on the Epidemiology of Disasters's Emergency Events Database (http://www.emdat.be, accessed 11 October 2020).

Even under a scenario with mitigation that might be consistent with the Paris Agreement goals, the number of days with extreme temperatures in developing countries is expected to increase substantially by 2100: by 49 days in low human development countries and 21 days in medium human development countries.[77]

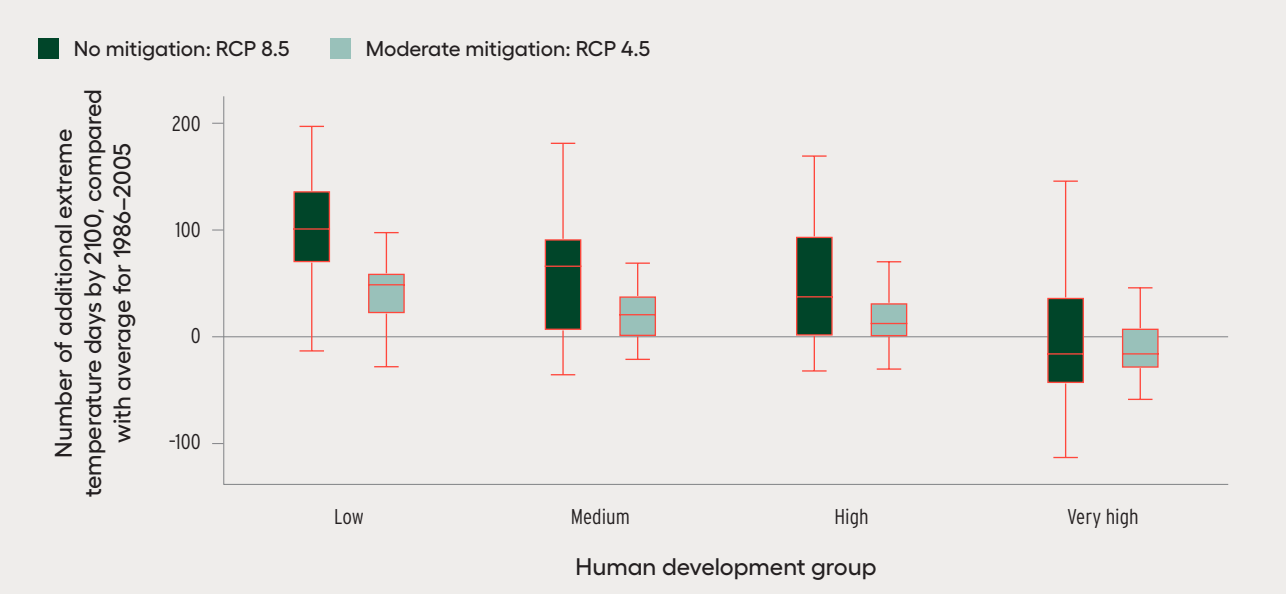
The effects on mortality are expected to be regressive, given the greater exposure and lower ability of poor countries to adapt. Indeed, in developed countries most of the health-related costs of climate change are expected to be economic—adaptation spending to cope with higher temperatures—with the number of deaths expected to decline by 2100. In low-income countries the economic burden of adaptation may be much lower, but the human cost in lives lost is likely to be extremely high, comparable to today's leading causes of death.[78]

Sea levels are expected to rise considerably in the coming decades. Climate change already caused a rise of 11–16 centimetres in the 20th century.[79] For the 21st century the estimated increase is much larger, in the range of 50–100 centimetres.[80] However, it could reach 2 metres in some (extreme) scenarios of no mitigation and early instability of the Antarctic ice sheet. More than a billion people live in low elevation coastal zones—contiguous areas along the coast that are less than 10 metres above sea level. More than three-quarters of them live in areas less than 5 metres above sea level,[81] vulnerable not only to average sea level rise but also to fluctuations caused by storms and high tides.

"Even under a scenario with mitigation that might be consistent with the Paris Agreement goals, the number of days with extreme temperatures in developing countries is expected to increase substantially by 2100.

The number of people vulnerable to permanent sea level rise is estimated to increase from 110 million today to more than 200 million by 2100.[82] These median values represent around a fifth of people in low elevation coastal zones in models with stable Antarctic conditions. In the case of Antarctic instability, between a quarter and a third of people in these zones become vulnerable. Even high mitigation scenarios project a large increase. Globally, the number of additional people on land at risk is expected to increase by 80 million in the high mitigation scenario (RCP 2.6),

Figure 2.7 By 2100 the number of days a year with extreme temperatures is expected to increase more in lower human development countries



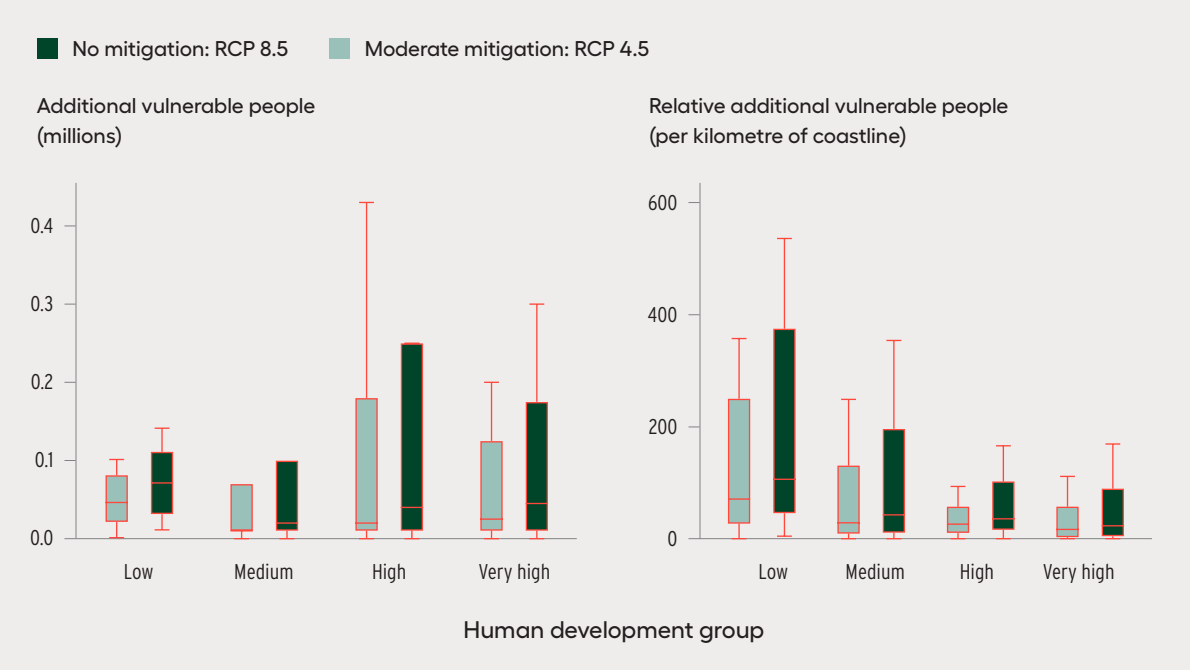
Note: Each box plots the middle 50 percent of the distribution; the central line is the median. Outside the box, the extreme lines are the approximate minimum and maximum of the distribution. Outliers are not shown. The figure compares the number of days of extreme temperature (below 0 degrees Celsius and above 35 degrees Celsius) between 1986 and 2005 (actual) and between 2080 and 2099 (median projected values).
Source: Human Development Report Office based on Carleton and others (2020).

by 90–140 million in the moderate mitigation scenario (RCP 4.5) and by 120–230 million people in the no mitigation scenario (RCP 8.5).[83]

The impacts are regressive (figure 2.8). Most of those vulnerable to the rise in sea level live in developing countries, particularly in Asia. Low human development countries are less exposed in absolute terms because they have much shorter coastlines than higher human development countries on average. But they face greater relative exposure per kilometre of coastline. People and societies adapt to changes. But adaptation can also be extremely costly in human development terms. Environmental shocks are already a leading source of forced displacement in the world (25 million people among only the internally displaced, in 2019; box 2.3). Some estimates indicate that 1 billion people worldwide could face forced displacement by 2050.[84]

The realities of the Anthropocene are overlaid on existing massive inequalities in human development. Nature's contributions to people are declining where people's needs for nature are now greatest, with up

Figure 2.8 Low human development countries have less exposure to sea level rise in absolute terms but greater relative exposure per kilometre of coastline



Note: Each box plots the middle 50 percent of the distribution; the central line is the median. Outside the box, the extreme lines are the approximate minimum and maximum of the distribution. Outliers are not shown. The panel on the right normalizes by coastline length to show that the vulnerability of people per kilometre of coastline is greater in lower human development countries. Estimates are based on the current population living in coastal zones and do not account for population growth or migration.
Source: Human Development Report Office based on Kulp and Strauss (2019).

Box 2.3 Natural hazards and displacement

Land degradation, water scarcity, natural hazards and biodiversity depletion are related to conflict, violence and migration.[1] Wetter coasts, higher temperatures, drier midcontinent areas and rising sea levels may cause the gravest effects of climate change by forcing sudden human displacement.[2] By 2070 extremely hot zones, similar to the Sahara, could cover nearly a fifth of the world's land, and a third of humanity could be living in unbearable conditions.[3] Shoreline erosion, river and coastal flooding, and severe drought have already displaced millions of people.[4] In 2019, 25 million people worldwide were internally displaced because of natural hazards.

(continued)

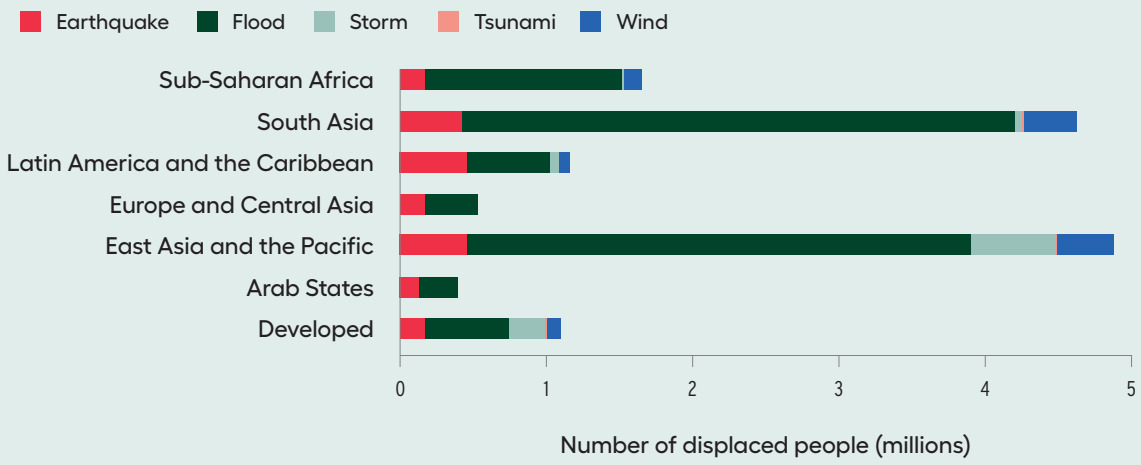
Box 2.3 Natural hazards and displacement *(continued)*

Disasters continued to trigger most new displacements in 2020. Cyclone Amphan hit Bangladesh and India, driving the largest single displacement event in the first half of the year, triggering 3.3 million pre-emptive evacuations. Several East African countries were hit by major floods and a locust infestation that aggravated food insecurity. And intense bushfires led to unprecedented displacement in Australia.[5] The expected annual number of people displaced after 2020 is about 13.7 million globally (see figure), most due to floods (72 percent).

Many people born in areas with low carbon footprints per capita are more likely to migrate to areas with higher carbon footprints. Migration is an adaptation strategy, but social patterns of discrimination and exclusion often persist even after people move.[6]

Africa is expected to experience a 10 percent decline in rainfall by 2050, potentially resulting in massive migration.[7] In Somalia drought episodes have forced entire communities to move to urban and periurban settlements.[8] New displacements in 2017 were 12 times larger than the previous year, reaching 899,000 people, and a million people were displaced in 2018 and in 2019. Informal urban settlements and displacement sites are creating new pressures on infrastructure and services, with evictions identified as a cause for secondary displacement.[9] Displaced people surveyed in Mogadishu experienced some improvements in access to education and health but faced reduced access to job opportunities and lower incomes.

Globally, about 13.7 million people a year are expected to be displaced after 2020, most due to floods



Source: IDMC 2020b.

Displacement can also differ by gender. Women's displacement can be linked to their role and status in society.[10] In 141 countries from 1981 to 2002, disasters killed more women than men on average.[11] Natural hazards with high female fatalities include the 1991 Cyclone Gorky in Bangladesh (91 percent women), the 2004 Indian Ocean Tsunami in Banda Aceh (75 percent) and the 2008 Cyclone Nargis in Myanmar (61 percent).[12] Women might be unwilling to evacuate for cultural reasons of not being able to swim or escape.[13]

But even when they survive, they are at greater risk of displacement. Women working in agriculture in Latin America, South Asia and Sub-Saharan Africa depend on forests, land, rivers and rainfall for their livelihoods.[14] Female migration intentions increase with the severity of food insecurity.[15] Changes in rainfall affect how women allocate time to paid work, unpaid care work and education, and girls can be forced to drop out of school to engage in household duties.[16]

Notes

1. Barbier and Homer-Dixon 1999; Barnett and Adger 2007; Gupta, Dellapenna and van den Heuvel 2016; Homer-Dixon 1991. **2.** IPCC 2014a. **3.** Xu and others 2020. **4.** IPCC 1995. **5.** IDMC 2020b. **6.** Singh and others 2012. **7.** Cechvala 2011. **8.** Hassan and Tularam 2017. **9.** Cortés Fernández 2020. **10.** Jungehülsing 2011. **11.** Neumayer and Plümper 2007. **12.** Oxfam 2005; Rex and Trohanis 2012. **13.** Alam and Rahman 2014; Chew and Ramdas 2005; Oxfam 2005. **14.** East Africa is defined in the cited article as generally including Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Malawi, Rwanda, Somalia, South Sudan, Sudan, Tanzania, Uganda, Zambia and Zimbabwe (Abebe 2014). **15.** Smith and Floro 2020. **16.** Abebe 2014.

Source: Human Development Report Office.

to 5 billion people facing higher water pollution and insufficient pollination for nutrition under future scenarios of climate change and land use, particularly in Africa and South Asia.[85] Humans can survive within only a narrow temperature range,[86] and temperatures are projected to shift outside that range more over the next 50 years than in the past 6,000 years—negatively in developing countries, positively in developed countries (figure 2.9).

In summary, unprecedented global planetary change is posing existential risks to humans and all forms of life but also driving deeper wedges between those more and less prepared to cope with the change. The impacts are affecting not only the well-being of the most vulnerable people in the world; they are also disempowering them.

Covid-19: An x-ray exposing how shocks exacerbate human development inequalities

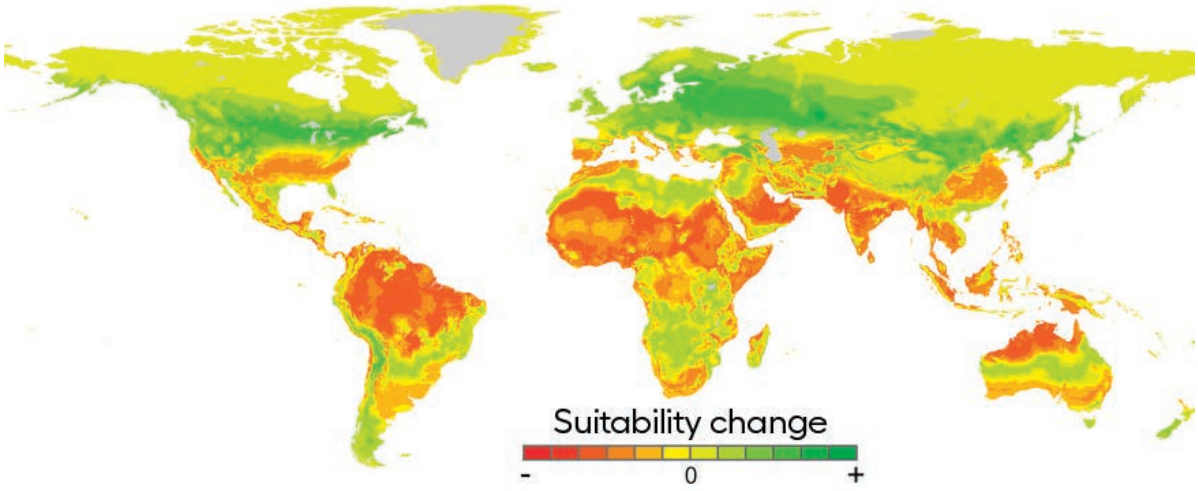
As an illustration of the disempowering effect of natural hazards, take the Covid-19 pandemic, which shows how environmental hazards exacerbate existing within-country inequalities, as the next section elaborates. Consider the two countries with the most confirmed Covid-19 deaths at the time of writing. In the United States Black and African American people and Hispanic and Latino people are nearly three times as likely as White people to test positive for Covid-19 and five times as likely to be hospitalized as White people.[87] In Brazil being of mixed ethnicity was the second most important risk factor (after age) for death among hospitalized Covid-19 patients.[88]

> "When new shocks interact with intersecting horizontal inequalities, they reinforce patterns of disempowerment of specific groups—including ethnic minorities and indigenous populations, women, children and young people.

In Latin America the pandemic has spread across rural indigenous communities,[89] home to nearly 42 million people, 80 percent of them in Bolivia, Guatemala, Mexico and Peru.[90] In Peru 75–80 percent of the population in villages with the indigenous communities of Caimito, Pucacuro and Cantagallo has been infected.[91] In Mexico indigenous people who contract Covid-19 have a higher risk of pneumonia, hospitalization and death.[92]

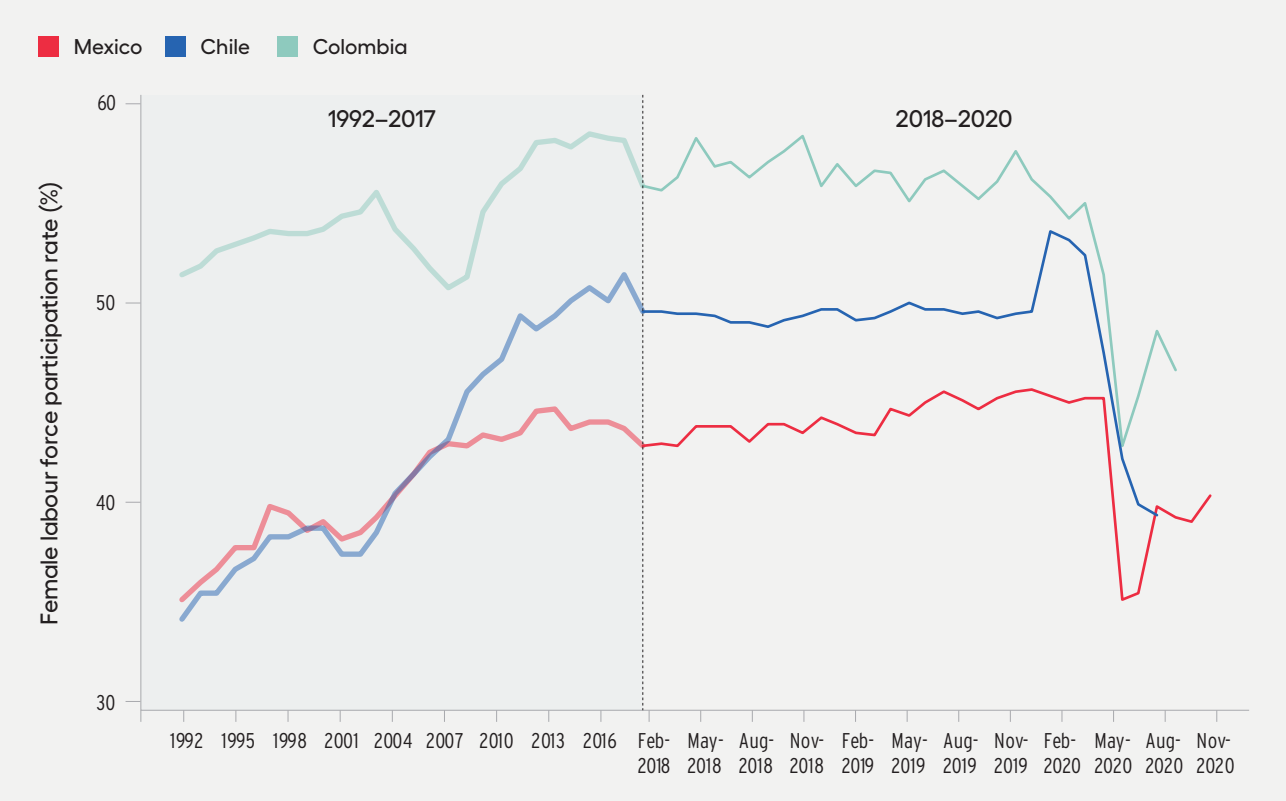
As the next section elaborates, women and girls are disproportionately affected by shocks because of their traditional roles and responsibilities,[93] including around three-quarters of unpaid care work

Figure 2.9 By 2070 temperatures are projected to shift outside the range of human survivability more over the next 50 years than in the past 6,000 years—negatively in developing countries and positively in developed countries



Source: Xu and others 2020.

Figure 2.10 The Covid-19 pandemic has erased decades of progress in the female labour force participation rate



Note: Refers to the population ages 15 and older.
Source: Yearly data for 1992–2017 from the International Labour Organization's ILOSTAT database; monthly data for 2018–2020 from the National Institute of Statistics and Geography, the National Survey of Occupation and Employment and the Telephone Survey of Occupation and Employment for Mexico and from the ILOSTAT database for Colombia and Chile.

at home.[94] This burden, combined with the lockdowns, has reduced the female labour force participation rate in Mexico, Chile and Colombia by 10 percentage points, erasing decades of progress (figure 2.10).

School closures have affected approximately 90 percent of children worldwide. While some have had the opportunity to keep learning remotely, thanks to access to the internet, others have experienced an almost complete loss of formal learning through 2020. During the peak of the pandemic in countries with school closures, the estimated short-term out-of-school rate in primary education was 20 percent in high human development countries, compared with 86 percent in low human development countries.[95] Girls and young women are particularly vulnerable—to early pregnancy, child marriage and gender-based violence.[96] The education shock might result in a loss of key capabilities[97] and of effective empowerment for the first generation embarking on the human development journey in the Anthropocene.

Planetary change is disempowering

The impacts of planetary change are diverse and context specific. For instance, countries with high ecological threats (defined by scenarios of resource scarcity and disasters linked to natural hazards) tend to be also countries with greater social vulnerability: where within-country inequalities in human development are larger, where women face larger empowerment gaps (proxied by the Gender Inequality Index) and where children—the new generation burdened by the responsibility to act—will represent a larger share of the population by 2030 (figure 2.11).

This poses a challenge in that it exacerbates inequalities in wellbeing. When new shocks interact with intersecting horizontal inequalities, they reinforce patterns of disempowerment of specific

Figure 2.11 Countries with higher ecological threats tend to have greater social vulnerability

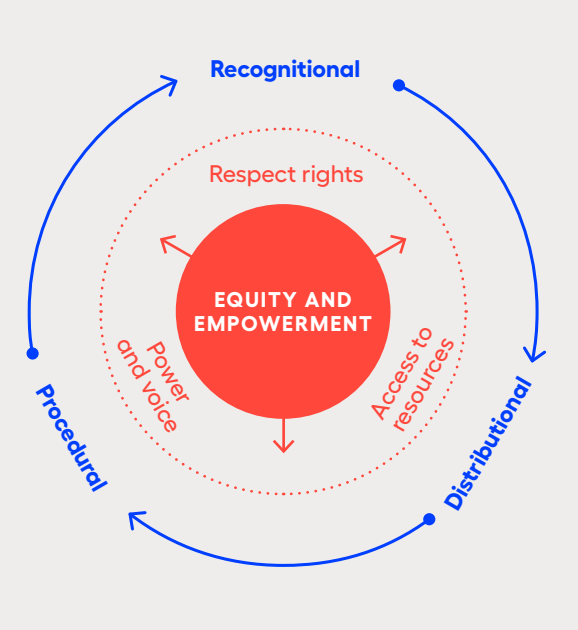
Note: Each box plots the middle 50 percent of the distribution; the central line is the median. Outside the box, the extreme lines are the approximate minimum and maximum of the distribution. Outliers are not shown.
Source: Human Development Report Office based data from the United Nations Department of Economic and Social Affairs and IEP (2020).

groups[98]—including ethnic minorities and indigenous populations, women, children and young people.[99] To see how, consider three forms of equity[100]—recognitional equity, distributional equity and procedural equity— each of which is directly linked to a key aspect of empowerment (figure 2.12).[101]

- Recognitional equity refers to recognition of interest holders and respect for their identity, values and associated rights. Empowerment is positively associated with the recognition of human rights and principles of nondiscrimination.[102]
- Distributional equity refers to the distribution of resources, costs and benefits among people and groups. Access to resources enhances an individual's ability to choose, so those resources are channels to exercise empowerment and agency.[103]
- Procedural equity relates to how decisions are being made in reference to institutions, governance and participation. Representation, power and voice are linked directly to empowerment—they shape communities' and individuals' ability to influence and participate in decisionmaking to achieve their desired outcomes and goals.[104]

As explored next, inequities in each of these three areas often reflect, and interact with, the asymmetric impacts of planetary change, given the intertwined character of social and ecological systems.[105]

Figure 2.12 Links between equity and empowerment



Source: Human Development Report Office based on Leach and others (2018).

Recognitional equity and human rights

The lack of recognition of human rights amid dangerous planetary change perpetuates discrimination and injustice. Take the example of land. Though it is a source of livelihood and economic resilience linked to identities and tied to social and cultural rights, three-quarters of the world's people cannot prove that they own the land where they live or work.[106] And local efforts to manage common land, forests and fisheries have often been undermined by group-based inequities or class differences.[107] One of the biggest disadvantages faced by indigenous peoples is the lack of recognition and protection of their rights, including their right to land, which can disempower them and limit the opportunities to expand their capabilities.[108]

> "The lack of recognition of human rights amid dangerous planetary change perpetuates discrimination and injustice.

This reflects longstanding patterns of discrimination, exclusion and nonrecognition of human rights linked to the fact that indigenous peoples have historically been denied the right to own land.[109] Only a few countries recognize indigenous peoples' land rights, but incomplete land demarcation and titling can mean that rights are not systematically protected and are vulnerable to changes in political leadership and policies. Even having legal title over land does not ensure indigenous peoples' security, as land can be leased by others without consulting them. Systemic discrimination permeates actions by governments and others, reflected, for instance, when indigenous peoples' ownership of land historically assumed to be worthless is disposed when that land is found to be rich in natural resources.

Ancestral relationships with the land have been a source of cultural and social identity for indigenous communities, as have their traditional knowledge systems. Even well intended policies have failed to acknowledge indigenous peoples' custodianship of ecosystems.[110] Conservation programmes can blunt indigenous peoples' rights, especially when excluding them in the design of conservation programmes or, worse, through forced evictions and other harms.[111] These challenges in recognitional equity extend beyond land. For example, indigenous peoples face lack of recognition of historical water uses and water rights, leading to conflicts over water in the Andes.[112]

Women in many countries also confront challenges in recognitional equity that are similar to those faced by indigenous peoples. In more than 90 countries female farmers lack equal rights to own land.[113] The asymmetries between women owning land and living off the land are striking. The lowest rates of land ownership occur in low and medium human development countries (16.4 percent and 14.4 percent) and the highest in very high human development countries (over 20 percent). But more than half of women live off the land in low human development countries compared with only 3.4 percent in very high human development countries (figure 2.13).[114] Statutory laws and restrictions on the ownership of land act as a mechanism for discrimination that exacerbates these inequalities. Even when laws are in place, enforcement can be lacking. Discriminatory social norms and practices are among the strongest barriers between women and their land rights.[115]

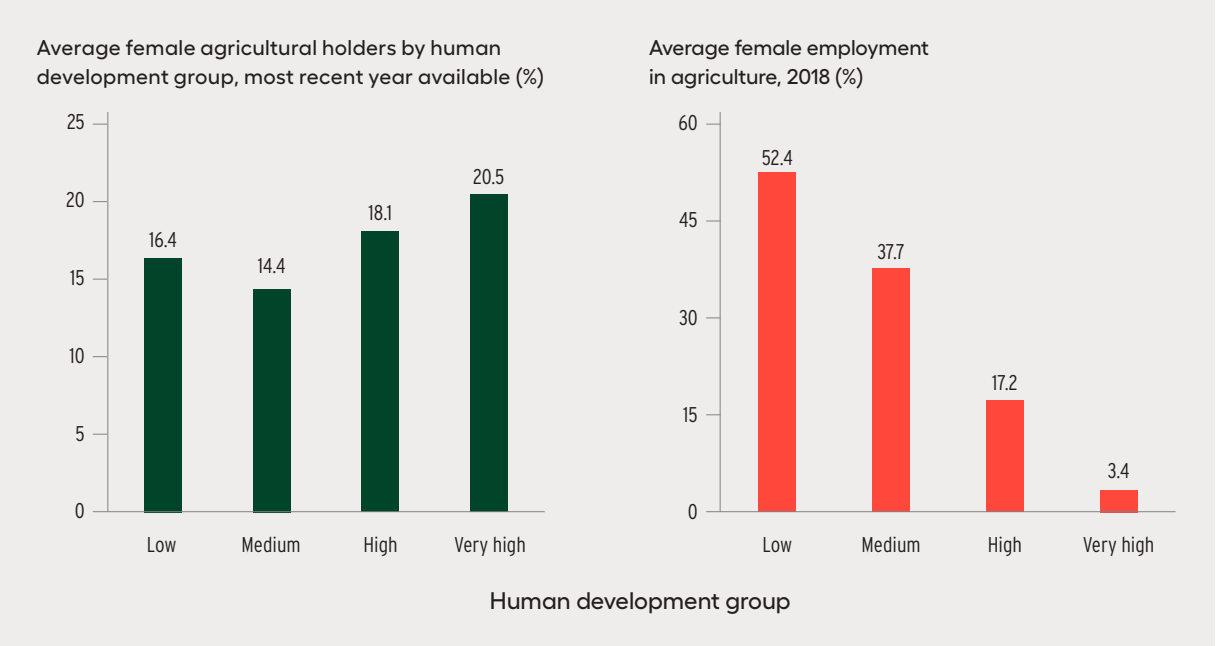
The implications of lack of recognitional equity disempower women in ways that have consequences beyond their wellbeing, because land use and management also determine agricultural productivity and the welfare of household members. Given that women are more likely to address their children's nutrition and education needs,[116] owning property gives them more bargaining power in their households to make decisions that benefit their families' long term capabilities.[117] Evidence from Colombia to India indicates that financial security and ownership of land improve women's security and reduce the risk of gender-based violence, clearly indicating that owning land can empower women.[118]

Distributional equity and access to resources

Inequalities in vulnerability to planetary change can be heightened by the uneven distribution of resources across groups (chapter 3).[119]

Consider indigenous peoples, who face a disproportionate burden of malnutrition.[120] Their food supply is diversified and linked to local ecosystems, which makes it highly vulnerable to environmental shocks.[121] Changes in rainfall, land degradation and

Figure 2.13 The asymmetries between women owning land and living off the land are striking



Note: The agricultural holder is the civil or juridical person who makes the major decisions regarding resource use and exercises management control over the agricultural holding.
Source: The Food and Agriculture Organization's Gender and Land Rights Database and the International Labour Organization's ILOSTAT database.

variations in ecosystem species and crops complicate indigenous peoples' access to their traditional food sources. In Australia indigenous mothers have a higher risk of giving birth to babies of low birthweight, and poor nutrition is higher among indigenous children.[122] The same happens in Asia, where indigenous children in Cambodia, India and Thailand show more malnutrition-related issues such as stunting and wasting.[123] These vulnerabilities extend to the lack of access to safe drinking water and wastewater treatment.[124] In Canada, a water-rich country, First Nations disproportionately risk exposure to contaminated and low-quality water. Water advisory alerts, informing communities when their water is unsafe to drink, were sent to 86 First Nation communities across the country in 2016.[125]

As with recognitional equity, women also confront systematic inequalities in access to resources and related vulnerabilities. Of the 2 billion food-insecure people worldwide in 2019, rural women were among the worst affected.[126] The prevalence of severe food insecurity in Africa, Asia and Latin America is slightly higher among women, with the largest differences in Latin America, where the gaps are rising.[127] Traditional gender roles can determine women's access to food within the household—with consequences not just for their own food security and nutrition but also for their children's, as noted above. Women, along with their children, suffer the most from nutrient deficiencies, especially during reproductive years. While in some cases women must bargain for their fair share of food, they also are more likely to voluntarily relinquish food for their families.[128] In India different responses in parent behaviour as well as some disinvestment in girls' health and education have led to higher malnutrition among girls than among boys as a consequence of shocks likely linked to climate change.[129] In Rwanda girls born during crop failure showed more stunted growth than girls born when there was no crop failure.[130]

"Traditional gender roles can determine women's access to food within the household—with consequences not just for their own food security and nutrition but also for their children's.

The consequences of inequalities in access to resources are intensified when women are also producers of food. This often happens in countries with

high shares of women employed in agriculture, typically with lower human development (see figure 2.13), mainly in South Asia and Sub-Saharan Africa, where rural women make up almost half of the agricultural labour force. Women farmers face challenges not only with the ownership of land, as discussed above, but also with accessing productive resources such as livestock, agricultural inputs, technology and finance.[131]

"When schools cannot reopen after a natural hazard, there is a long-term impact on students' learning. After 80 days of school closures, the children in areas affected by the 2005 earthquake in Pakistan were 1.5–2 years behind.

Unequal access to resources across groups also interacts with the costs and benefits linked to dangerous planetary change.[132] Consider the case of children, a vulnerable group, especially younger children who depend on adults for their survival and development.[133] Today, more than half a billion children live in extremely high flood occurrence zones, and nearly 160 million live in high or extremely high drought severity zones.[134] Changes in weather patterns, higher frequency of natural hazards and increased rainfall can interrupt children's education by displacing families (see box 2.3), destroying schools and pushing children into the labour force to help their families make ends meet.[135]

When schools cannot reopen after a natural hazard, there is a long-term impact on students' learning.[136] After 80 days of school closures, the children in areas affected by the 2005 earthquake in Pakistan were 1.5–2 years behind. Among children ages 3–5 whose mother had not completed at least primary education, those who lived close to the fault line scored significantly worse on academic tests than those who lived farther away; among children whose mother had completed at least primary education there was no gap in scores by distance. The gap is estimated to continue through adult life, leading to a 15 percent loss in lifetime earnings.[137] With the Covid-19 pandemic, school closures can create a multiplier effect on learning losses for millions of children.[138] Children may have to remain in unsafe conditions, and where there are no alternative childcare options, parents may be prevented from returning to work, creating further economic stress and possibly forcing children to drop out of school—and in some cases be driven into the labour force.[139]

Procedural equity and representation, power and voice

Asymmetries in the distribution of power parallel inequities in the distribution of the impacts of a wide range of environmental hazards across population groups.[140] These, in turn, can exacerbate exclusion of and discrimination against ethnic minorities, those at the bottom of the income distribution and other groups that face horizontal inequalities.[141] These groups can be disproportionally affected through seemingly economic decisions, such as when chemical plants or waste deposits are built in low-income communities because it is cheaper, when in fact the choices are also due to differences in representation and voice. Polluting industries choose to locate in areas where they will face less resistance. Many vulnerable communities lack the financial resources and organizational clout to sustain a long-term fight when there is a threat to their wellbeing. And they have fewer advocates and lobbyists pushing for their interests at the national level.

Consider indigenous communities, which have been disproportionately subject to air, water and soil pollution and systematically excluded from healthy environments.[142] In Esmeraldas, Ecuador, home of the Afro Ecuadorian Wimbi community, a conflict started with a palm and wood company taking over territory. The company claimed ownership over the territory and replaced existing cacao plantations with others intended to extract palm oil.[143] The change in land use, which included deforestation, affected 57 percent of the territory of Esmeraldas, and the province has turned into a palm oil producer. Water sources around the area are highly polluted, which combined with the existing malfunctioning of safe water and sanitation systems puts the local population at high risk.[144] The Niger Delta, the largest wetland in Africa and home to the Ogoni communities, has suffered from oil spills, impairing water quality.[145] Several Ogoni communities have been drinking water with high hydrocarbon levels at 41 sites, and community members of Nisisioken Ogale have been

drinking water with carcinogens.[146] The Peruvian Amazonia has also been affected by oil spills, which contaminated soil, water and the most important species for indigenous peoples' diets, with 50 percent of the general population and 64 percent of children in the area showing high levels of mercury.[147]

Women also face disproportionate burdens from planetary change due in part to the already prevailing uneven distribution of care work.[148] This includes caring for children, the elderly and the ill as well as household chores related to food production and fuel and water collection, activities that have become increasingly time consuming due to the impacts of climate change.[149] This not only reflects women's low bargaining power in household decisions but also further diminishes it. Women are left more vulnerable to external shocks and socially excluded because their higher household and care responsibilities affords them less time to participate in community decisionmaking or gain knowledge on adaptation strategies. They may also be excluded from the labour market, making them less independent.[150] Evidence bears out the relevance of these mechanisms. Ghanaian households headed by men were more resilient to climate shocks than those headed by women.[151] The differences were due to women's limited power in decisionmaking, coupled with low access to resources (illustrating how lack of distributional equity reinforces gaps in procedural equity).

Given that economic and political powerlessness can make poor and minority communities be seen as offering the path of least resistance for interests that pollute and degrade the environment,[152] the distribution of power is key.[153] Redressing these asymmetries in power has underpinned the environmental justice movement, which seeks to enhance the power of groups unseen, unheard and undervalued. Ethnicity can also reduce the options for minorities to "choose" a neighbourhood free of hazards.[154] Communities suffering environmental injustices do not lack agency; rather they are limited when they speak and act for justice by asymmetries in power that muffle their voices.[155]

This leaves some communities that have less power and voice disproportionally affected and exposed to toxic waste or excessive pollution,[156] as discussed in chapter 1. Racial disparities in environmental exposure have an impact on health: 5.6 percent of non-Hispanic Black and African American children have blood lead levels exceeding the US Centers for Disease Control and Prevention limit compared with 2.4 percent of non-Hispanic White children.[157] Possible reasons repeatedly documented for the disproportionate exposure of ethnic minorities to pollution are income inequality, discrimination, and costs of inputs, compliance and information. Disadvantaged populations can underestimate the effects that waste and pollution have on their households;[158] even when all households face the same lack of information, hidden pollution can lead to inequality.[159]

"Redressing asymmetries in power has underpinned the environmental justice movement, which seeks to enhance the power of groups unseen, unheard and undervalued.

In urban areas of Africa, Asia and Latin America, a high proportion of poor people face serious environmental hazards in their homes, surroundings and workplaces.[160] In some cases environmental inequities endure the passage of time and changes in values and political contexts. In 1980, under South Africa's apartheid regime, the Bisasar Road Landfill Site was created in the middle of a working-class Black African community to import waste from White communities. After the regime ended, and despite promises to the community to close the hazardous landfill, it has continued operations and developed further through the completion of an energy project to convert methane emissions into electricity on site. Exposure to the hazardous pollutants in the landfill has impaired the health of the surrounding community.[161]

This discussion has shown how gaps in procedural equity sustain control of voice and influence by those more powerful, leaving already disadvantaged populations further disenfranchised in the face of shocks linked to planetary change. In some cases those speaking and acting for these groups face threats to their physical integrity.[162] As discussed in chapter 3, supporting the agency and empowerment of disadvantaged populations—by respecting their human rights, increasing their access to resources and ensuring that they are represented and their voices are heard[163]—can break the vicious cycle of planetary and social imbalances identified in chapter 1.