CHAPTER

3

Empowering people for equity, innovation and stewardship of nature

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This is the age of humans.

Human development puts people at the centre of development—people are agents of change.

But humans are pushing interdependent social and ecological systems into the danger zone.

How can we use our power to expand human freedoms while easing planetary pressures?

This chapter argues that we can do so by enhancing equity, fostering innovation and instilling a sense of stewardship of the planet.

Chapter 1 concluded that confronting the challenges of the Anthropocene by expanding human agency and freedoms widens the scope for action. The alternative of trying to "defend our way of life" would result instead in an exercise of facing constraints. This chapter argues that to steer actions towards transformational change, it is important to empower people in three ways: by enhancing equity, by pursuing innovation and by instilling a sense of stewardship of nature.

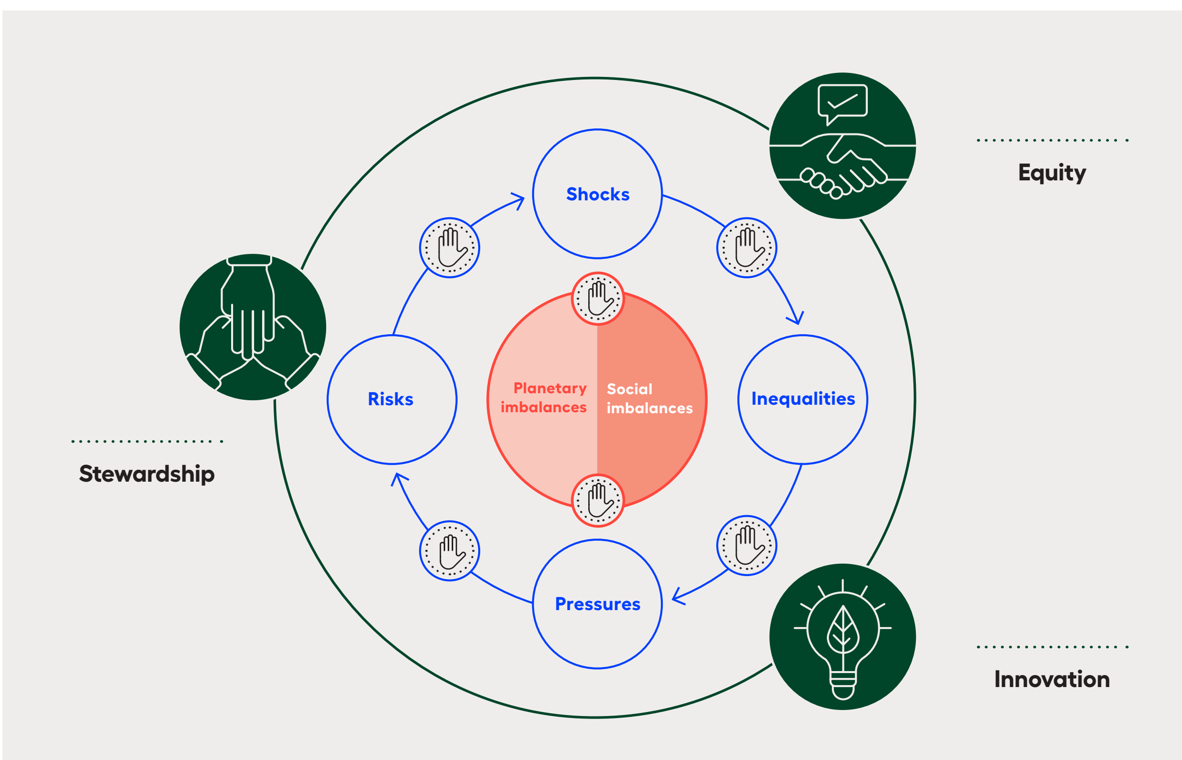
People can be agents of change if they have the power to act. But they are less likely or able to do so in ways that address the drivers of social and planetary imbalances if they are left out, if relevant technologies are not available or if they are alienated from nature. Conversely, equity, innovation and stewardship of nature each—and, more importantly, together—can break the vicious cycle of social and planetary imbalances (figure 3.1).

Equity is central in part because the inequalities documented in chapter 2 are reflected in asymmetries of power. The unequal distribution of nature's contributions to people and of environmental degradation's costs are often rooted in the power of a few to benefit without bearing the negative consequences—and in the disempowerment of the many that disproportionally bear the costs. The former group represents a minority of humans that biases collective decisions. Equity can rebalance these power asymmetries so that everyone can benefit from and contribute to easing planetary pressures. There is great potential to capture solar energy[1] and to expand forest areas to protect biodiversity and store carbon—if people are empowered to make those choices.[2]

> "To steer actions towards transformational change, it is important to empower people in three ways: by enhancing equity, by pursuing innovation and by instilling a sense of stewardship of nature.

Innovation—which gave humans many of the tools to influence Earth systems—can be harnessed to ease planetary pressures. Beyond advances in science from multiple disciplines that can support capturing

Figure 3.1 Equity, innovation and stewardship of nature can break the vicious cycle of social and planetary imbalances



Source: Human Development Report Office.

energy from the sun and closing material cycles, innovation should be understood here also as a social process of change, resulting from advances in science and technology that are embedded in social and economic processes. Moreover, innovation is more than science and technology; it includes the institutional innovations that ultimately drive social and economic transformations.

Stewardship of nature echoes the often-unheard voices of indigenous peoples and the many communities and cultures over human history that see humans as part of a web of life on the planet. Evolution has encoded the lessons of billions of years in the biodiversity surrounding us (see spotlight 1.2). We depend on this biodiversity, even though we are accelerating its destruction. Instilling a sense of stewardship of nature can empower people to rethink values, reshape social norms and steer collective decisions in ways that ease planetary pressures.

Empowering people in these three ways is self-reinforcing. Inequalities bias investments in science and technology towards the powerful—and alienation from nature may shift priorities away from mobilizing human creativity to ease planetary pressures. Inequalities can facilitate elite capture, with powerful and privileged groups exercising undue influence over decisionmakers, which can limit market competition and create barriers to entry for innovators and firms that could drive transformational change. As chapter 1 noted, cultural and linguistic diversity—which has evolved jointly with biodiversity—implies that losses of biological diversity parallel cultural losses.[3] Empowering people in this way can harness human agency for transformational change.[4] The remainder of this chapter considers each of the three areas for empowerment in turn.

Enhancing equity to advance social justice and broaden choices

Inequalities in human development not only represent unfairness and social imbalances that can destabilize societies, affecting wellbeing and the dignity of people,[5] but they also play a role in how people interact with nature, impacting planetary pressures. As chapter 2 discussed, different inequalities (often reflecting relative disempowerment) determine the distribution of risks across the population in response to changes in the biosphere.[6] Disadvantaged groups tend to bear a larger burden. And as documented below, nature's degradation is often linked with power imbalances.

> "An agenda centred on equity is important intrinsically, but it can also break socioenvironmental traps and ultimately ease planetary pressures.

The self-reinforcing cycle between social and planetary imbalances described in chapter 1 might also emerge as socioenvironmental traps at lower scales, making it difficult to escape from trajectories in which persistent inequalities compound behaviours that degrade nature and put pressure on the planet.[7]

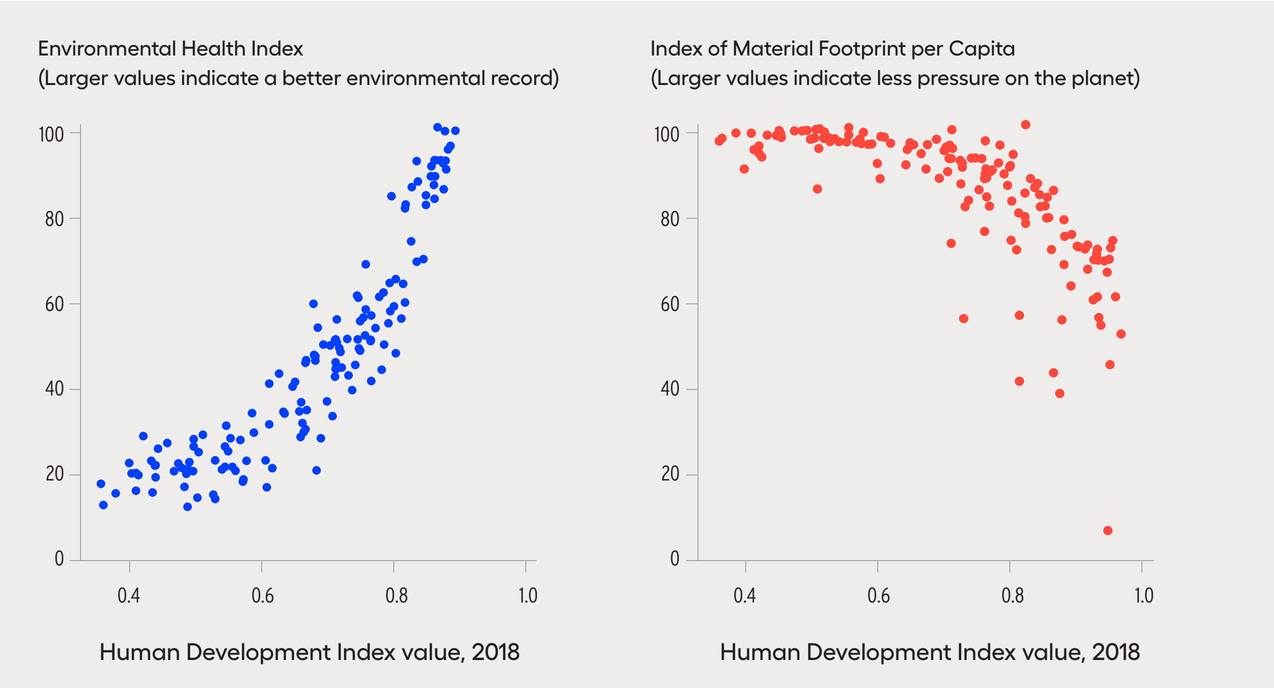
In fact, Anthropocene risks and their consequences (see chapter 2) are intimately linked to how societies work. The asymmetries of power across groups can set the social conditions (the mix of incentives and narrow possibilities) that result in overexploitation of resources. For instance, people and communities experiencing deprivations or a lack of power may be drawn to use inefficient production practices or to generate dangerous pollutants because of the narrow set of choices they confront.[8]

So an agenda centred on equity is important intrinsically, but it can also break socioenvironmental traps and ultimately ease planetary pressures. The ambition for transformational change is universally relevant, with common but differentiated responsibility—due to the vast asymmetries in capacities to respond. The challenge is making the distribution of power and agency more equitable to steer action towards transformational change everywhere.

Capturing benefits, exporting costs: Unequal distribution of nature's contributions across countries

Higher human development countries concentrate most of nature's contributions without fully internalizing the costs generated in the process. Two tales of environmental inequalities in human development across countries are reflected in the dispersion of values along the horizontal axis of two environmental outcomes in figure 3.2. The Environmental Health Index measures the benefits of a sound relation with the planet in terms of clean air and water and

Figure 3.2 Two tales of environmental inequality



Note: Includes countries with more than 1 million inhabitants.
Source: Human Development Report Office based on data from the Yale Center for Environmental Law and Policy and the United Nations Environment Programme.

effective management of waste and residuals. The Index of Material Footprint per Capita reflects use of materials for domestic consumption.[9]

Striking inequalities emerge across countries.[10] Low human development countries face substantial environmental challenges (they have low environmental health scores) and use much less material resources than countries at the other extreme. Higher human development countries have higher environmental health and material use scores.

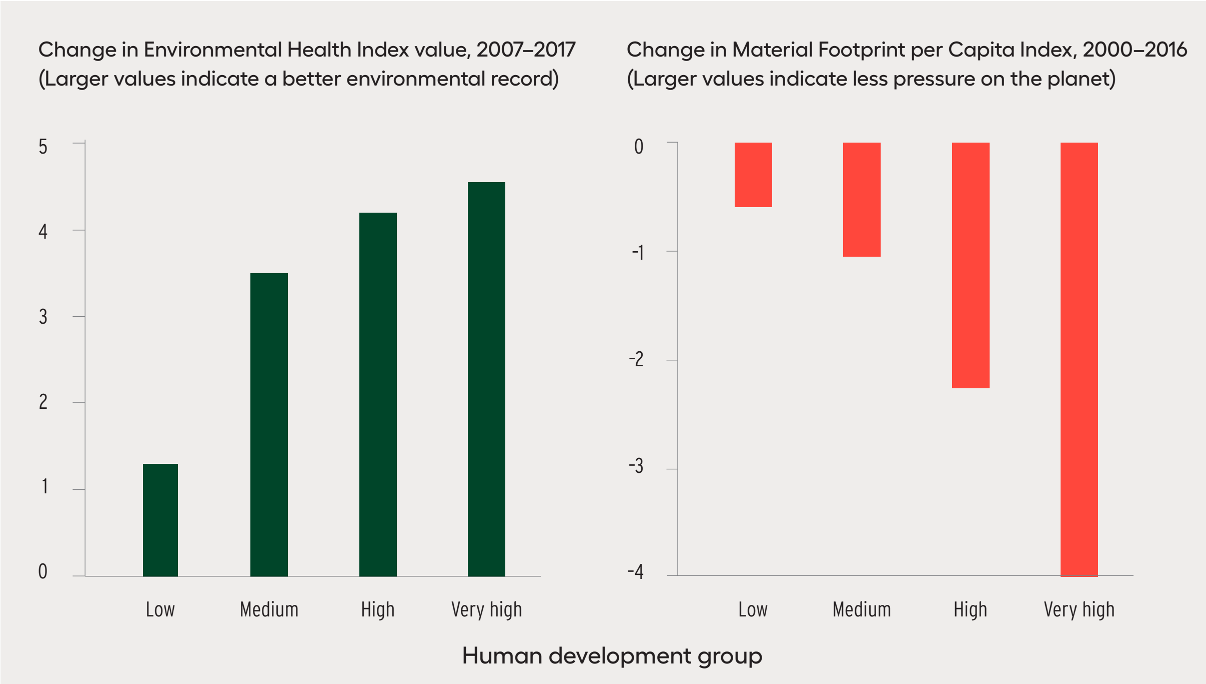
“The burden of planetary changes is not equally distributed across people. This is eminently destabilizing in that it rewards current production and consumption patterns.

And there is more: The burden of planetary changes is not equally distributed across people. Take climate change. On average, low human development countries are likely to have 50–100 additional days with extreme weather by century’s end, while very high human development countries might see a decrease in the number of days with extreme weather (depending on the mitigation scenario).[11] The human impact will be huge, even after adaptation efforts are taken into consideration: The number of excess deaths in poorer countries could be comparable to those from cancer today.[12]

This is eminently destabilizing in that it rewards current production and consumption patterns. And environmental inequalities are increasing across countries. For both the Environmental Health Index and the Index of Material Footprint per Capita, the gaps are widening (figure 3.3). This means that developed countries are improving their ability to benefit from nature (through cleaner water and air) faster than developing countries. At the same time, developed countries are increasing their already higher burden on the planet (in material footprint), despite some recent relative decoupling between greenhouse gas emissions and GDP growth in a few very high human development countries (chapter 1).[13]

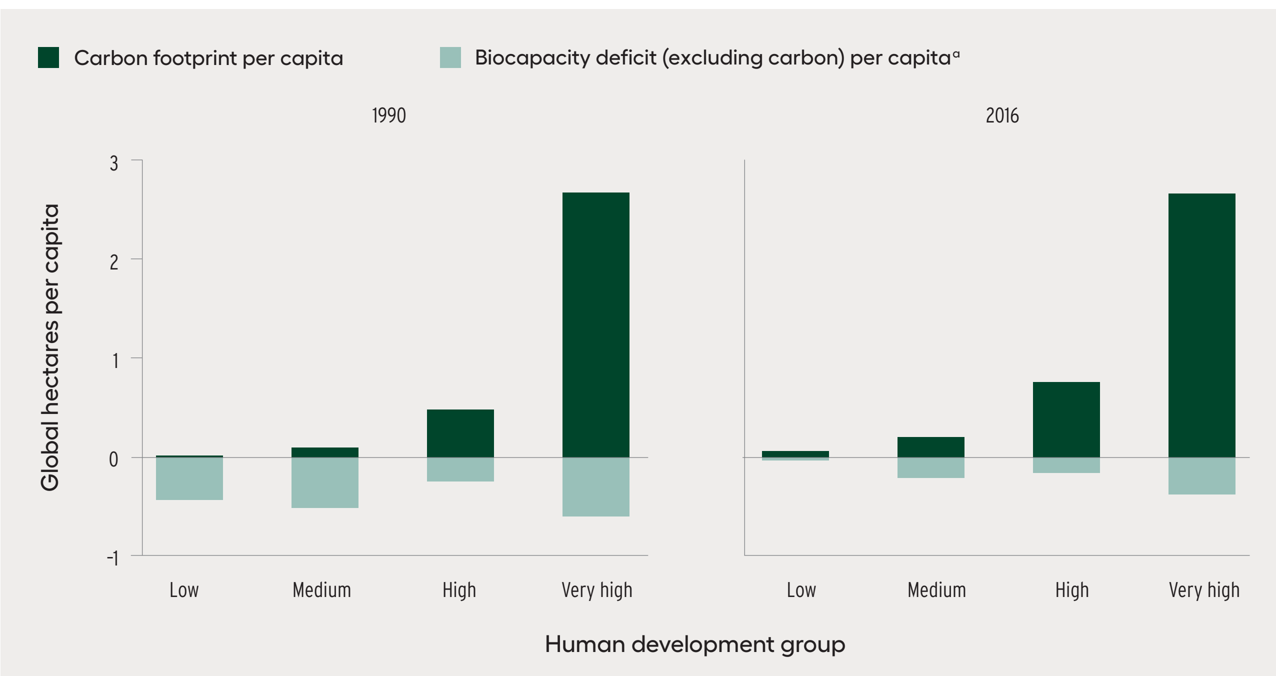
These patterns are also present in integrated ecological footprint accounts,[14] which compare the demand for biocapacity (footprint) with its availability. The resulting biocapacity deficit (or reserve) can be decomposed into its noncarbon and carbon components: the noncarbon biocapacity deficit reflects

Figure 3.3 Growing environmental inequality



Note: Includes countries with more than 1 million inhabitants. Data are median values.
Source: Human Development Report Office based on data from the Yale Center for Environmental Law and Policy and the United Nations Environment Programme.

Figure 3.4 Unequal dynamics: Carbon footprint and biocapacity deficit



a. Equals domestic noncarbon footprint per capita minus domestic biocapacity per capita. Negative values indicate "reserve."
Note: Country-level data using the median to aggregate across human development groups. Balanced panel of 104 countries, based on production accounts.
Source: Human Development Report Office based on Global Footprint Network (2019).

predominantly domestic overuse when using production accounts, and the carbon component (carbon footprint) measures emissions, some of which can be absorbed domestically, but the rest becomes a planetary externality (figure 3.4).[15]

In 2016 very high human development countries had the largest noncarbon biocapacity reserves per capita and the largest carbon footprints per capita. Lower human development countries had smaller noncarbon biocapacity reserves and even smaller carbon footprints per capita.

From 1990 to 2016 global overshoot increased susbstantially, from 29 percent to 70 percent.[16] In per capita terms noncarbon biocapacity reserves decreased across all groups but decreased more in lower human development countries. In turn, carbon footprint per capita increased most in high human development countries.

Reducing horizontal inequalities to break socioenvironmental traps

Conceptualizing sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[17] acknowledges the interests of both present and future generations. But this conceptualization does not fully account for the complex relationship between intragenerational and intergenerational inequalities.[18] Neither the current generation nor future generations are homogeneous in their relationship with nature. The differentiated use of natural resources within societies and the resulting differences in environmental degradation are fundamental to understanding how inequalities can be passed from one generation to the next and the implications for the evolution of environmental pressures.

The process is complex. The nominal possession of natural resources is important, but it is far from sufficient for equitable wellbeing. There is some evidence of the so-called natural resource curse.[19] What matters in most cases is not the availability of natural resources as such but the distribution of costs and benefits associated with them. These are influenced heavily by the interests of different groups and the relative distribution of power among them, often manifest as horizontal (or intergroup) inequalities.

Some have deep historical roots, with origins in colonialism. The unequal distribution of power during colonial times was explicit, with colonies meant to provide natural resources for the colonial power.[20] Power imbalances meant that most benefits were concentrated in the colonial power. Colonies retained limited rents and had their natural capital progressively depleted. The differentiated dynamics in capital accumulation, in turn, affect people's wellbeing across generations (table 3.1).[21]

"The differentiated use of natural resources within societies and the resulting differences in environmental degradation are fundamental to understanding how inequalities can be passed from one generation to the next and the implications for the evolution of environmental pressures.

Racism and classism reflect similar dynamics within countries—weakening long-term human development through exposure to environmental hazards, sometimes linked to extractive activities.[22] Some groups work in precarious conditions, degrading land and depleting natural resources as part of productive processes that yield rents for the elite or large companies.[23] In the process human rights violations intersect with unsustainable resource use. Exploitative labour practices, including slavery and human trafficking, have been documented, for instance, across seafood supply chains around the world.[24] Consumption often takes place in countries with strict sustainability requirements and a public sensitive to both resource overexploitation and poor working conditions, but

Table 3.1 Examples of horizontal inequalities and intergenerational inequalities connected to power imbalances

	Group concentrating and benefiting from power Colonial power Privileged groups Elites Large companies	**Disadvantaged groups** Colony Racial/ethnic minorities Low-earning workers Local communities
This generation	Extraction of benefits Often limited costs	Limited benefits External costs
Next generation Inherits:	High produced capital High human capital	Low produced capital Low human capital Depleted natural capital

Source: Human Development Report Office.

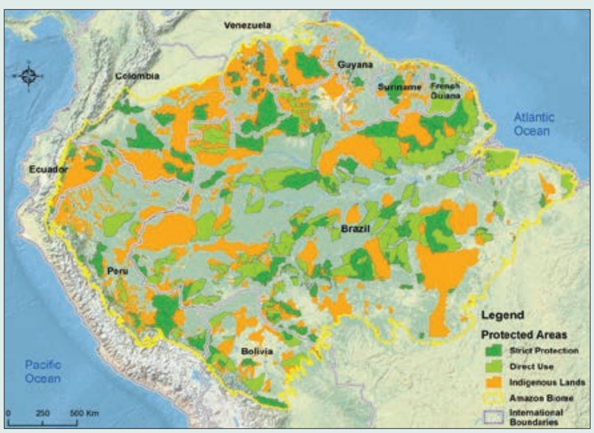
the complexity of supply chains weakens the price and information signals that link resource use and consumption. Worse, efforts to safeguard sustainability in a location can heighten resource overexploitation elsewhere. For instance, beginning in the late 1990s, concerns about cod stocks in the Baltic Sea led to a large reduction of local cod consumption in Sweden, after strong civil society mobilization. But overall cod consumption changed little, having been met through imports.[25] The complexity and opacity of seafood supply chains can increase even further with the growing commercial interest in marine resources. And even with progress on the most egregious human rights violations, other more subtle violations can perpetuate discrimination or deny fair access to and sharing of marine benefits.[26]

Two long-term outcomes of these dynamics are inequality in human development and excessive resource use, potentially leading to biodiversity loss (box 3.1). Depletion of natural resources is likely to take place when the most powerful group has limited incentives to care about the consequences of overexploitation on others (including pollution, full depletion of reserves and other environmental damages).

Box 3.1 The Amazon's biodiversity loss and disempowerment

Critical ecosystems such as the Amazon face the risk of shifting from rainforest to savannah as forest loss increases, caused primarily by fires and changes in land use. Farmers and agricultural workers sometimes set fires to prepare land for replanting or to clear weeds. In 2018 and 2019 Bolivia and Brazil experienced high losses in primary forests—for Bolivia due to fires and large-scale agricultural activity and for Brazil mostly logging and clear-cut deforestation for new land use and agriculture (see map).[1]

Vanishing forests in the Amazon



Source: World Wildlife Fund, based on WRI (2019).

Deforestation has led to biodiversity loss, habitat degradation, higher pollution, loss of water cycling and increased poverty.[2] A longitudinal study of Amazonian villages in Peru over 30 years finds strong evidence of path dependence in poverty traps.[3] Past household landholdings and assets can have a major impact on future land ownership and land use. Initially, land-poor households are typically limited to subsistence-oriented annual crops or cannot leave their land in fallow to restore soil nutrients. They can fall into land-use poverty traps. Poorer households' income relies more on fishing, day labour, small livestock and unsustainable harvesting of nontimber forest products.[4] These have direct effects on people's wellbeing as well as on the dynamics of tropical deforestation and secondary forest regrowth. One way poorer households have found to escape the trap is outmigration, which can also reduce pressures on the land.

Notes

1. Weisse and Dow Goldman 2020 ; WRI 2019. **2.** WWF 2020b. **3.** Coomes, Takasaki and Rhemtulla 2011. **4.** Barrett, Travis and Dasgupta 2011.

These outcomes have little to do with preferences about the wellbeing of future generations. The dominant groups can transmit their privileges to their descendants, and the disadvantaged groups face hugely restricted choices.

"Inequalities in empowerment today are at the root of environmental problems, many threatening the wellbeing of future generations. Important for a better tomorrow is to empower disadvantaged groups and actors today.

Case studies suggest that today's intragenerational inequalities are linked to intergenerational inequality and environmental degradation[27] through multiple channels, some of which are summarized in table 3.2. Generally, these are not about income inequality but about a variety of context-specific dynamics of inequality that produce a negative effect on nature, including the procedural and distributional inequalities analysed in chapter 2.[28] The local, national and global interactions underscore inequality's pervasive effects, including local environmental degradation, natural resource overexploitation and greenhouse gas emissions. In all the channels inequalities in empowerment today are at the root of environmental problems, many threatening the wellbeing of future generations. Therefore, an important part of the strategy for a better tomorrow is to empower disadvantaged groups and actors today.

These patterns can be exacerbated by climate change. As chapter 2 documented, disadvantaged groups face a disproportionate burden because of different forms of environmental imbalances, both across and within countries, which reinforce existing inequalities. One example is people living in less-favoured agricultural areas and rural low elevation coastal zones. These people are already suffering the effects of climate change, which exacerbate existing poverty–environment traps. One manifestation is that reduction of infant mortality is slower in these areas—precisely where the problem is more intense in the first place—widening gaps in human development (figure 3.5). The divergence in infant mortality contrasts sharply with the convergence observed on average across developing countries, with greater reductions in poorer countries[29]—underscoring how environmental factors affect social imbalances.

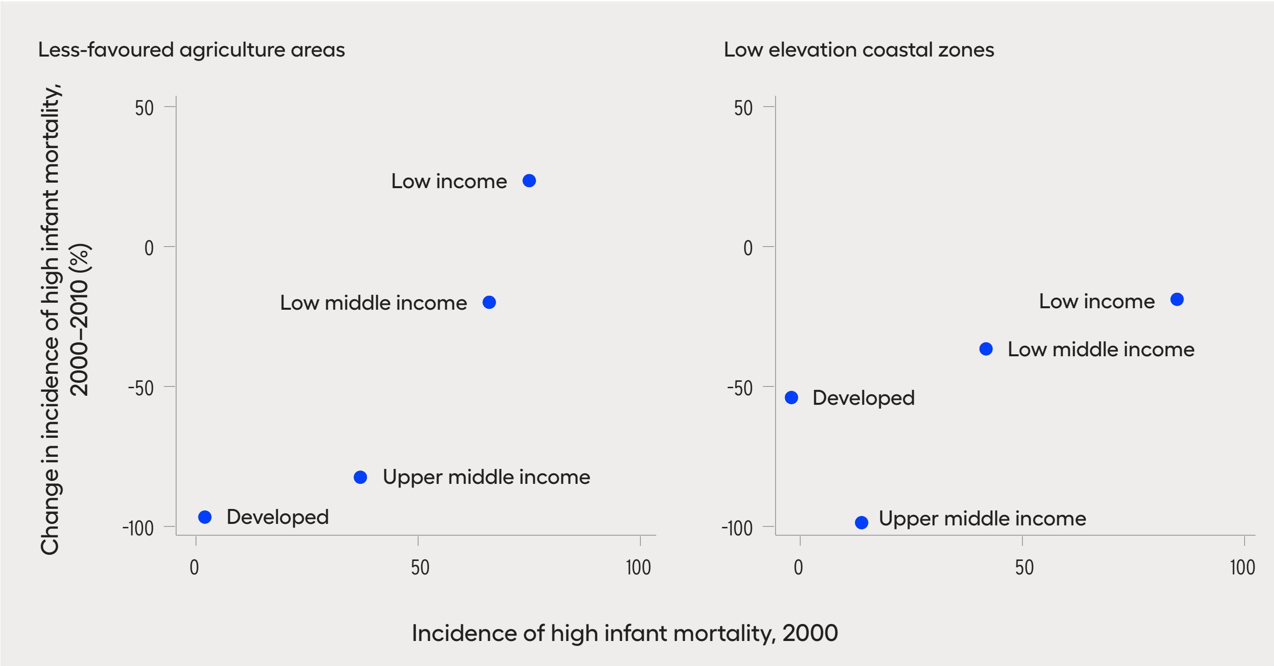
Table 3.2 Typologies of interaction dynamics between inequality and sustainability

How intragenerational inequality today affects sustainability		Response
Interaction dynamic	**Sustainability consequences**	**Actors to be empowered**
Resource distribution	Low environmental services	Disadvantaged groups
Ecological space	Greenhouse gases	Developing countries
Elite capture	Overexploitation, pollution	Majorities through social incentives
Marginalization	Low environmental services	Disadvantaged groups
Status and consumption	Overexploitation, greenhouse gases, pollution	Everyone through knowledge, change in norms and stewardship of nature
Environmental disconnection	Overexploitation, greenhouse gases, pollution	Everyone through knowledge, change in norms and stewardship of nature
Market imperfections	Overexploitation, greenhouse gases, pollution	Majorities through social incentives, local communities
Narrow environmental intervention	Low environmental services	Local communities
Collective action	Overexploitation, pollution	Disadvantaged groups, local communities
Morality–power–knowledge	Overexploitation, greenhouse gases, pollution	Indigenous peoples, local communities

Note: Resource distribution: inequality and unsustainability result from uneven distribution of resources, such as water and land, across groups. Ecological space: unequal distribution of "ecological space," such as greenhouse gas budget, reflects and reproduces economic, spatial and political inequalities. Elite capture: concentration of power and wealth in the hands of an elite facilitates pollution and environmental degradation with impunity. Marginalization: environmental shocks exacerbate existing inequalities, contributing to spirals of impoverishment and environmental degradation. Status and consumption: status hierarchies can drive unsustainable forms of material consumption. Environmental disconnection: urbanization can reduce people's direct reliance on nature, intensifying social inequities and reducing interest in sustainability. Market imperfections: deregulated markets can contribute to both economic inequality and environmental unsustainability. Narrow environmental intervention: interventions aimed only at environmental sustainability can lead to social exclusion. Collective action: inequalities can compromise sustainability by making cooperation more difficult. Morality–power–knowledge: potential disrespect for diverse moral options can contribute to political and knowledge inequalities and to unsustainability.

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

Figure 3.5 In vulnerable areas in poorer countries, gaps in infant mortality are widening



Note: High infant mortality refers to at least 32 deaths per 1,000 live births
Source: Human Development Report Office based on data from Barbier and Hochard (2018).

Thus, inequalities, particularly horizontal inequalities, can drive both environmental degradation and intergenerational inequality.[30] Enhancing equity can empower people to advance human development and ease planetary pressures. More cohesive societies have social mechanisms that can reduce gaps in empowerment encoded in legislation and policies, ranging from fiscal measures (both taxation and social protection) to regulation and competition policies (which preclude the excessive concentration of economic power in monopolies).[31] In less cohesive societies group-based inequalities, amplified by environmental factors, can generate social costs[32] that have inspired social mobilization, such as the environmental justice movement (box 3.2).

Redressing within country inequalities to ease pressures on the planet

But it is not only horizontal inequalities that matter. Addressing inequalities across people can also enable societies to advance human development while limiting planetary pressures. Consider the current frontiers of achievement in life expectancy at birth and mean years of schooling for different incomes (figure 3.6). For any income level there is wide variation in health and education outcomes, pointing to the potential for enhancing both without increasing income (and associated planetary pressures). In other words there is much potential at every income level for advancing human development by closing gaps in achievements in health and education, advancing equity in either dimension.

Progress in equity might also contribute to resetting priorities. Within-country inequality can be a factor behind the social need to increase material consumption[33] and the importance of economic growth in generating opportunities for those less well off.[34] With high inequality there are expenditure cascades[35] and moving targets: People make progress in material conditions, but it does not necessarily translate into greater capabilities[36] or sizeable increases in happiness.[37] In more unequal societies there is a greater search for status through consumption, sometimes leading people with low income to reduce caloric intake in favour of aspirational purchases.[38] Tragically, low-consuming and socially equitable communities, such as many indigenous peoples, have been increasingly marginalized.[39]

Box 3.2 The environmental justice movement

Environmental justice emerged in the last century as an international, intergenerational and multiracial movement. It seeks to promote environmental, economic and social justice. It recognizes the links among environmental, economic and health issues and demands a safe, clean community and environment. Environmental justice evokes not just official regulations and policies but also social and cultural norms and values, behaviours and attitudes. From its early years environmental justice has been a hybrid, growing out of the civil rights movement in the United States into a social and political concept in the spheres of nongovernmental organizations and academia.[1]

The movement emerged in the 1960s when Black and African American communities in the United States were disproportionately affected by pollution from unwanted land use and waste facilities in their neighbourhoods. Blacks and African Americans mobilized against environmental injustice in Tennessee, where they advocated for better working conditions for garbage workers. Later in the 1980s a manufacturer of electrical transformers in North Carolina placed its toxic waste facility in a predominantly Black/African American town.[2] Around the same time Robert Bullard collected data for several civil rights lawsuits from 1930 to 1978 to show that 82 percent of the waste in Houston, Texas, was dumped in Black and African American neighbourhoods, a consistent pattern in the country's south.[3]

The movement expanded to the rest of the world around the 1990s, when it caught the attention of activists, researchers, academics and politicians. In 2002, 71 percent of Blacks and African Americans in the United States lived in counties that were in violation of federal air pollution standards.[4] These constitute examples of environmental injustice in which areas where vulnerable people live are chosen to place landfills or waste facilities that other areas would not allow. Now a field of study, environmental justice concerns itself with the "fair treatment and meaningful involvement of all people regardless of race, colour, national origin or income, with respect to the development, implementation and enforcement of environmental laws, regulations and policies."[5]

Notes

1. Rasmussen and Pinho 2016. **2.** Mayhew Bergman 2019. **3.** Bullard 1983. **4.** Southern Organizing Committee for Economic and Social Justice 2002. **5.** EPA 2020a.

Source: Human Development Report Office.

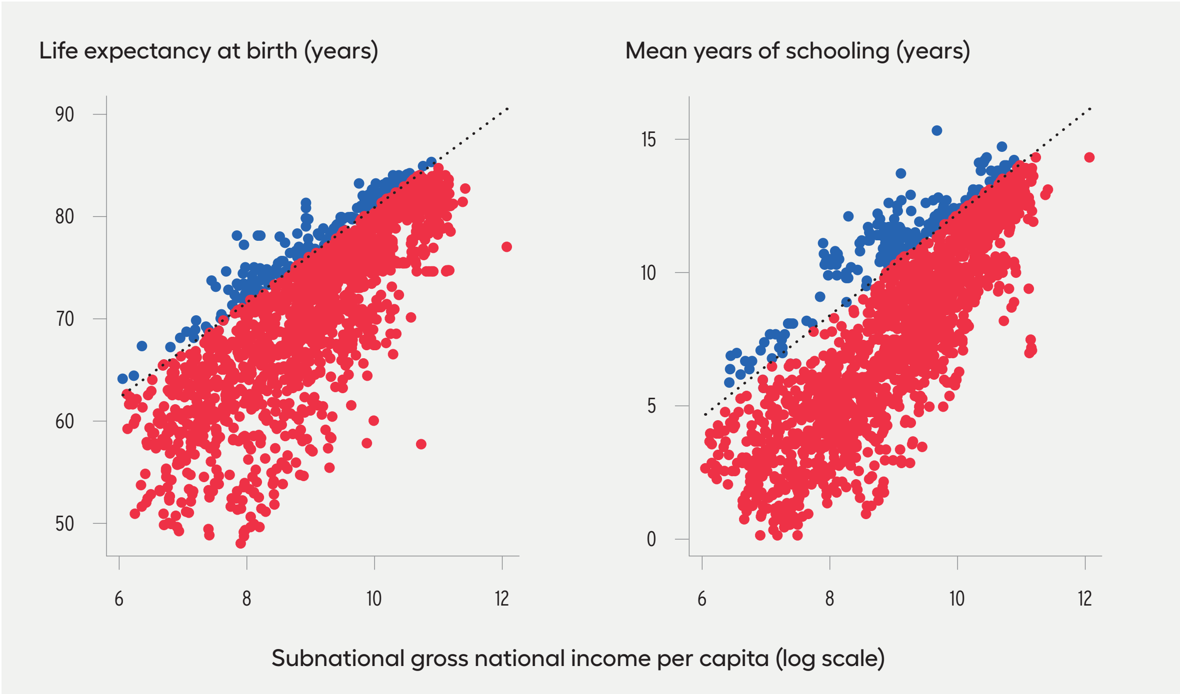
In sum, greater equity can be a powerful social stabilizing force and ease environmental pressures. It is not the only factor, and enhancing equity alone may not lead to these outcomes. That is why, along with equity, it is crucial to empower people through innovation and a sense of stewardship of nature. For instance, the equity lens is fundamental for transformations in the energy sector to achieve decarbonization. Indeed, some key instruments for decarbonization—such as carbon prices and reduced fossil fuel subsidies—have complex distributional impacts (chapter 5). This might feed a narrative of conflict between equity today and the wellbeing of future generations, complicating the political implementation of these measures. The tension can be relaxed if policymakers embed equity considerations in policy design.

Progressive taxation and transfers, for instance, will have key roles, something achievable with compensatory packages[40] and affordable alternatives to carbon-intensive goods and services.[41] Much of this can also be facilitated by innovation, be it renewable energy at competitive prices or innovations in allocating fiscal resources. Stewardship of nature should also have an equity component. As chapter 6 discusses, a new generation of bottom-up policies simultaneously targets the responsible use and protection of the environment and advancement of human development. In many cases, their success depends on empowering indigenous peoples and local communities.

Pursuing innovation to widen opportunities

The generation and diffusion of new ideas and technologies have improved people's wellbeing but have also given humanity the instruments to capture

Figure 3.6 Greater social efficiency of income (moving to the frontier) can enhance equity and ease planetary pressures



Note: The efficiency line approximates achievements in health and education at a given income, calculated using quantile regressions for the 90th percentile.
Source: Human Development Report Office based on calculations of subnational Human Development Index values by Smits and Permanyer (2019).

energy, use materials and put pressure on the biosphere that have resulted in today's unprecedented planetary imbalances.[42] Some were unintended consequences of technical change, as with synthetic fertilizers that vastly increased crop productivity but are now disrupting the nitrogen cycle. On a planet with bounded resources, ideas and the ability to use resources in ever more efficient ways have enabled human flourishing.[43] More important than any single idea or technology is the pursuit of innovation, broadly understood, in what Stiglitz and Greenwald call "learning societies."[44]

As chapter 1 discussed, shifting towards renewable energy and closing material cycles would be important manifestations of the transformational change to ease planetary pressures. For energy the goal should be decarbonization, ideally towards capturing energy directly from the sun, a limitless source of energy on human timescales. For materials the goal should be reducing waste and converging towards closed material cycles. These two goals require substantial technological innovation,[45] along with broader economic and social innovations that ultimately determine the impact of new technologies on people and planet.

"Shifting towards renewable energy and closing material cycles would be important manifestations of the transformational change to ease planetary pressures. These two goals require substantial technological innovation, along with broader economic and social innovations.

The pace of technological change, for issues ranging from artificial intelligence to gene editing, is such that new institutions that cannot necessarily be predicted in advance may be required. This is in part because science has to confront normative and value-laden issues, and the challenges of the Anthropocene bring new dimensions.[46] The process of innovation, social and technological, is likely to continue to evolve and accelerate given that our "collective brain" expands and becomes more interconnected, facilitated by digital technologies.[47] For instance, a recently identified material exhibiting superconductivity at room temperature (but at high pressure) could dramatically reduce losses in energy transmission and the need for energy storage.[48]

In fact, digital technologies may directly ease planetary pressures and advance human development, even though there are also risks, as discussed below. From mobile payments to crowdfunding, digital technology is already a critical enabler in development.[49] During the Covid-19 pandemic digital technology has proved indispensable for work, education, health care and staying connected.[50] An expanded digital sphere has also eased planetary pressures, showing a way forward if temporary changes in behaviour can become more ingrained.[51] The UN Secretary-General's high-level Task Force on Digital Finance made several recommendations to leverage digital finance for attaining the Sustainable Development Goals.[52] It concluded that digitalization will give people greater control over how global finance—their own money—is used. The democratization of finance, enabled by digitalization, could empower people by ensuring that their values are translated into how global finance is channelled, as when taxpayers hold governments to account or investors hold financial institutions to account.

Shaping economies, societies and people's wellbeing

Modern communication technologies such as the internet have taken idea sharing and the democratization of production and access to knowledge to unprecedented heights.[53] The paths that modern societies follow going forward—and their pressures on the planet—rely on these knowledge networks. Digital technologies also have direct impacts on resource use. Innovation is constantly generating new applications that, if scaled, could lower the use of energy and other resources.[54] Remote meetings and telecommuting reduce air travel and commuting, cutting down energy use and carbon emissions.

Sharing resources, such as office space, with different sets of workers rotating through the same space, improves the efficiency of energy use and the use of space and other resources. In the aftermath of the Covid-19 pandemic, the trend for offices to have a smaller presence may continue. And shared vehicles, such as Didi Chuxing, Grab, LittleCab, Lyft, Uber and Zipcar, can reduce car ownership, eventually leading to less resources needed to build cars and less fuel use.[55] Applications powered by artificial intelligence can improve energy and material efficiency. Smart appliances can considerably reduce energy use. Smart thermostats can detect when a building is occupied, learn occupants' preferences and encourage energy-efficient measures. In the United Kingdom smart heating controls in buildings could reduce carbon dioxide emissions by 1.2–2.3 percent.[56]

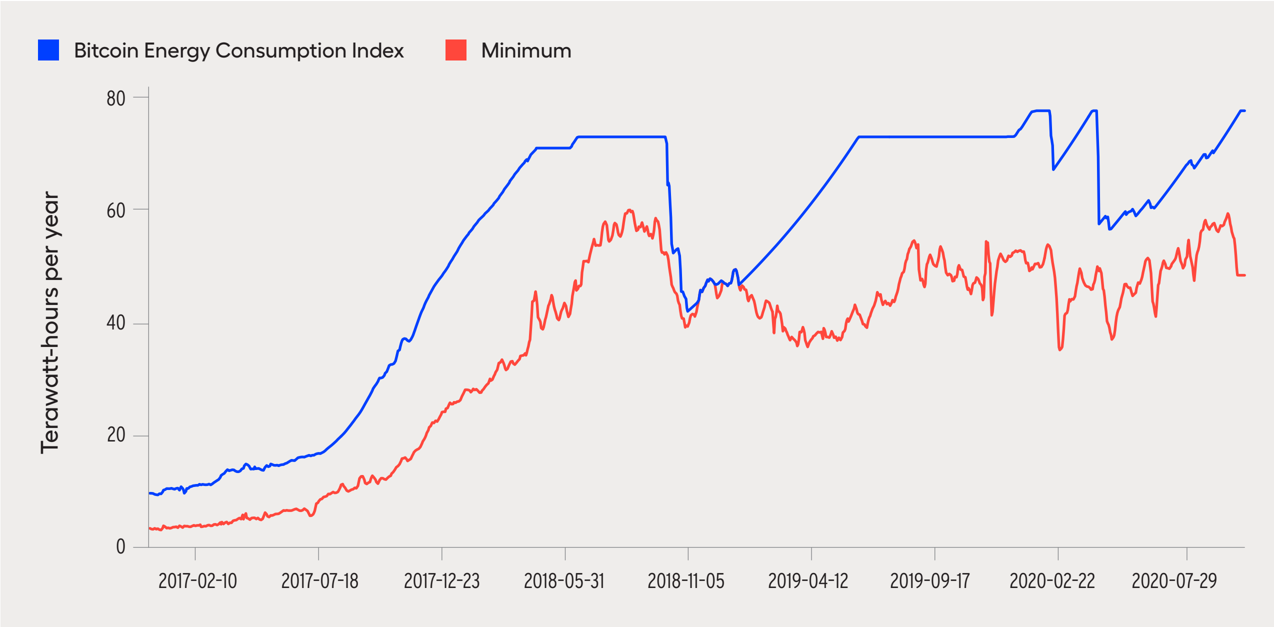
“Technological breakthroughs without changes in regulations and behaviours are not enough to ease planetary pressures. Data and artificial intelligence applications also have a big impact from their own energy use.

The sharing economy has connected excess food that would likely go to waste with food-insecure households. In high-income countries most food waste is at the retail and consumer stages. OLIO, a popular food-sharing platform in the United Kingdom, has successfully distributed 60 percent of the 170,000 listings for food items on its website, diverting a substantial amount of food from waste.[57] Artificial intelligence–based technologies can also increase recycling rates.[58] Digital technologies can monitor resource use and illegal resource extraction.[59]

A note of caution. Technological breakthroughs without changes in regulations and behaviours are not enough to ease planetary pressures. Data and artificial intelligence applications also have a big impact from their own energy use. While there is no standard method for calculating internet-related energy consumption, estimates suggest that approximately 10 percent of global electricity in 2018 was consumed by information and communication technology.[60] The carbon footprint of training a single artificial intelligence system can be as much as 284 tonnes of carbon dioxide equivalent—five times the lifetime emissions of the average car.[61] Each year global online video streaming produces as much emissions as Spain.[62] And bitcoin energy use is alarming (figure 3.7). The digital economy also makes an impact through its material footprint—large and growing—including in the form of electronic waste (see box 3.3 later in this section).

Sometimes temporary incentives are enough to redirect technical choices towards clean technologies.

Figure 3.7 Bitcoin energy use is alarming



Note: The Index contains the aggregate of Bitcoin and Bitcoin Cash (other forks of the Bitcoin network are not included). The minimum is a lower bound calculated from the total network hashrate, assuming the only machine used in the network is Bitmain's Antminer S9 (drawing 1,500 watts each; Digiconomist 2020).
Source: Digiconomist 2020.

When two technologies, clean and dirty, are relatively substitutable, an unregulated economy would head towards environmental damage because the initial productivity advantage of dirty technologies would lead profit-maximizing firms to adopt them. However, with environmental regulation, taxes and subsidies, technical change can be redirected.[63] Once clean technologies are advanced enough, firms will adopt them and invest in research and development to cultivate them further.

Beyond innovation, diffusing new technology across an economy and across international borders is crucial. Many factors are at play.[64] One challenge is to make the economic, social and political systems that embed science and technological change cognizant of planetary pressures. The next two sections zoom in on technological innovations that can support the energy transition and the closing of material cycles.[65]

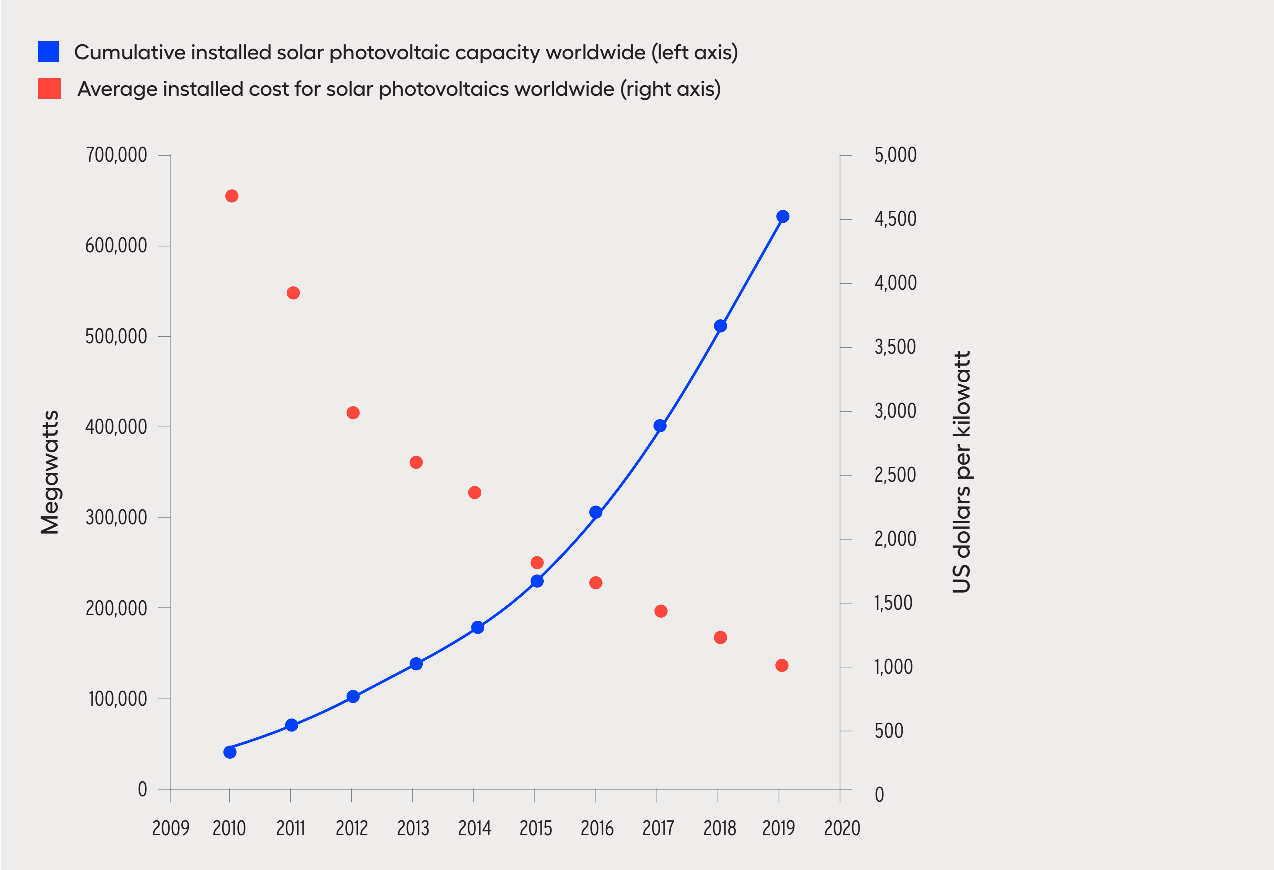
Advancing innovations for renewable energy

In 2018 the energy sector accounted for two-thirds of carbon dioxide emissions growth.[66] Switching from fossil fuel–based energy production to alternative sources requires new technologies and the diffusion and adaptation of existing technologies. Switching from mainstream established energy production can be challenging. Governments and investors with a long-term horizon can invest in new promising technologies, bringing them close to the point where they can compete in price with incumbent technologies. This is an example of a sensitive intervention point.[67]

Solar photovoltaics

Take investments in solar photovoltaics.[68] Deployment has clearly resulted in falling costs, and public policies could accelerate progress by neutralizing resistance to change based on economic costs.[69] The real cost of photovoltaic modules has dropped by more than a factor of 6,000 since 1956—and by 89 percent since 2010 (figure 3.8).[70] If their deployment continues to increase at the current rate, its price is likely to fall considerably.[71] In addition, the right sequence of policies can create political conditions for more ambitious climate policies in subsequent rounds of debate and policymaking,[72] as in California and the European Union, where policymakers first supported low-carbon technologies and

Figure 3.8 The real cost of photovoltaic modules has dropped 89 percent since 2010



Source: IRENA 2019b.

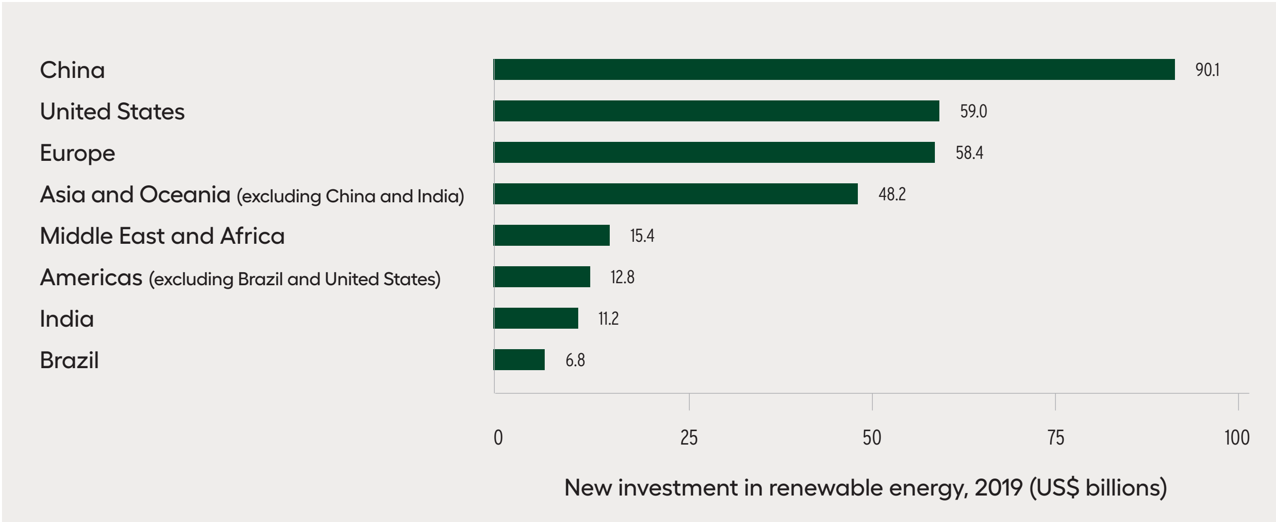
then carbon trading schemes.[73] And across the world, national policymaking has taken up the charge for promoting renewable energy (figure 3.9).

In 2008 India launched the National Action Plan on Climate Change, a sensitive intervention point because it was a formal recognition of the threat of climate change and the need to act at home, even as international negotiations were ongoing.[74] Under the Paris Agreement, India pledged to reduce the emission intensity of its GDP from the 2005 level by 33–35 percent by 2030 and to obtain 40 percent of electric power capacity from non–fossil fuel sources by 2030.[75] As part of the plan, the National Solar Mission aims to promote solar energy for power generation and other uses to make solar energy competitive with fossil fuel–based options.[76] Solar capacity in India increased from 2.6 gigawatts in March 2014 to 30 gigawatts in July 2019, achieving its target of 20 gigawatts four years ahead of schedule.[77] In 2019 India ranked fifth for installed solar capacity.[78]

Complementary storage and smart grids

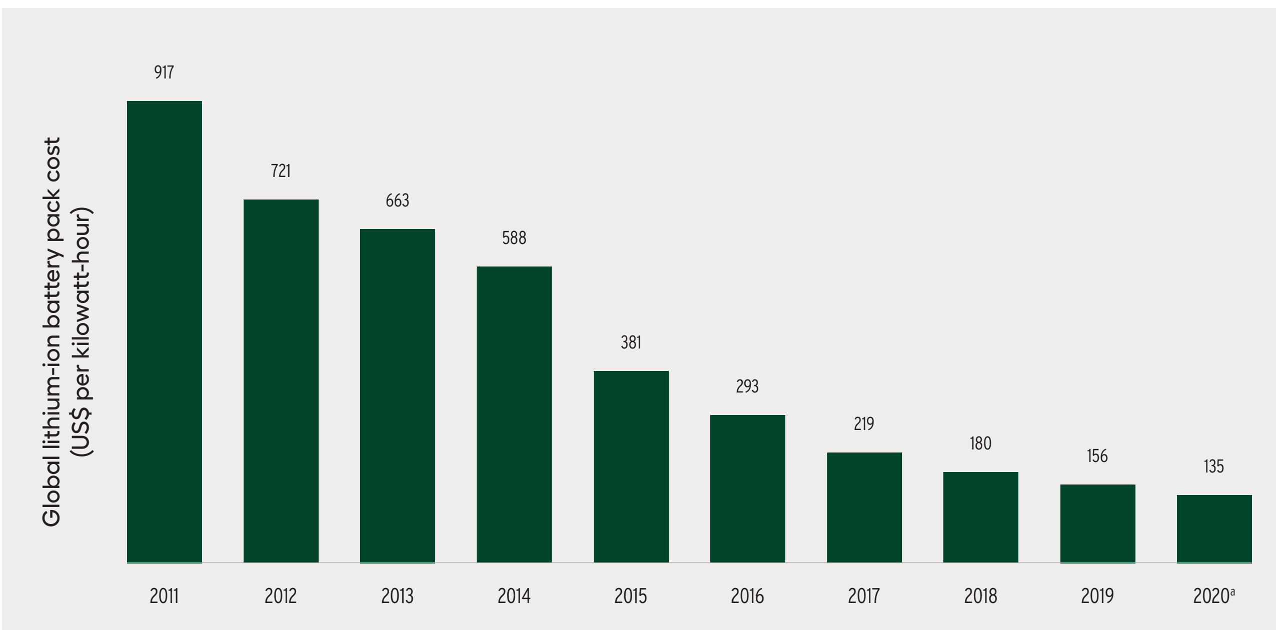
With solar, wind and other intermittent sources of energy, complementary technologies such as storage systems (including lithium-ion batteries) are important—and here too prices are falling (figure 3.10). Integrating renewables in the mix of energy sources requires smart electric grid transmission systems that can integrate renewable and conventional sources of supply.[79] Smart grids are "electricity networks that can intelligently integrate behaviour and actions of all users connected to it—generators, consumers and those that do both—to efficiently deliver sustainable, economic and secure electricity supplies."[80] This involves a host of technologies, including smart meters, that measure output and consumption in real time, and algorithms to share and manage the data to unlock efficiency gains.[81]

Figure 3.9 Across the world, national policymaking has taken up the charge for promoting renewable energy



Source: REN21 2020.

Figure 3.10 Lithium-ion battery prices fell between 2011 and 2020



a. Estimated.
Source: Statista 2020d.

Electricity markets may also need to be redesigned.[82] Nowadays, the price of electricity typically does not vary with supply and demand over short timeframes, but variable pricing (which adjusts frequently, even within the same day, in response to changes in demand and intermittent supply) may be more appropriate for systems that have a high share of energy from renewables.[83]

Despite these advances and future potential, challenges persist. The political economy of displacing established sources, such as coal-based power generation, is complex.[84] Economic growth will continue to put upward pressure on total energy demand and emissions. Energy efficiency is crucial in mitigating the rise of greenhouse gas emissions from the expanding pace of worldwide energy demand.[85]

But in 2018 primary energy intensity improved by just 1.2 percent, the slowest rate since 2010.[86] And as the technology frontier expands, access to the latest technologies by developing countries becomes ever more relevant. Developing countries face a dual challenge: Many of them are still working towards universal access to electric power while moving towards renewable energy. There are many impediments to accessing solar photovoltaics, batteries and smart grids. Financing (chapter 5) and intellectual property regimes[87] will be key to deploy these technologies at scale in developing countries.

> "With solar, wind and other intermittent sources of energy, complementary technologies such as storage systems (including lithium-ion batteries) are important—and here too prices are falling.

Negative emissions technologies

Technological solutions have also been proposed for directly capturing carbon dioxide from the atmosphere—with negative emissions technologies, such as carbon capture and storage.[88] Some involve storing atmospheric carbon dioxide in geological formations.[89] Despite considerable research, carbon capture and storage have not been widely deployed due to a range of technical, economic and commercial challenges.[90] The UK Committee on Climate Change finds that the cost of meeting the United Kingdom's 2050 targets will be twice as high without carbon capture and storage as it would be with them.

Another negative emissions technology, bioenergy with carbon capture and storage, requires growing plant biomass to sequester carbon dioxide from the atmosphere, harvesting the biomass and burning it for energy, while capturing the carbon dioxide emissions from the power stations and storing the waste underground. The Intergovernmental Panel on Climate Change scenarios consistent with representative concentration pathway 2.6 (RCP 2.6), which offers the best chances of staying below the 2 degrees Celsius limit, rely on bioenergy with carbon capture and storage drawing excess carbon dioxide from the atmosphere in the second half of the century.[91]

Direct air capture requires stripping carbon dioxide out of the atmosphere with renewably powered open-air chemical engineering.[92] This idea is being implemented in experimental installations in Canada and Switzerland. One issue is that it requires a substantial amount of energy and water.[93]

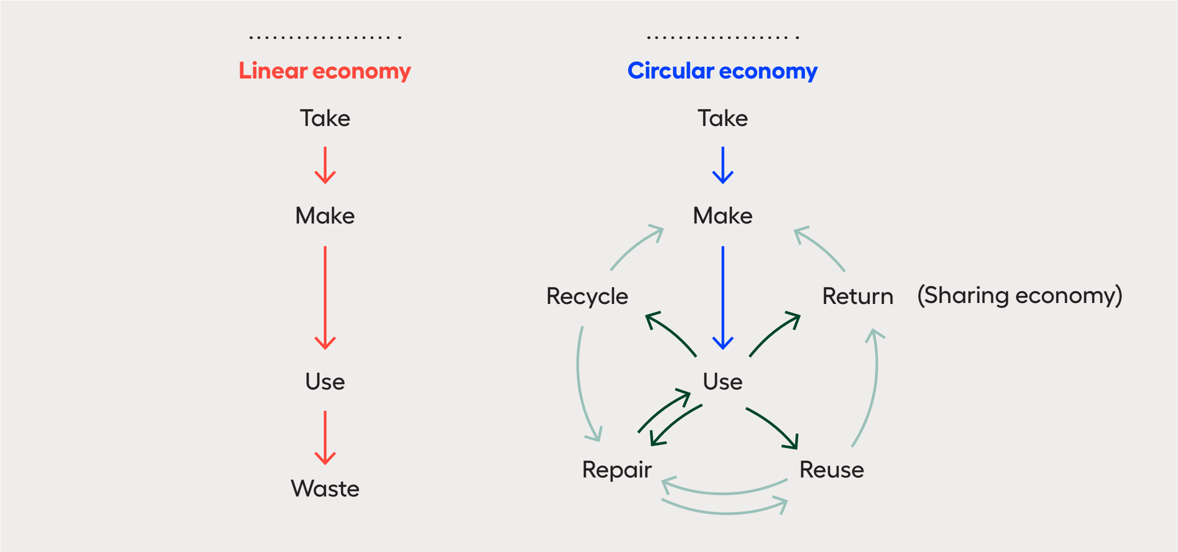
As they currently stand, these technologies face scepticism and concerns that their claims on land use could compete with food production, drive biodiversity loss and deplete water.[94] Ultimately, the potential of negative emissions technologies will depend on adopting a portfolio of approaches (since relying on a single solution—such as bioenergy with carbon capture and storage—increases the risk of limited feasibility) and of further scientific and technical advances, which can be encouraged with structured incentives for innovation.[95]

Closing material cycles: The potential of circular economies

A circular economy can be key to decoupling production from planetary pressures.[96] Unlike the dominant linear extractive industrial approaches, circular principles require closing loops through reuse and recycling all along the supply chain to form circular supply chains (figure 3.11).[97] According to the European Commission, "the transition to a more circular economy, where the value of products, minerals and resources is maintained in the economy for as long as possible, and the generation of waste minimized, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy."[98] But strong incentives for a circular economy cannot simply displace linear economy activities to places lacking those incentives. For instance, firms headquartered in countries with strict environmental policies might perform their polluting activities abroad in countries with weaker policies, with evidence suggesting that when this happens, it is driven primarily by an incentive to avoid tight environmental policies in home countries rather than by purposefully pursuit of places with lenient environmental policies.[99]

> "Strong incentives for a circular economy cannot simply displace linear economy activities to places lacking those incentives.

Figure 3.11 How the circular economy differs from the linear



Source: Human Development Report Office.

Consider food systems. Nitrogen, phosphorus and potassium are essential for food production and life. About half the world's food production depends on mineral micronutrient fertilizers.[100] For the most part these fertilizers have been used with little consideration of their disruptive effects on biogeochemical cycles and even the local environment. Take nitrogen. The Earth's natural nitrogen cycle, with robust feedback and controls, is steered by a suite of microbial processes.[101] Providing the world's food supply disrupts that cycle, as noted in chapter 1. The use of nitrogen fertilizer increased by about 800 percent from 1960 to 2000, with its application to grow wheat, rice and maize accounting for half that.[102]

It was a technological breakthrough, the Haber-Bosch industrial process developed in the early 20th century, that enabled the production of ammonia, a chemically reactive, very usable form of nitrogen, to be synthesized using atmospheric nitrogen,[103] heralding the age of large-scale production and application of agricultural fertilizers.[104] Since the introduction of the process, reactive nitrogen in the Earth system has increased 120 percent over the Holocene baseline. As noted earlier in the Report, this influx has had the largest impact on the nitrogen cycle in 2.5 billion years.[105]

This reactive nitrogen largely ends up in nitrogen-limited ecosystems, leading to unintentional fertilization, loss of terrestrial biodiversity and lower quality surface and ground waters in coastal ecosystems.[106] Added to this are nitrogen oxides from fossil fuel combustion.[107] Globally, 4 million new paediatric asthma cases a year are attributable to nitrogen dioxide pollution, 64 percent of them in urban centres.[108]

> "Opportunities for efficiency gains can be explored along the entire food chain —from more efficient use in cropping to reducing postharvest losses in storage.

But with much leakage and inefficiency at every stage, the potential for improvement is great.[109] In 2005 about 100 teragrams of nitrogen was applied in global agriculture, though humans consumed only 17 teragrams in crop, dairy and meat products.[110] The efficiency of nitrogen use for main crops is below 40 percent.[111] Most applied fertilizer is washed out or lost to the atmosphere. And a lot of agricultural output is simply wasted. Food waste accounts for 8 percent of global anthropogenic greenhouse gas emissions, 20 percent of freshwater consumption and 30 percent of global agricultural land use.[112] Opportunities for efficiency gains can be explored along the entire food chain—from more efficient use in cropping to reducing postharvest losses in storage. This extends to boosting the efficiency of food consumption patterns and improving the treatment of human and animal waste. Helpful approaches include some time-tested practices such as systematic crop rotation. For example, in maize production legume cropping supplies the nitrogen that would otherwise be provided by synthetic fertilizers.[113]

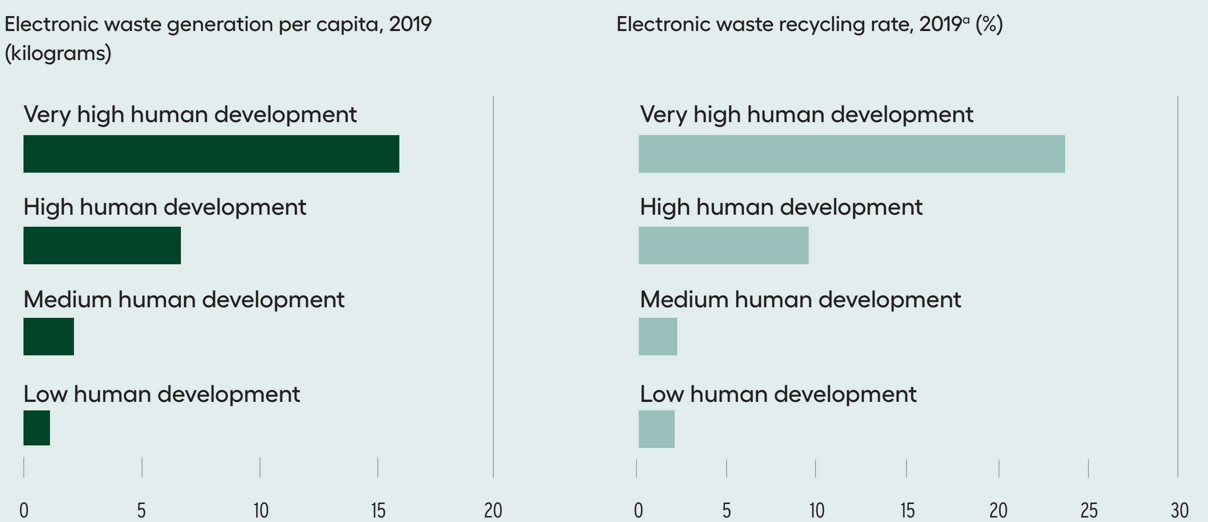
More generally, improving agricultural efficiency requires a broad range of innovations, encompassing also new food production processes (including precision agriculture).[114] Technologies could be harnessed to understand the current state of affairs (perhaps through satellite-based observation) and to advance efforts to reduce planetary pressures. Targeted breeding for old and new crops could provide reasonable avenues to meet human needs.[115] Dietary shifts could increase the efficiency of agricultural input use.[116]

This example shows the potential in food systems to move from a linear approach that begins with exploring and processing and ends with applying fertilizer towards a circular economy that could help close the cycle of resource use.[117] This potential is more broadly

Box 3.3 The potential in recycling electronic waste

Electrical and electronic equipment consumption is increasing by 2.5 million tonnes a year. After being used, it is disposed of as electronic waste (e-waste), a waste stream that contains hazardous as well as valuable materials. In 2019, 53.6 million tonnes of e-waste was generated globally, or 7.3 kilograms per capita. Fuelled by higher consumption, short lifecycles and few repair options, global e-waste has grown steadily, projected to double between 2014 and 2030.[1] Recycling is not keeping pace with the growth of e-waste (see figure). In 2019, 17.4 percent of e-waste was recycled globally, with variation across regions; the rest has adverse health and environmental impacts. In many countries e-waste is handled by informal sector workers, under inferior working conditions. There are also health impacts on children who live, work and play near e-waste.[2]

E-waste generation and recycling rates vary widely



a. Estimates are based on limited cases.
Source: Human Development Report Office calculations based on United Nations Statistics Division (2020a).

In 2019 the value of raw materials in e-waste, including iron, copper and gold, was about $57 billion, roughly $10 billion of which was recovered through recycling.[3] Recovering some materials, such as germanium and indium, is challenging because of their dispersed use in products. Collecting and recycling e-waste can be economically viable for products with higher concentrations, but recycling rates are very low. For one, base metals such as gold, used in mobile phone and personal computers, have a relatively high concentration, about 280 grams per tonne of e-waste. But products are typically neither designed nor assembled with recycling in mind.

Notes
1. Forti and others 2020. **2.** Forti and others 2020. **3.** Forti and others 2020.

applicable to how societies extract and use resources (see box 3.3 for an example using e-waste). And as the German *Energiewende* (energy transition) illustrates, transitions of this nature call for government leadership and incentives.[118] Investing in new technologies and, through deployment, rendering them more competitive are essential parts of the process—in fact, sensitive intervention points[119]—but ones that need to be embedded in broader and more fundamental economic and social changes. That is why it is important to pursue innovation along with enhancing equity and stewardship of nature—to which we now turn.

Instilling a sense of stewardship of nature

Can you imagine a world where nature is understood as full of relatives not resources, where inalienable rights are balanced with inalienable responsibilities and where wealth itself is measured not by resources ownership and control, but by the number of good relationships we maintain in the complex and diverse life systems of this blue green planet? I can.

From the introduction to *Climate Change and Indigenous Peoples in the United States*[120]

The Human Development Report has a long tradition of thinking beyond the basic needs of people and how expanded freedoms, for everyone, align with stewardship of nature. The 2008 Human Development Report explored stewardship of the planet as a central pillar of a long-term inclusive solution for climate change.[121] We again take up empowering people through stewardship of nature—also referred to as environmental stewardship—as the responsible use and protection of the natural environment through conservation and sustainable practices to enhance ecosystem resilience and human wellbeing.[122] This stewardship is coupled with ambitions of social justice and expanded freedoms and control over people's own lives for current and future generations.

Stewardship can be supported by considering philosophical perspectives that value both thriving people and a thriving planet. This requires understanding how the relationship is and has been manifest in philosophical traditions, ancient knowledge (sometimes codified in religions and taboos) and social practices. Many religions around the world and over time—including Buddhism, Christianity, Hinduism, Islam and Judaism—have developed complex views of intergenerational justice and shared responsibility for a shared environment. The Quaranic concept of "tawheed," or oneness, captures the idea of the unity of creation across generations. There is also an injunction that the Earth and its natural resources must be preserved for future generations, with human beings acting as custodians of the natural world.[123] The encyclical Laudato Si, issued in 2015, provides a Christian interpretation that speaks also to our embeddedness in nature and the notion of the planet as our common home, which we have a moral obligation to protect.[124]

Recognizing our humanity as part of a larger network of connections that include all living things is part of philosophical traditions worldwide.[125] These perspectives can help us rethink and reshape our places in this world. For many indigenous peoples, flourishing communities are grounded in equitable and sustainable relationships. Wellbeing and development begin where our lives with each other and with the natural environment meet. These intersections generate responsibilities for remembering and learning from the past and for creating equitable and sustainable conditions now and for the future. In Aotearoa, New Zealand, Māori philosophies ground the naming of Te Awa Tupua (the Whanganui River) and Te Urewera (previously a national park) as legal entities with rights.[126] At the root of rights of nature movements globally is the contention that navigating our complex responsibilities to people and other living things is fundamental to understanding ourselves and to leading lives we have reason to value.

"Recognizing our humanity as part of a larger network of connections that include all living things is part of philosophical traditions worldwide. These perspectives can help us rethink and reshape our places in this world.

Such understandings are not confined to indigenous communities. From global youth climate justice movements to local environmental protection and low-carbon initiatives—recognizing human–nature relationships can be found in communities and socioenvironmental movements worldwide. These renewed perspectives create space for us to reweave our intimate, caring connections with nonhuman-natures

Box 3.4 Human–nonhuman natures: Broadening perspectives

By Melissa Leach, Director, Institute of Development Studies, United Kingdom

A rethinking of our humanity can include its co-construction with nonhuman natures. This recognizes the intimate interconnectedness of human lives with all living things, their dynamism and agency, whether in our bodies, our homes or our communities; in landscapes and ecologies; and in biophysical processes extending up to the planetary, even cosmological scale. As recognized in growing bodies of work in multispecies ethnography[1] and "more than human" geography,[2] these interrelationships are often intimate, affective, emotional and embodied. They are important to our individual and collective senses of ourselves, wellbeing and identities as well as to the status and future of the plants, animals and other aspects of nonhuman nature with which they are inextricably entwined. Intersecting with advances in ecological and animal science that recognize modes of intelligence and communication among plants and animals, with each other and with humans, these perspectives in effect redefine humanity as part of nature, or at least as part of interconnected socionatural networks or assemblages[3] that question the boundaries between the human and the nonhuman.

It is important to avoid "othering" such perspectives into so-called indigenous societies and cultures. While understandings of human–nonhuman natures as deeply, intimately interconnected and their importance to human thriving and identity are sometimes most obviously found among such groups in the Amazon, Asia-Pacific region and beyond, they are by no means confined there. Among Māori people today, for instance, the dynamic agency that entwines human and nonhuman action extends to views of capabilities and rights, and court cases involving trees and rivers as claimants and rightsholders are commonplace. But there are plenty of similar cases in European history (the celebrated trial of a pig for murder in 15th century Britain is a well documented example[4]). And were we to think that these are outdated notions of the past, look at how people in so-called modern industrial societies relate to their pets,[5] accuse particular dogs of viciousness or attacks, engage with their garden plants and the animal life in cities and seek to protect particular, individual trees from road developments. In these examples[6] elements of nonhuman nature have personalities and communicative capacities, and people develop intimate connections with them that are important to their humanity.

One implication of these perspectives is the questioning of the widespread disconnection that results when "modern" Cartesian scientific and industrial cultures divide the human and the nonhuman. This disconnect underpins seeing nature as generalized "environment," "biodiversity" and "natural capital"—separate from humans and thus able to be commoditized, priced or exploited.[7] Instead, the new perspectives invite us to reweave our intimate, caring connections with nonhuman natures in all their characters and capabilities.

Notes

1. For example, Kirksey and Helmreich (2010), Lock (2018) and Locke and Muenster (2015). **2.** Dowling, Lloyds and Suchet-Pearson 2017. **3.** Haraway 2016. **4.** Cohen 1986; Sullivan 2013. **5.** Haraway 2003. **6.** Dowling, Lloyds and Suchet-Pearson 2017. **7.** More intertwined perspectives on human–nonhuman natures bring an important counter to views of nature as provider of discrete services as well as of current market logics in environmental governance for conservation and sustainability, which then disaggregate nonhuman natures into discrete units to which monetary value can be attached (Sullivan 2013).

in all their characters and capabilities (box 3.4). In doing so, they highlight the urgency and centrality of environmental concerns, the value of diverse knowledge and the need for local and global solutions. By transforming the way we think about our places in this world, these movements bring into focus how human flourishing concerns people, connected to each other, to nonhuman nature and ultimately to this planet. The magnitude and urgency of dangerous planetary change that we confront today require a broad response to reconnect with some of that knowledge.

Nurturing stewardship of nature

The vast literature on environmental stewardship provides frameworks and recommendations that are a helpful starting point.[127] Nathan J. Bennett and colleagues propose three fundamental elements—motivations, capacities and agents—that "are influenced by the socioecological context and that converge to produce both environmental and social outcomes" (figure 3.12).[128] These three elements can be explored through the lens of human development and agency.

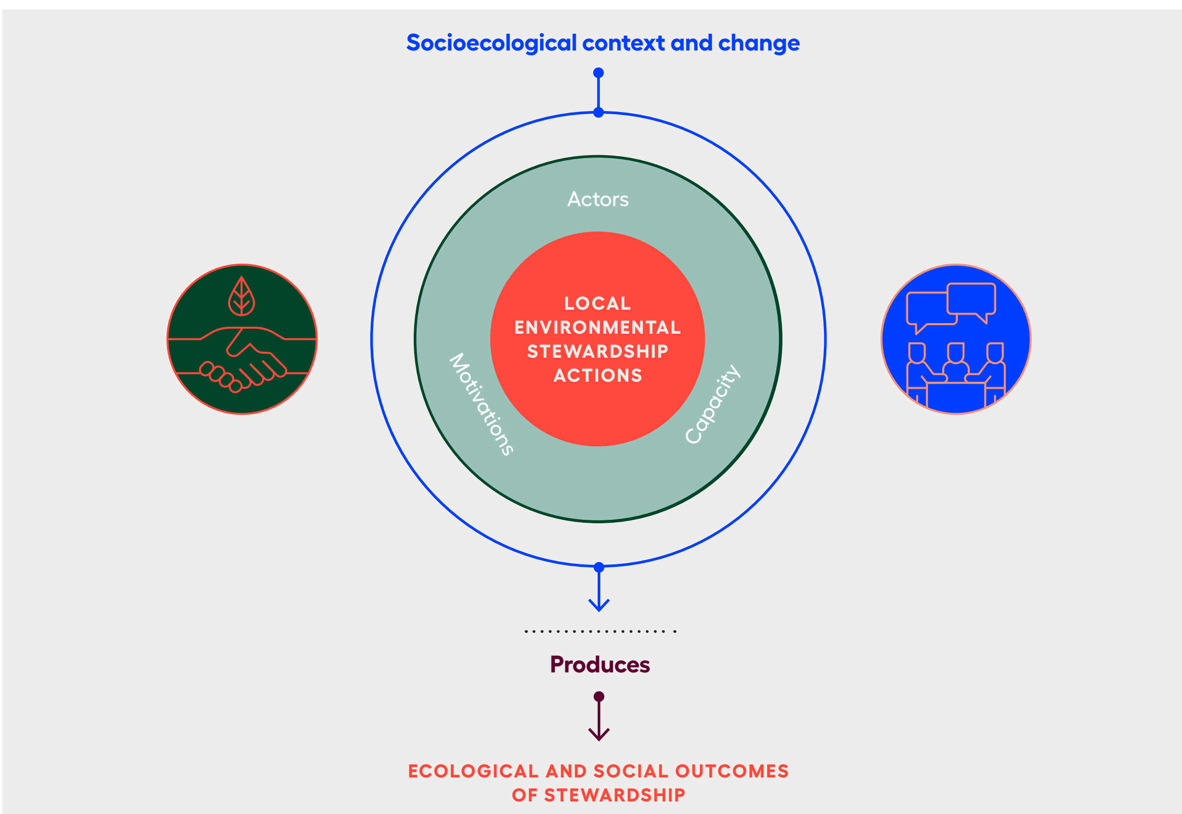
For motivation there are two different but related ways to understand why we as humans should take care of the planet: intrinsic and extrinsic. Intrinsic motivations refer to the reasons associated with individual and collective wellbeing. They are closely related to belief systems and our fundamental values about what it means to live well. Extrinsic motivations are linked to external rewards or sanctions, be they social, legal or financial, as well as the evaluation of costs and benefits of stewarding the planet.

Intrinsic and extrinsic motivations are analytical categories because individuals, communities and societies have a mix of both. Separating them, though, allows identifying roadblocks and opportunities for strengthening the overall motivation in different contexts. Identifying the external and internal drivers and reasons to protect the environment also speaks to the concept of human development and agency, where a given development outcome, say education, is valued not only for its external rewards—employment and salaries—but also as something in itself, as a positive freedom.

There are several examples of both types of motivation to protect the planet. Illustrations of intrinsic motivation could refer to religious beliefs (briefly described above). Others to how indigenous peoples and other local communities have managed their relationship with natural entities. Indigenous socioenvironmental movements, grounded in indigenous philosophies, have become political signifiers able to express our shared humanity.[129] These philosophies are grounded in a profound respect for each other and the natural world. These movements place human–nature relationships at the centre. Such a relational approach draws out the interdependence of all things for wellbeing and the reciprocal relationships among people and between people and the planet.

In Aotearoa, New Zealand, the notion of "whakapapa" (to place in layers) sets out the connections among people, ecosystems and all flora and fauna.[130] The practices of "manaakitanga" (to care for) and "kaitiakitanga" (multispecies and intergenerational

Figure 3.12 A conceptual framework for local environmental stewardship



Source: Bennett and others 2018.

trusteeship) play key roles in articulating the responsibilities that fall out of these relationships.[131] These and other core concepts shape and centre collective responsibilities to protect and enhance socioenvironmental relationships.[132] Māori health models such as Te Whare Tapa Whā frame health and wellbeing around physical, spiritual, community and psychological dimensions.[133] Such multidimensional and community-engaged understandings of health continue to inform the delivery of health services and health policy in Aotearoa.[134] Other programmes of work build community and cultural capability to drive transitions to low-carbon futures.[135] A large part of their work is to detail the various ways in which local communities and relationships between people and the environment can be enhanced and protected through land and water development initiatives. The needs and aspirations of communities guided by intergenerational principles and practices seek to secure pathways towards sustainable and just futures.[136]

> “In Aotearoa, New Zealand, the notion of ‘whakapapa’ (to place in layers) sets out the connections among people, ecosystems and all flora and fauna. Fundamental to the Quechua concept of ‘Sumac Kawsay’ (good living) is reciprocity, relationality and ‘a profound respect of the differences (and an emphasis on the complementarities) among human beings and between human beings and the natural environment.’

Indigenous philosophies in Australia take as vital “collective responsibility and obligation to look after land, family, and community.”[137] For the Yawuru community of Broome in Western Australia, wellbeing and development refer to the interconnectedness of “mabu buru” (strong country), “mabu ngarrungu” (strong community) and “mabu liyan” (strong spirit or good feeling).[138] Intergenerational transmission of knowledge and practice, as well as reciprocal sharing of gifts from lands and waters, exemplifies these connections. But these connections depend heavily on the freedom of the Yawuru to live in ways they value and to carry out these responsibilities.

The Anishinaabe concept of “Minobimaatisiiwin” (the good life) is similarly grounded in connections and the need for cooperation and justice among all beings.[139] The continuation of creation—and the relationships central to responsibilities to creation and re-creation—stem from the way all beings of Creation have duties and responsibilities to each other.[140] We see this philosophy in socioenvironmental movements and in governance and law.[141] According to Aimee Craft, Anishinaabe law and treatymaking are centrally about relationships and relationship-building, understood to include “relationships among and between ourselves, [as well as] relationships with other animal beings.”[142]

Fundamental to the Quechua concept of “Sumac Kawsay” (good living) is reciprocity, relationality and “a profound respect of the differences (and an emphasis on the complementarities) among human beings and between human beings and the natural environment.”[143] Similarly, “Ayni” (reciprocity) is “one of the most important tenets for the Andean people and is exemplified in the adage “what is received must be returned in equal measure.”[144] According to Mariaelena Huambachano, these and other concepts enabled and ensured that Inca agricultural systems were grounded in sustainable production methods and food security.[145]

External incentives, where care of and respect for the Earth bring additional benefits, are also well documented. These include payments to enable certain management actions, payments for ecosystem services and market premiums for more environmentally sustainable products (chapter 5).

Beyond motivations, the environmental stewardship framework includes agents’ capacity to actually undertake stewardship actions. This ability of people and communities to conduct specific activities in benefit of the planet will depend on the communal and individual assets—including infrastructure, technology, financing, income and wealth, rights, knowledge, skills, leadership and social relations—at their disposal as well as the decisionmaking structures within and across communities and groups.

Governance, understood as the process for state and nonstate actors to interact to reach and sustain agreements, is of particular importance.[146] These interactions shape and are being shaped by the distribution of power, as analysed earlier in this chapter and in chapter 2 (the agreements reached are typically called institutions). And wherever power imbalances are present, the poorer members of society end up losing more. The 2019 Human Development Report explored the elite capture of institutions, where the ability of government policy to address inequalities is constrained by powerful interest groups.[147] The policy outcomes then reflect the distribution of power in society. That is why enhancing equity, as underlined earlier in this chapter, is key.

“Reflecting the connectedness between nature and humanity, indigenous Hawaiians developed and applied a model for sustainable resource management, the ahupua'a system, designed more than 500 years ago to prevent overfishing and deforestation.

Again, there are lessons about governance from indigenous peoples. Making decisions in sync with the planet is part of indigenous cultures around the world—and it is the result not of chance but of finely tuned knowledge accumulated over long periods. Indigenous communities developed a deep understanding of their natural world to survive and ensure that it would provide resources in the future. This need to live sustainably is reflected in many practices and traditions that promote a general philosophy of subsistence not waste. In North America the Iroquois expected that a hunter who killed more deer than needed would be punished for it.[148] The Maasai pastoralist culture in East Africa has “always been one that has nurtured the land and used only the resources that were needed for the people. Abuse of the land or its animals and plants was frowned upon in the old days and still is by elders today.”[149]

Reflecting the connectedness between nature and humanity, indigenous Hawaiians developed and applied a model for sustainable resource management, the ahupua'a system, designed more than 500 years ago to prevent overfishing and deforestation. Many other indigenous communities arrived at a similar concept of connectedness and used it to develop careful land and water use practices—and development approaches more generally.[150]

Other practices are more specific and demonstrate a profound knowledge of natural resources and sophisticated management practices, as with Amazonian communities that, to maintain healthy river ecosystems, “fish only for particular species in certain oxbow lakes at determined times of year. They also avoid certain parts of the rainforest altogether, ensuring that wildlife have a refuge where they can reproduce.”[151] In Central Africa, when the Ba'aka dig up wild yams they return the stems to the ground so that the yams grow again. And they restrict “what you can hunt, when you can hunt it, who can hunt it … a whole area of forest can be closed off from hunting or gathering activities in order to let it rest.”[152]

These practices demonstrate a commitment to what Kyle Whyte refers to as “Collective Continuance” or “a community's capacity to be adaptive in ways sufficient for the livelihoods of its members to flourish into the future.”[153] Not only does this require the capability to respond and adjust to changes as they arise, it also requires the ability to contest longstanding inequities (such as colonial hardships) and to build strong and cohesive relationships at all levels of engagement.

Promising initiatives link international law with indigenous communities through human rights. The International Labour Organization has led the global push for international law to recognize indigenous peoples' participation in decisions that affect them. Important advances have occurred in the context of Convention 169 on Indigenous and Tribal Peoples, adopted in 1989. Article 15 refers specifically to the participation rights of indigenous and tribal communities in managing and conserving the natural resources traditionally associated with them. The first element of the article reads, “The rights of the peoples concerned to the natural resources pertaining to their lands shall be specially safeguarded. These rights include the right of these peoples to participate in the use, management and conservation of these resources.”[154]

Convention 169 demonstrates how different stakeholders' voices are given prominence through changes in decisionmaking processes—and is even more relevant since it refers to the rights of groups historically marginalized and discriminated against. And although much remains to be done to guarantee the rights of indigenous and tribal peoples—especially in societies with deep-seated inequalities—the convention has contributed. Under Convention 169, free, prior, informed consent responds to demands for self-determination, dignity and cultural integrity in international recognition of indigenous peoples' rights. It seeks to “regulate and operationalize the participation of indigenous peoples in environmental decisionmaking and political processes on questions where their interests are directly affected." While free, prior, informed consent is a welcome development in participatory processes, it still raises concerns and challenges. An adequate bottom-up approach would recognize indigenous peoples' right to self-determination while allowing the state to mediate and solve conflicts, strengthen local representative and democratic institutions, recognize existing national legislation and solve any contradiction emerging from the process. Moreover, free, prior, informed consent is not immune to elite capture, and with large power imbalances it can be detrimental.[155]

Knowledge is central to stewardship, and an opportunity exists for interchange between the types of knowledge just described and some of the tools of science. Recognizing both forms of knowledge can promote rich interactions and can give rise to relationships of trust able to navigate the shared opportunities and challenges that arise. This convergence of knowledge has been described variously, including as two-eyed seeing,[156] "He Awa Whiria"[157] and "Haudenosaunee Kaswentha."[158] As Priscilla Wehi notes, the convergence of multiple knowledges "can yield more comprehensive and detailed information" and "provides a strong ecological basis to quantify new hypotheses of ecological functioning, and add to the detailed information required in both conservation practice and restoration ecology."[159] We find such work undertaken by and with indigenous (and other local) communities all around the world.[160] This ongoing work remains critical since much of it must be undertaken on indigenous peoples' homelands.

Empowering agents as stewards

Stewardship of nature requires the commitment and will of billions of people around the world—from the communities and societies they construct, including leaders in every realm of society. It can unleash a new sense of agency and responsibility through a connection with nature, with the planet and with all living things. As Tim Lenton writes in spotlight 1.2, "To meet the challenge of expanding human freedoms in balance with the planet, there will surely need to be much learning-by-doing. Innovation usually happens from the 'bottom up,' driven by human agency at small scales, and with the scope to spread if successful."

"Stewardship of nature requires the commitment and will of billions of people around the world—from the communities and societies they construct, including leaders in every realm of society.

Amartya Sen defines an agent as someone "who acts and brings about change, and whose achievements can be judged in terms of his or her own values and goals, whether or not we assess them in terms of some external criteria as well."[161] Sen has also argued that rethinking the relationship of people and the planet requires new ways of thinking, including recognizing agency as a central tenet. In his own words, "We must think not just about sustaining the fulfilment of our needs, but more largely about sustaining, and extending, our freedoms (including, of course, the freedom to meet our own needs, but going well beyond that). The sustaining of ecosystems and the preservation of species can be given new grounds by the recognition of human beings as reflective agents rather than as passive patients."[162] Sen's argument focuses on people's ability to act on their own volition and reasoning—and on what people have reason to value. It puts at the centre people, their freedoms and their capacity to be an agent of change.

Stewards could be individuals or a group organized at different scales. Their actions can occur at different levels (community, ecosystem, national or even global) and depend on capacities and institutional context. The examples described here suggest myriad possibilities for stewardship, reflecting the complex interaction between humans and the planet. Several levers could be harnessed to expand stewardship, including limiting the harvest of a species, establishing marine protected areas, managing comprehensive watersheds, and creating and maintaining urban green spaces and gardens (see chapter 6 on the potential of this type of interventions). Broader initiatives could span transboundary and regional scales. Successful stewardship requires not only motivated actors with the capacity to push the agenda but also a clear follow-up system in which metrics can evaluate social and environmental justice outcomes and provide the basis for learning and innovation.

Learning from sustainability science to guide sustainable human development

Andrea S. Downing, Stockholm Resilience Centre at Stockholm University and Global Economic Dynamics and the Biosphere programme at the Royal Swedish Academy of Sciences; **Manqi Chang,** Department of Aquatic Ecology at the Netherlands Institute of Ecology; **David Collste,** Stockholm Resilience Centre at Stockholm University; **Sarah Cornell,** Stockholm Resilience Centre at Stockholm University; **Jan. J. Kuiper,** Stockholm Resilience Centre at Stockholm University; **Wolf M. Mooij,** Department of Aquatic Ecology at the Netherlands Institute of Ecology and Department of Aquatic Ecology and Water Quality Management at Wageningen University; **Uno Svedin,** Stockholm Resilience Centre at Stockholm University; and **Dianneke van Wijk,** Department of Aquatic Ecology at the Netherlands Institute of Ecology

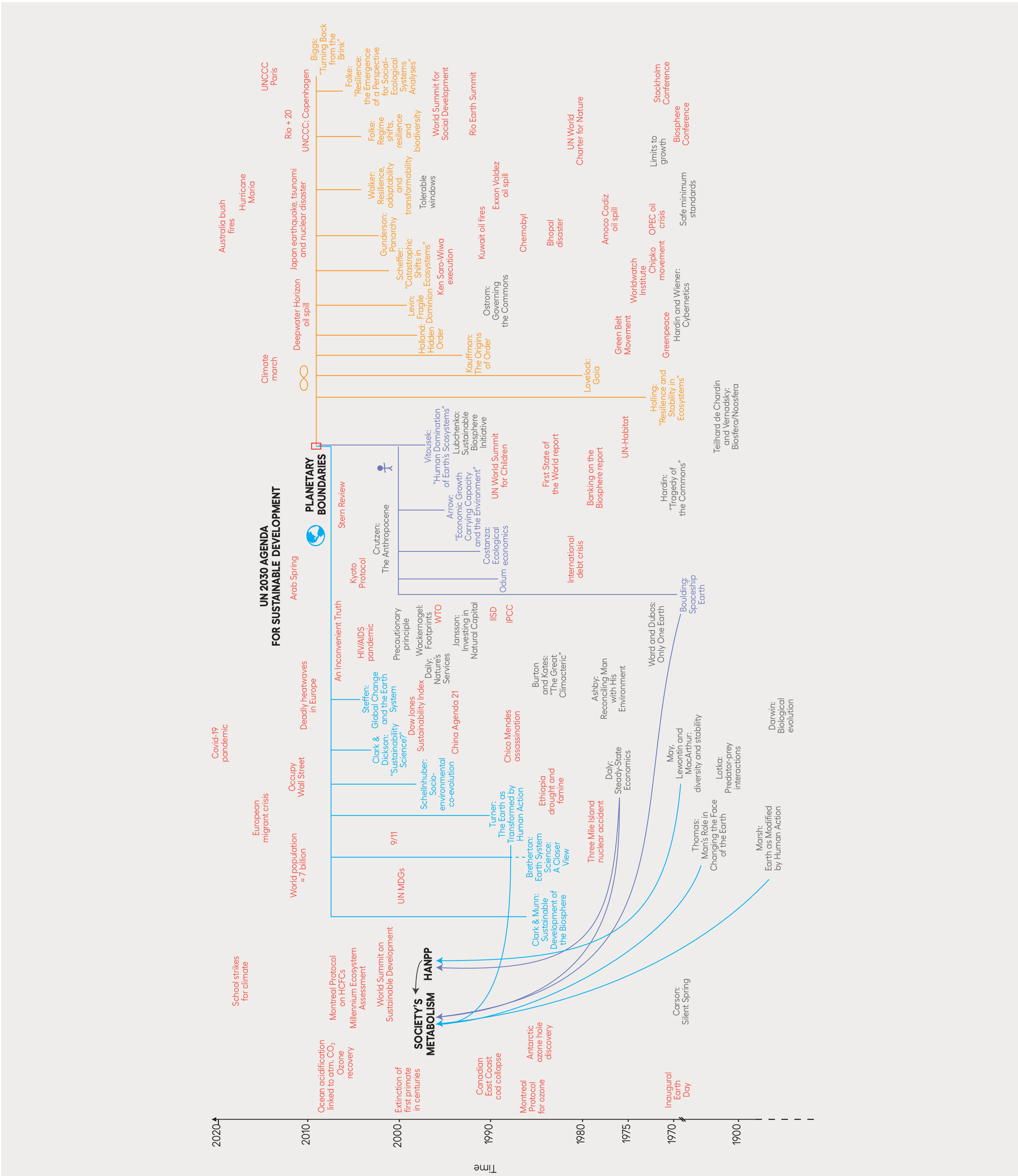
The 1960s mark a slow turning point for the "Western" world and international development in recognizing and understanding the interconnections among human wellbeing, the economy and the environment. In 1962 Rachel Carson linked industrial chemical pollution to biodiversity loss and human diseases in her highly influential book *Silent Spring*.[1] In 1968 the first Intergovernmental Conference for Rational Use and Conservation of the Biosphere took place, followed by the 1972 Stockholm Conference, where ecologically sustainable development was discussed in depth. International cooperation has evolved, coordinated and culminated in the United Nations 2030 Agenda for Sustainable Development[2] and the Paris Climate Agreement, which are soon to be complemented by the Post-2020 Global Biodiversity Framework of the Convention on Biological Diversity.

The timeline of scientific findings and international conferences is dotted and interwoven with human, economic and environmental catastrophes, including the 1973 Organization of the Petroleum Exporting Countries oil crisis; the 1984 drought in Ethiopia, which caused the loss of 1 million human lives; the fatal Bhopal toxic chemical leak that same year in India, which caused massive environmental damage; nuclear accidents; countless oil spills; epidemics; disproportionately extensive forest fires; and more.[3] At the time of writing, the Covid-19 pandemic is still spreading and has cost over 1.5 million lives, with an unprecedented economic downturn and social unrest in its wake.

Social movements calling for fair and sustainable development have grown and multiplied in parallel to these disasters: from Greenpeace's first civil protests (1971), the Chipko movement in India (1973), the greenbelt movement (1977), the Occupy Movement against inequality (2011), the climate march that preceded the UN Climate Change Conference in 2015 and many others (figure S1.1.1), culminating in today's global youth-led climate-related strikes and movements, which have engaged millions of people around the world, as well as worldwide protests against systemic racism and police brutality.

Over these decades scientific research has built an extensive body of knowledge on the connections between the biosphere—the thin layer of life that covers the earth—and human activities[4] and has taken multiple approaches to understanding the relations and dynamics between the two. Metabolic approaches describe a system's dynamics as generated from the flows of matter and energy between societies and their natural environments.[5] Human appropriation, metabolic approaches and planetary boundaries have common roots in the ecological and early Earth system sciences and in ecological economics (see figure S1.1.1). Planetary boundaries include resilience and complexity science. This implies analysing the dynamics that emerge from interactions and combinations of processes that constitute systems and how those dynamics in turn influence the processes and interactions that generated them. Complexity helps increase understanding of development in the face of both surprising and expected change and of the existence of alternative pathways.[6] Whatever the approach and regardless of whether it is used to eradicate poverty and hunger or for nature conservation, humanity and biosphere are indissociable. The

Figure S1.1.1 The knowledge, social will and political power needed to achieve sustainable development exists



Note: Three interconnected branches of scientific inquiry—resilience (orange), human wellbeing through ecological economics (purple) and Earth system sciences (blue)—shape most of today's sustainability science and have common roots and shared knowledge (grey) dating back centuries. The mix of policy, social movements and disasters (red) speckle the timeline.
Source: Adapted from figure 1 in Downing and others (2020).

biosphere provides the energy and resources that constitute and support human life, and resource acquisition and matter disposal from human activities alter the biosphere and its functioning.

International cooperation, social movements, disasters and research all reinforce the consensus around and knowledge of the deep interdependencies between human wellbeing and environmental sustainability. Although we have known of the importance of the interdependencies between the biosphere and human wellbeing for over 60 years, unsustainable development has only increased, as human development has progressed at the cost of sustainability of the biosphere.[7] Climate-related disaster events are growing in frequency, and with the increased interconnectedness of socioecological systems around the globe, those systems have become more vulnerable to these environmental changes, to financial crises, to inequalities in society and to the unequal impacts of disturbances and disasters[8]—systemic shocks that are undoing decades of development. Unsustainable development is changing Earth system dynamics in such ways that Earth socioecological systems are increasingly unsuitable to provide equal and sufficient wellbeing for all.[9] All trends indicate that humanity is on an unsustainable development pathway that points away from human development goals. To meet sustainable development goals, transformations in how societies interact with the biosphere are necessary.

The problem is not a lack of knowledge, awareness or understanding of the threats that continued unsustainable development poses to societies worldwide (see figure S1.1.1). Across research, policy and social movements there has long been a general consensus that to achieve sustainable and just human development, the ways that socioeconomic systems function need to change fundamentally. Here we summarize some of the main messages from this body of research and bring forward where progress is needed.

Global sustainable human development is enacted at the subglobal level

The space view of planet Earth, which inspired Kenneth Boulding's "Spaceship Earth" in 1966[10] and many others, is a classic illustration of the global limits of resources and space. It continues to inspire the global footprint calculator[11] and the Earth Overshoot Day movement. That there is only one planet for humanity to live on and that humanity is using up 1.6 Earths are effective ways of illustrating the problem of unsustainability (for example, Earth Overshoot day[12]).

But at the subglobal level we have continuously shifted our baselines and overshot limits through at least three mechanisms:

- Adapting—changing our diets as we deplete food resources, for example (fishing down food webs).
- Relativizing situations to newer or different contexts. We shift or ignore limits to how much we can consume by expanding extraction and waste deposition across ecosystems. This is done regardless of the specific impacts of our consumption on individual resources and ecosystems.
- Pushing problems across borders and time[13]—displacing the socioeconomic and environmental impacts of production to countries with fewer regulations or to future generations.

It is time to act on the knowledge that unsustainability at the subglobal level leads to overshooting global limits. Process-level definitions of sustainability must hold across scales: ensuring the emissions and waste produced by human activities can be absorbed at balanced rates so that ecosystems can regulate and produce at rates that might suffice for fair and just human development.

Sustainable processes and distributive approaches

Research has a strong focus on identifying limits to unsustainability—such as limits to growth, emissions, land use, the appropriation of natural resources or energy, and more. This focus comes from the research's deep roots in environmental sciences and does little to bridge with human development needs.

Indeed, fairness and justice are not Earth system biogeophysical processes, and they are not default outcomes of sustainability, but taking a distributive approach to sustainability—and thus complementing a focus on limits to sustainability—could go hand-in-hand with addressing inequality.[14] Distributive approaches can measure the same variables as those that focus on limits but with attention to the process rates needed for individuals to thrive sustainably—that is, rates of (minimum) necessary resource extraction or of waste production that can be assimilated and processed—rather than identifying a total available amount of resources or total allowable depletion rate. Distributive approaches do not necessarily assume that all individuals require equal amounts of resources but account for context-specific differences in access to resources and in production of waste, information that may guide sustainable and equitable human development. Analysing how diverse needs and processes of sustainable consumption and production combine to shape global development can go beyond approaches that tend to maximize towards resource limits and from the deeply unequal and unequitable distribution of benefits and impacts that ensue.

Sustainable human development as forging new realities

Global perspectives on development are useful dashboards to indicate what is unsustainable—where limits are—and the risks posed by unsustainability, such as greater climate system variability and catastrophic shifts in the functioning of Earth system dynamics or social order.

Taking the next steps to identify what is sustainable and how to achieve it requires recognizing contexts, their differences and connections. Contexts are—especially in the Anthropocene—more than the "here and now" of specific situations: They include distal processes and historic legacies. Foreign and international policies, commodity prices abroad, conflicts or changes to land use and hydrology on a different continent, and much more influence national and local contexts. Past injustices, conflicts and ecosystem degradation can define what constitutes an acceptable or effective sustainable development option and for whom. A sustainable development process does not displace its social, economic, environmental or even discursive burdens across borders[15] or generations.[16] There is no panacea for achieving sustainable human development that fits the whole of humanity; instead, each approach must be fit to and evolve with the context in which it is set. Importantly, each approach must be inclusive of other approaches. Research on sustainable human development could then boost understanding of how different realizations of sustainable development combine to shape global development.

Using future goals to address present problems

An important objective of sustainability research is to clarify consequences of continued unsustainability, or projecting problems of unsustainability into the future, looking at what might happen when we cross limits of emissions or biodiversity loss, for example. Projecting problems rather than goals into the future is a critical issue in current sustainability and development discourses, as illustrated, for example, by the statement, "Two degrees warming will be a problem."

When the problem being addressed is seen as a present one, action can effectively be taken, such as the pesticide regulations that followed Rachel Carson's book or restrictions on chlorofluorocarbons triggered by the hole in the ozone layer.[17] More vividly, perhaps, the regulatory, governance, social, academic and financial responses to the Covid-19 pandemic have been unprecedented in speed and magnitude—though it is too early to assess their effectiveness. Just like the Covid-19 pandemic, unsustainable human development is a problem today that is affecting 7.8 billion people. It is not only a future risk or a problem elsewhere, as no country or region is developing sustainably. Understanding the problems as present and placing constructive goals in the future are framings that could trigger positive action towards solving today's unsustainability, poverty and injustice.

Understanding contexts as connected in time and space can inspire new thinking and designs of sustainable futures: What can sustainable and just futures look like in different contexts? What inequalities do different conceptions of futures bring to light? How, specifically, do these futures differ from present situations? Which processes need to be broken, and which need to be nurtured to achieve such futures?[18] Futures that are built on sustainable processes—that is, balanced rates of waste production and resource extraction—and that account for the distribution of access, impact, opportunities and responsibilities are engaging, constructive goals to work towards.

Transformative pathways for sustainable and just outcomes

Achieving sustainable development, and even meeting the Sustainable Development Goals, will require more than adaptations and gradual changes. It will require transformations that break current locked-in systems of unsustainability. Measures aimed solely at reducing carbon dioxide emissions and slowing biodiversity loss, for example, equate to "doing less bad" but do not represent "doing right." Compensation and offsetting mechanisms might have behavioural benefits—helping recognize the costs of specific unsustainable activities. But these mechanisms are neither sustainable nor transformative and cannot undo the unsustainability of the processes being offset or compensated for. We need to distinguish between end goals and outcomes. When reducing specific environmental and social impacts is a goal in itself, development still points in the wrong direction. Even optimistic scenarios of reduced consumption and material growth are likely to result in massive biodiversity loss[19]—and this may be an outcome of sustainability transformations, but it cannot be the goal. We need to aim for transformative changes in how societies relate to the biosphere, focus on distributive approaches and ensure extraction and emission rates align with the rates at which resources are produced and waste and emissions can be absorbed by the environment. Outcomes, such as biodiversity conservation and climate stabilization, can be measured as single variables, but the goals of sustainable human development must be rooted in integrated, transdisciplinary understandings of the connections of societies in the biosphere. Development pathways and goals will vary over time and space, as they are met or redefined. This requires adaptive management,[20] the ability to better understand, learn and act accordingly in an endless, iterative process.

All these findings apply to the 2030 Agenda: For the Sustainable Development Goals to be transformative, we must see them in their entirety as integral environmental, social and economic goals. They must be adapted to and consistent with the contexts in which they are being applied. Long-term sustainability is more than meeting quantitative targets; it requires reshaping the processes of development. Goals must be periodically re-evaluated in light of new knowledge and development to ensure that they represent just and sustainable futures for all.

Sustainable human development is not a checklist but a dynamic and continued process, and ample research, human will and political power—as well as urgency—exist to actively engage in that process.

NOTES

1 Carson 2002.
2 United Nations 2015b.
3 Creech 2012.
4 Downing and others 2020.
5 Fischer-Kowalski and Hüttler 1998.
6 Downing and others 2020; Holling 1973; Walker and others 2004.
7 Rockström and others 2009a.
8 Keys and others 2019.
9 Clark and Munn 1986; Rockström and others 2009a.
10 Boulding 1966.
11 http://www.footprintcalculator.org.
12 See https://www.overshootday.org.
13 Liu and others 2013; Pascual and others 2017.
14 Downing and others 2020.
15 Pascual and others 2017; Persson and Mertz 2019.
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18 Sharpe and others 2016.
19 Powers and Jetz 2019.
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Learning from Life—an Earth system perspective

Timothy M. Lenton, Director, Global Systems Institute, University of Exeter

Human development thus far has brought about the Anthropocene, a term that recognizes that humans are now a planetary force. It is highly unusual for one animal species to have global impacts, and we are certainly the first species to have a dawning collective awareness that it is changing the world. However, we are far from the first living things to change the planet. Rather, we exist—let alone develop—only because of the extraordinary consequences of 4 billion years of ongoing collective activity by other living things that have made the planet habitable for us. They range from the humblest bacteria to the mightiest trees—all unconsciously networked together. This totality of all living things is referred to here as "Life."

The idea that physics, chemistry, geology and climatology set a planetary stage on which Life has merely been an actor, adapting to what it is given, turns out to be an illusion. Instead, what we see as the nonliving physical world—the atmosphere, oceans, ice sheets, climate and even the continents—are (to varying degrees) created or affected by Life on Earth.[1] These factors in turn shape Life, closing myriad feedback loops (of varying strength). These closed loops of causality, in which the consequences of actions feedback to their originators or their descendants, can give rise to recognizable behaviour across a wide range of scales, right up to the planetary. Earth's history is characterized by long intervals of stable self-regulation interspersed with tipping points of abrupt change.

This new understanding has been unearthed over the last half century by the emerging field of Earth system science.[2] This perspective of Life in the Earth system offers some humbling yet empowering lessons on expanding human freedoms in balance with the planet.

How we got here

Humans owe our very existence to the activities of past and present life forms, which have created a world that we could inhabit.[3] This is true not just in the evolutionary sense that we are descended from earlier life forms but also in the Earth system sense that the atmosphere would be unbreathable and the climate intolerable were it not for the accumulated actions of other living things, past and present. Three pivotal revolutions stand out in Earth history, in which the Earth system was radically transformed. Each depended on the previous one, and without them we would not be here. They offer important lessons about the value of Life and about what supports its flourishing.

Life started on Earth remarkably soon after the planet formed 4.56 billion years ago and cooled enough to be inhabitable. The latest estimates put Life's origin at more than 4 billion years ago, and sedimentary rocks that could record the presence of Life, more than 3.7 billion years ago, suggest it was already there. Early Life was exclusively bacteria and archaea, the two kingdoms of prokaryotes (simple cells). All organisms need a supply of energy and materials to stay alive. The earliest cells probably got their energy in chemical form, from reacting compounds in their environment (just as humans burn fossil fuels with oxygen to power our societies today). However, a shortage of chemical energy at the time would have severely restricted the collective productivity of early Life.[4]

The first revolution started when some organisms evolved to harness the most abundant energy source on the planet—sunlight—and used it to fix carbon dioxide from the atmosphere in various forms of anoxygenic photosynthesis (which do not release oxygen).[5] At that point shortage of materials, rather than of energy, would have become limiting to global productivity. All forms of photosynthesis need a source of electrons (to reduce carbon), and the compounds used in the earliest forms of photosynthesis, such as hydrogen gas (H_2), were in short supply.[6] This illustrates a general problem for Life that is still with us today: The fluxes of materials coming to the surface of Earth from geologic (volcanic and metamorphic) processes are meagre, many orders of magnitude less than the needs of Life today—or indeed the needs of current human civilizations. There are two possible evolutionary answers to this problem: increase the inputs of materials needed or increase their recycling within the Earth system. Early Life's overwhelming answer was to evolve the means of recycling all the materials it needed to metabolize, using some of the energy captured in photosynthesis to power that recycling. This established what scientists call global biogeochemical cycles. A few scant clues suggest that global-scale recycling of hydrogen and carbon was in place by around 3.5 billion years ago. However, global productivity would still have been limited to less than 1 percent of today's.[7]

The second revolution started around 3 billion years ago with the evolution of oxygenic photosynthesis, which uses abundant water as a source of electrons.[8] This was a spectacularly difficult process to evolve[9] because splitting water requires more energy —that is, more high energy photons of sunlight—than any photosynthesis before. Around a billion years after the origin of Life, evolution chanced on a solution: wiring together two existing photosystems from completely different bacterial lineages in one cell and bolting on the front of them a remarkable piece of biochemical machinery that can rip apart water molecules.[10] The result was the first cyanobacterial cell: the ancestor of all organisms (cyanobacteria, algae and plants) performing oxygenic photosynthesis on the planet today. Life then became limited by the supply of different materials—the essential nutrients nitrogen and phosphorus—and new ways of recycling them evolved.

Production of the most abundant waste product of Life, oxygen, had begun. Yet oxygen did not rise in the atmosphere immediately or steadily. Instead, it remained a trace gas for hundreds of millions of years. Then in a spectacular transition around 2.4 billion years ago known as the Great Oxidation, oxygen rose abruptly and irreversibly to be the chemically dominant gas in the atmosphere.[11] This illustrates one of the key properties of the Earth system, which it shares with other complex systems: It possesses alternative stable states and occasionally passes tipping points when it goes abruptly from one (no longer stable) state to another. At the Great Oxidation the Earth system tipped from a stable low oxygen state without an ozone layer to a stable high oxygen state with an ozone layer.[12] The tipping point was triggered when the balance of gaseous inputs to the atmosphere shifted from an excess of reductants (that is, electron-rich compounds) to an excess of oxygen. The transition was self-propelling thanks to self-amplifying (positive) feedback: Once enough oxygen built up for the ozone layer to start to form, this shielded the atmosphere below from ultraviolet light and slowed the chemical reactions that remove oxygen by reacting it with methane. More oxygen produced more ozone, letting through less ultraviolet light and further suppressing oxygen consumption in a runaway rise of oxygen. Among the consequences were severe ice ages, thanks to the removal of methane, a potent greenhouse gas.[13] A new stable state was established when a new sink (removal process) for oxygen kicked in: oxidation of sedimentary rocks and of the continents themselves. Oxygen may have overshot for hundreds of millions of years until a 1.5 billion year period of stability was established.[14]

The biosphere was supercharged by the Great Oxidation because respiration of organic matter with oxygen yields an order of magnitude more energy than breaking food down anaerobically. Key beneficiaries about 2 billion years ago were the first eukaryotes, complex cells. They evolved from a fusion of once free-living prokaryotes. Their energy factory (mitochondria) were once free-living aerobic bacteria, and the plastids where photosynthesis occurs in plant and algal cells were once free-living cyanobacteria. Using their larger energy supply, eukaryotes increased their genetic information storage and processing, copying many chromosomes in parallel (whereas prokaryotes copy their DNA in one long loop). This gave eukaryotes the capacity to create more complex, multicellular lifeforms. However, that capacity was suppressed under still low oxygen levels about 2 billion years ago to about 600 million years ago, while the deep ocean remained largely devoid of oxygen.[15]

The third revolution started around 700 million years ago in a period of extreme climate changes—"Snowball Earth" events during which the planet froze over completely—and a second rise in oxygen levels, when animals began to evolve.[16] The scientific details of what caused what in this revolution are still being untangled. Suffice to say there was (again) a link between environmental instability and the evolution of more complex life forms, which were themselves made up of pre-existing components (eukaryote cells). Furthermore, increased oxygen levels were a necessary condition for more complex forms of animal. The revolution did not finish until around 400 million years ago, when complex plants, in partnership with fungi, colonized the land and pushed oxygen up to modern levels, radically lowering carbon dioxide levels and cooling the climate. This land colonization hinged on evolving ways of extracting phosphorus from rocks and of efficiently recycling nutrients within terrestrial ecosystems. It doubled global productivity.[17] Through this success, plants created wildfire-supporting, carbon dioxide–limiting conditions, which entangled them in feedbacks that stabilize atmospheric oxygen, carbon dioxide and global temperature levels. The resulting stability and high oxygen levels were crucial for the further evolution of complex Life—including us.[18]

Why it is a bad time to perturb the planet

What can we draw out from this brief history of the Earth system? It was characterized by long intervals of stability and self-regulation, interspersed with tipping points of abrupt change. The most revolutionary changes were driven by Life, specifically new evolutionary innovations that increased energy and material consumption and generated new waste products (notably oxygen). Revolutions relied on some inherent instability in the Earth system to become planet changing. They sometimes took Life to the brink of total extinction in events such as "Snowball Earth." Stability was restored only when effective means of recycling materials were (re)established. Each revolution built on the previous one. Complex life forms are built from simpler ancestors. Greater biological complexity also relied on increased atmospheric oxygen and stronger environmental regulation (because complex life forms have narrower habitability requirements). Looking at the unfolding Anthropocene from this long-term vantage point raises the question: Could this be the start of another revolutionary change of the Earth system?

This is a bad time to be perturbing the Earth system because it is unusually unstable. Just as our hominin ancestors began to use stone tools around 2.6 million years ago, a roughly 40 million years cooling trend culminated in a series of Northern Hemisphere ice age cycles, initially every 40,000 years. Then as our ancestors were first taming fire, around a million years ago, these ice ages became more severe and less frequent, roughly every 100,000 years. This transition from a stable climate state to progressively deeper and stronger glacial-to-interglacial oscillations clearly indicates the Earth system's loss of stability.[19] These sawtooth oscillations—during which the climate cools progressively into an ice age then snaps rapidly out of it, only for the cycle to repeat soon after—are a classic example of a system that, despite being bounded by negative feedback, contains a strong amplifier (positive feedback), as should be familiar to students of electrical engineering. At the termination of an ice age, the Earth system goes into near runaway positive feedback, with carbon released from the deep ocean, amplifying global climate change. Looking at the last ice age, the sense of instability gets worse: It contained at least 20 abrupt climate change events[20] during which large areas of the Northern Hemisphere warmed markedly within a few years (followed later by abrupt cooling).[21]

Humans have unwittingly started the Anthropocene against this backdrop of long-term climate instability. Climate scientists often comfort themselves and their audience with the knowledge that the last 10,000 years of the Holocene interglacial period look climatically more stable[22] (until we started to mess it up). Indeed, a favoured origin story is that this stability provided an essential foundation for the multiple independent origins of agriculture and human civilizations. This Neolithic (agricultural) revolution controlled the means of (solar) energy input to societies and supported new levels of social organization (states). However, civilizations overwhelming arose in dry climates, often where the environment had been deteriorating. These novel complex social systems were then rather vulnerable to multiple internal and external factors, including abrupt regional climate changes. The path of human history too, it seems, is one of periods of stability interspersed with short intervals of abrupt, revolutionary change, with much trial and error.

A new, concentrated (but finite) source of energy —fossil fuels—propelled the industrial revolution, which continues to spread across the world today, increasing global energy and material consumption. Combusting fossil fuels breaks the natural (recycling) balance of the carbon cycle and generates our most abundant, invisible waste product: carbon dioxide. In industrial economies, about 80 percent of the total annual outflow of materials by weight is carbon dioxide[23] and global fossil fuel emissions account for around 35 billion tonnes of carbon dioxide a year, with another 5.5 billion from land use change.[24] The accumulation of this carbon dioxide and other anthropogenic greenhouse gases in the atmosphere and the resulting roughly 1 degree Celsius of global warming is already destabilizing the Earth system. Several tipping elements exist in the climate system that have alternative stable states and can pass tipping points between them.[25] Some involve abrupt shifts in modes of circulation of the ocean or atmosphere, some involve abrupt loss of parts of the cryosphere and some involve abrupt shifts in the biosphere. There is already evidence that parts of the West Antarctic and East Antarctic ice sheets may be in irreversible retreat, the Greenland ice sheet is shrinking at an accelerating rate, the overturning circulation of the Atlantic Ocean is weakening and the Amazon rainforest is burning.[26] In each case there is strong self-amplifying feedback within the system, which propels change.

For other crucial elemental cycles our collective activities exceed those of the rest of Life combined. We fix more reactive nitrogen from the atmosphere than the rest of the biosphere, and after it is added to our agricultural fields, most ends up elsewhere. Bacteria denitrify some of it back to atmospheric N_2 but also generate nitrous oxide, a potent, long-lived greenhouse gas. Other nitrogenous gases contribute to air pollution. Much reactive nitrogen leaks into fresh waters, estuaries and shelf seas, where it fuels productivity, often of cyanobacteria.[27] We also mine, refine and add to the Earth system about three times as much phosphorus as the natural processes of rock weathering. This also fuels productivity far beyond the fields where it is applied.[28] Together nitrogen and phosphorus loading contribute to eutrophication, deoxygenation of subsurface waters and toxic blooms. The deoxygenation of lakes and restricted shelf seas (such as the Baltic Sea) involves tipping point dynamics. As bottom waters deoxygenate, microbes in sediments are triggered to recycle phosphorus back to the water column, adding to productivity and deoxygenation in a potent positive feedback cycle.[29]

Human activities have also made the Earth system—and our societies—less stable by forming more homogeneous and connected networks. All Life, including humanity, comprises interacting networks of actors. However, the stability of those networks depends crucially on the diversity (heterogeneity) or lack of it (homogeneity) within them and on how strongly connected they are. A more homogeneous and strongly connected network, though it may perform well at resisting small perturbations, is more prone to global collapse.[30] The Covid-19 pandemic has highlighted this for our interconnected, human societies. Today's dominant political economy has been busy homogenizing and interconnecting both the human world and the rest of the living world. About half the Earth's productive land surface is devoted to farming, dominated by a few staple crops and a handful of domesticated animal species. Those animals outweigh us, and we in turn outweigh all the remaining wild animal life. The resulting artificial ecosystems are vulnerable. Vast scientific efforts go into suppressing pathogens. Three-quarters of crops and 35 percent of crop production depend critically on natural pollinators,[31] which are often vulnerable to our pesticides.[32] The transfer of invasive species between continents is homogenizing Life. Our ongoing destruction of remaining natural habitats and our extraction and exchange of wild species as economic commodities (think the Wuhan wet market) are introducing new threats into the fragile networks we have created.

Given the Earth system's present underlying climate instability and our efforts to erode the stability of its networks, we need to confront the possibility that our actions could trigger a global tipping point. Already, the long lifetime of the carbon dioxide we have added to the atmosphere may have prevented the next ice age. If we burn all known fossil fuels, climate forcing from carbon dioxide could exceed anything the Earth has experienced in the last 400 million years.[33] Long before that happens, we risk tipping the Earth system into a hothouse state similar to those associated with past oceanic anoxic events and mass extinctions.[34] Our globalization and homogenization of the web of Life could also perhaps cause its networks to collapse in a mass extinction. We need to avoid such outcomes at all costs. Our very existence requires that Life survived such past scrapes with disaster,[35] but past survival provides no guarantee of future survival. After past close shaves, it typically took millions of years for the slow workings of evolution and Earth system dynamics to restore a well functioning, self-regulating biosphere. We do not have the luxury of waiting that long.

How we can save ourselves

This new knowledge emerging from Earth system science has important implications for how we can reduce the risks we pose to ourselves and other living beings. If we recognize the agency of humans, and all other Life, it can also show us a way forward to future flourishing.[36]

Energy and materials

If we continue to let our waste products accumulate, trouble will ensue—as it did during the revolutions that made the Earth. But what the biosphere illustrates is that solar energy and nearly closed material recycling are the basis of productivity and flourishing. Instead of just retreating to a world of lower energy and material consumption, we can open up a space for human flourishing—within planetary boundaries[37] —by changing our dominant source of energy and learning to recycle all the materials we need. The emphasis of industrial and agricultural activity needs to shift from increasing the inputs of carbon, nitrogen, phosphorus and other elements into the Earth system to increasing the recycling of these elements within the Earth system, powered by sustainable energy. Happily, the input of solar energy can far outstrip current fossil fuel energy consumption. Renewables are already cost-competitive with fossil fuel energy for electricity generation in much of the world—and will be much cheaper within a decade. There should thus be no long-term shortage of energy. Renewable energy is also more distributed than fossil fuels, offering the opportunity to (literally) put the power back with the people, democratizing energy supply. The challenge is to design and incentivize a transition to a circular economy. Waste products must become useful resources to make new products. Despite practical obstacles and thermodynamic constraints, there is huge potential to increase material recycling. Innovation and engineering need to shift attention to achieve nearly closed material cycling powered by sustainable energy.

Information and networks

The biosphere is built from adaptive networks of microbial actors that exchange materials, electrons and information—the latter through ubiquitous horizontal gene transfer. These microbial networks form the basis of the recycling loops that make up global biogeochemical cycles. Nowadays they are augmented by networks of macroscopic life, such as plants and mycorrhizal fungi. The topology of these networks and their feedback loops are persistent, even when the taxa performing particular functional roles within them change. Sufficient biodiversity to provide functional redundancy adds to network robustness. Self-regulation is a distributed property—that is, there is no centralized control—further adding to network robustness.[38] Humans have been busy creating more homogeneous, hierarchical—and therefore less stable—networks in the biosphere and their own realm. Shifting to more horizontal transfer of information, functional diversity with redundancy and distributed control will all likely be important to a successful circular economy. The challenge is to support diverse, autocatalytic networks of human agents that can propel transformations towards goals such as sustainable energy, fuelling the efficient cycling of resources. This is particularly challenging given the social and economic paradigm of short-term localized gain and weak global, unifying, long-term structures to counteract it.

Evolving solutions

All the living, networked actors in the Earth system continuously transform their stage in an interplay of action and reaction. Evolutionary experiments or innovations have consequences, and those consequences are filtered. Natural selection can help explain resource recycling and environmental regulation at small scales of space and time. But at larger space and time scales simpler dynamical mechanisms are at play: Systems that find self-stabilizing configurations tend to persist, and systems that persist have a greater likelihood of acquiring further persistence-enhancing properties.[39] Through these cruder filtering mechanisms, the Earth system appears to have acquired and accumulated stabilizing feedback mechanisms involving Life (including biogeochemical cycles). Major transitions in evolution[40] have created new levels of biological organization out of pre-existing components, including the eukaryote cell, multicellular complex life forms, social animal colonies, (human) states and who knows what next.

To meet the challenge of expanding human freedoms in balance with the planet, there will surely need to be much learning-by-doing. Innovation usually happens from the bottom up, driven by human agency at small scales and with the scope to spread if successful. These experiments will be subject to filtering, but we need to re-examine the values and priorities driving that filtering. If it is just the invisible hand of deregulated markets doing the filtering, based on short-term financial gains that concentrate power with the few, outcomes that promote sustainability, equity or collective flourishing are highly unlikely. After all, that filter got us into this mess in the first place. To change the filter will require conscious, collective leadership—and some things will need to be more tightly regulated than others.

Tipping positive change

While today's policymakers seem paralyzed by complexity, it should not be a barrier to action. The complex Earth system runs itself automatically. Indigenous cultures worldwide have developed sophisticated ways of flourishing with the ecological complexity around them—for example, the Yap people of the Federated States of Micronesia have used adaptive management to sustain high population density in the face of scarce resources.[41] Contemporary science is developing a powerful toolkit to sense and understand complex systems and guide action. Frameworks such as adaptive management have been established. Perhaps a partial liberation for policymakers can come from realizing that action does not reside just with them; it continually comes—as it always has—from living free agents.

Improving our relationship with the rest of Life, as well as with each other, relies on having an advanced sensing capability. We need to be able to sense where things are going wrong—and where they are going right—to have any chance of correcting errors or charting a new course. More boldly, science has shown that tipping points in complex systems carry generic early warning signals.[42] Climate change and biosphere degradation have already advanced to the point where we are triggering damaging tipping points. Avoiding worse ones ahead will require finding and triggering positive tipping points towards sustainability in coupled social, technological and ecological systems.[43] The same methods that can provide early warning of damaging environmental tipping points could be used to detect when sociotechnical or socioecological systems are most sensitive to being deliberately tipped in a desirable direction. Participating in that deliberate tipping would expand human freedom. Policymakers have a special opportunity to provide a guiding framework, incentivizing some outcomes over others and thus playing a key part in tipping positive change.

NOTES

1 Lenton, Dutreuil and Latour 2020.
2 Lenton 2016.
3 Lenton and Watson 2011.
4 Lenton, Pichler and Weisz 2016.
5 Canfield, Rosing and Bjerrum 2006; Lenton and Watson 2011.
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30 Scheffer and others 2012.
31 Klein and others 2007.
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33 Foster, Royer and Lunt 2017.
34 Steffen and others 2018.
35 Lenton and Watson 2011.
36 Lenton and Latour 2018.
37 Rockström and others 2009a.
38 Barabás, Michalska-Smith and Allesina 2017.
39 Lenton and others 2018.
40 Maynard Smith and Szathmáry 1995.
41 Falanruw 1984.
42 Scheffer and others 2012.
43 Lenton 2020.

SPOTLIGHT 1.3

Existential risks to humanity

Toby Ord, Senior Research Fellow, The Future of Humanity Institute, University of Oxford

Humanity has a vast history, spanning hundreds of thousands of years. If all goes well, we can look forward to a future of equal or greater length. And just as our past saw profound expansions in our capabilities —through our lifespans, our education, our prosperity and our freedoms—so the future offers the possibility for this development to continue. We have the potential for every place on Earth to reach the highest standards seen today and to continue far beyond what has yet been achieved.

But this potential is at risk. Like every species, humanity has always been subject to the risk of extinction from natural catastrophes. And to this we have added risks of our own. Humanity's power over the world around us has increased tremendously over the past 200,000 years. In the 20th century, with the development of nuclear weapons, we became so powerful that we posed a threat to our own continued survival. This risk declined with the end of the Cold War but did not disappear. And it was joined by other risks that could threaten our continued existence, such as extreme climate change.

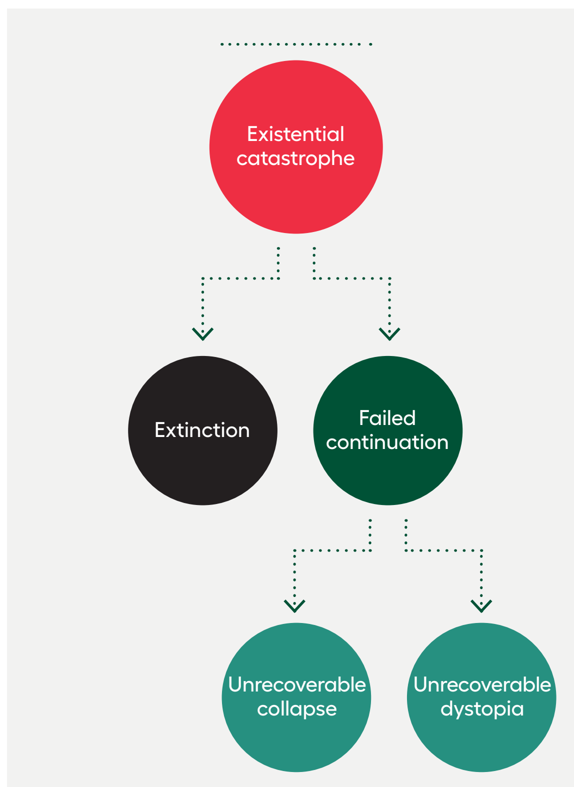
The 20th century thus ushered in a new period in which humanity has acquired the power to end its story without yet achieving the collective wisdom to ensure it does not. This period of heightened risk, known as the Precipice,[1] is closely related to the Anthropocene—indeed one suggested definition for the Anthropocene would have them begin at the same moment: 16 July 1945, when the first atomic bomb was detonated. Just as the Earth has entered a geological period in which humanity is the dominant force shaping the planet, so humanity has entered a historical period in which the dominant risks to its survival come from humanity itself. Both periods were triggered by our increasing power but may end at very different times: We could imagine a future in which humanity has found a path to safety, creating new institutions to govern global risks, such that while humanity continues to shape the planet, it has ceased to pose a substantial risk to itself.

To understand humanity's predicament, it is helpful to define two terms:

- An existential catastrophe is the destruction of humanity's long-term potential.
- An existential risk is a risk that threatens the destruction of humanity's long-term potential.[2]

The most obvious form of existential catastrophe would be human extinction, for it is clear how that would permanently foreclose our potential (figure S1.3.1). But there could be other forms too. A global collapse of civilization would also count, if it were so deep and unrecoverable that it destroyed

Figure S1.3.1 Three types of existential catastrophe



Source: Reproduced from Ord (2020).

(most of) humanity's potential. And it may also be possible for civilization to survive but be drawn into an unrecoverable dystopian future, with little value remaining.

What these outcomes have in common is that they would foreclose the possibility of human development. If such a catastrophe occurred even once, the great gains we have achieved would be permanently undone, and the possibility of reaching a more equal or more just world would be gone forever. Such risks thus threaten the most basic foundations on which almost all other value rests.

The risks

What risks could pose such a threat to our long-term potential? The most well understood are the natural risks. Take the possibility of a large asteroid impact. The mass extinction at the end of the Cretaceous 65 million years ago is widely agreed to have been caused by an asteroid, 10 kilometres in diameter, colliding with the Earth. The impact threw vast amounts of dust and ash into the stratosphere—so high that it could not be rained out. Atmospheric circulation spread this dark cloud around the planet and caused a massive global cooling, lasting years. The effects were so severe that all land-based vertebrates weighing more than 5 kilograms were killed.[3]

Scientists now have a good understanding of the chance that such an asteroid could hit us again. It is reassuringly low (table S1.3.1). In a typical century the chance of being struck by a 10 kilometre across asteroid would be just 1 in 1.5 million.[4] What about the next 100 years in particular? Scientists have modelled the orbits of all four known near-Earth asteroids of that size and confirmed that they will not hit the Earth in the next 100 years. So the remaining chance lies in the unlikely possibility that one remains undiscovered. The situation is somewhat less reassuring with asteroids between 1 and 10 kilometres across, for which detection and tracking are incomplete. Fortunately, they would also be less likely to cause a truly unrecoverable catastrophe.

Asteroids are the best-understood existential risk. They clearly pose a risk of human extinction (or unrecoverable collapse), but the risk is well understood and small. Moreover, they are the best managed existential risk: There is an effective international research programme directly working on detecting and understanding these threats.

Table S1.3.1 Progress in tracking large near-Earth asteroids

Asteroid diameter	Number	Percentage found	Chance of being struck in an average century	Change of being struck in next century
1–10 kilometres	~920	~95	1 in 6,000	1 in 120,000
10 or more kilometres	~4	> 99	1 in 1.5 million	< 1 in 150 million

Source: Adapted from Ord (2020).

There are several other known natural existential risks, including comets and supervolcanic eruptions. These are less well understood than asteroids and may pose a greater risk. Because most of these risks were discovered only within the last century, there are presumably unknown natural risks too.

Fortunately, there is a way of using the fossil record to estimate an upper bound for the total extinction risk from all natural hazards—including those that have not yet been discovered. Since humanity has survived the entire array of natural risks for thousands of centuries, the chance of extinction per century must be correspondingly small. This produces a range of estimates depending on how broad we take "humanity" to be (table S1.3.2). We can also estimate this natural extinction risk via how long related species have survived, with a range of estimates depending on how closely related they are (table S1.3.3). Both techniques suggest that the total natural extinction risk is almost certainly below 1 in 300 per century and more likely to be 1 in 2,000 or lower.[5]

Unfortunately, there is no similar argument to help estimate the total anthropogenic risk because the track record is too short. Surviving 75 years since the invention of nuclear weapons does very little to

Table S1.3.2 Estimates and bounds of total natural extinction risk per century based on how long humanity has survived, using three conceptions of humanity

Conception of humanity	Years	Best guess of risk	99.9 percent confidence bound
Homo sapiens	200,000	< 1 in 2,000	< 1 in 300
Neanderthal split	500,000	< 1 in 5,000	< 1 in 700
Homo	2,000,000 – 3,000,000	< 1 in 20,000	< 1 in 4,000

Source: Adapted from Ord (2020).

Table S1.3.3 Estimates of total natural extinction risk per century based on the survival time of related species

Species	Years	Best guess of risk
Homo neanderthalensis	200,000	1 in 2,000
Homo heidelbergensis	400,000	1 in 4,000
Homo habilis	600,000	1 in 6,000
Homo erectus	1,700,000	1 in 17,000
Mammals	1,000,000	1 in 10,000
All species	1,000,000–10,000,000	1 in 100,000–1 in 10,000

Source: Adapted from Ord (2020).

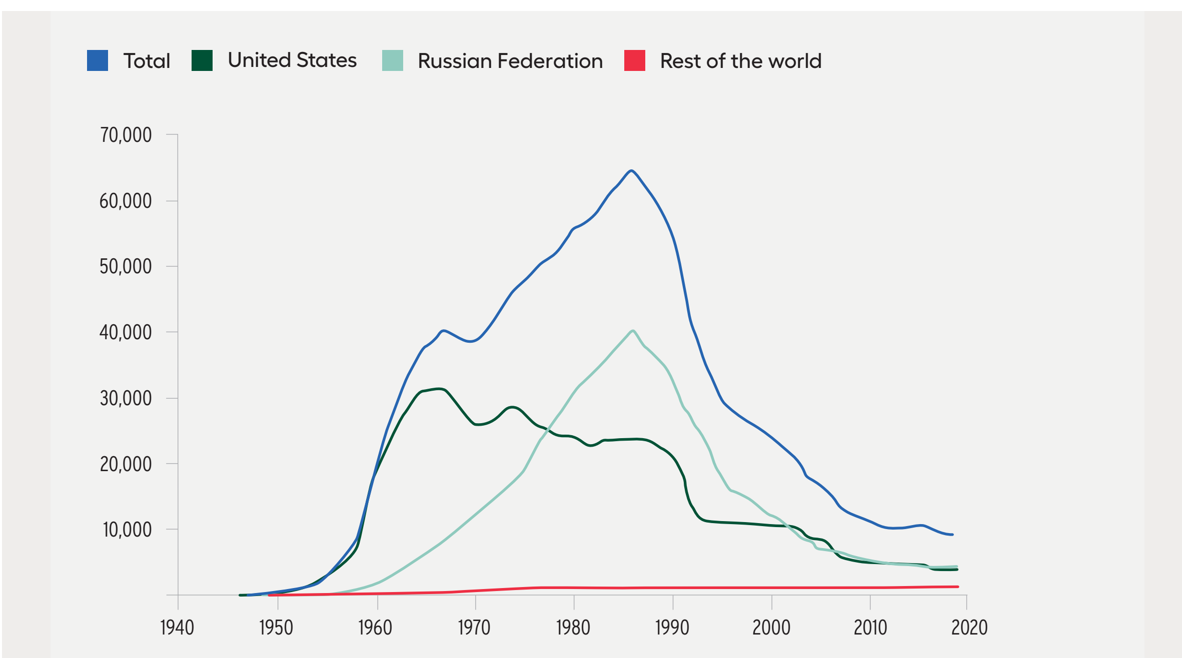
constrain the amount of existential risk from nuclear weapons over a century. We therefore have to confront the possibility that this risk may be substantial.

In the early 1980s scientists discovered that nuclear war could create a global cooling effect similar to that of large asteroid impacts.[6] While initially controversial, subsequent research has mostly supported this "nuclear winter" effect in which ash from burning cities would rise into the stratosphere, causing severe cooling lasting for years.[7] This would cause massive crop failures and widespread starvation. Researchers studying nuclear winter now suggest that a collapse of civilization might be possible, though it would be very difficult for nuclear winter to directly cause human extinction.[8]

Fortunately, the existential risk posed by nuclear war has been declining. Since the late 1980s the size of the nuclear arsenals has been substantially reduced, lowering the severity of an ensuing nuclear winter (figure S1.3.2). This appears to stem in part from concern about the existential risk the weapons posed, with both US President Ronald Reagan and USSR General Secretary Mikhail Gorbachev reporting that the possibility of nuclear winter weighed heavily on their minds.[9] Another major reduction in risk was the end of the Cold War, which has reduced the chance that the arsenals will be used at all. However, the chance has by no means been eliminated: Nuclear war could still begin through an accidental launch (and retaliation) or if tensions between great powers flare up once more.

Climate change may also pose an existential risk to humanity. Much of the scientific focus has been on the most likely scenarios. While these could be devastating by any normal measure, they would not be existential catastrophes. But some of the extreme possibilities may reach that threshold. For example,

Figure S1.3.2 While there have been substantial reductions in the number of active stockpiled nuclear warheads, the total number—especially in the Russian Federation and the United States—remains high



Source: Reproduced from Ord (2020) and adapted from Kristensen and Korda (2019).

we cannot yet rule out climate feedbacks taking us substantially beyond 6 degrees Celsius of warming —perhaps as far as 10 degrees Celsius or more.[10] It would be extremely valuable to have a better idea of the likelihood of such extreme scenarios and of whether civilization, or humanity itself, would survive them. But the lack of scientific research on them means existential risk from climate change remains poorly understood.

Several of the greatest catastrophes in human history have been caused by pandemics. The Black Death of 1347 killed 25–50 percent of people in Europe—about a tenth of the world's population.[11] The introduction of diseases from Europe (beginning in 1492) may have killed as much as 90 percent of the population in the Americas—again about a tenth of the world's population.[12] The 1918 flu killed roughly 3 percent of the world's population.[13]

So the current worldwide pandemic is not at all unprecedented. It is the worst pandemic in a century, but far from the worst in a millennium. Indeed, it is the idea that such catastrophes were left forever behind us that would have been unprecedented. Covid-19 shows us that this is false, that humanity is still vulnerable to global catastrophes. While we have made substantial improvements in medicine and public health (which have greatly reduced the burden of endemic disease), it is unclear whether we are any safer from pandemics. This is because there are also ways that human activity has made pandemics more dangerous, such as intensive farming, urbanization and rapid international travel. So even when pandemics are natural in origin, the argument for bounding natural extinction risk does not apply—that argument assumes the risk has been stable or declining over human history, which may not be true here. Though Covid-19 itself does not pose an existential risk to humanity, other pandemics might.[14]

And this situation looks considerably worse when we consider the possibility of engineered pandemics. Humanity has a long and dark history with using disease as a weapon, dating back at least 3,000 years.[15] Indeed, there are credible claims that the Black Death was introduced into Europe by catapulting plague-ridden bodies into the besieged city of Caffa on the Crimean Peninsula.[16] The 20th century saw many countries adopt major biological weapons programmes, and while these were officially outlawed by the Biological Weapons Convention of 1972, it would be a serious mistake to think that the convention has stopped all bioweapons programmes.[17] Though it is an important symbol and a useful forum, it is very under-resourced: with just four employees and a budget smaller than that of a typical McDonald's.

Biotechnology is advancing at an extremely rapid rate. And while these advances bear great promise for medical and industrial progress, they also aid progress in biological weaponry. This makes the weapons of a major state more powerful and opens up the possibility of extremely damaging weapons being deployed by small nations or subnational groups. If biotechnology continues to advance, this may create a very unstable strategic situation.

And there are other important technological risks on the horizon, such as those posed by advanced artificial intelligence and nanotechnology.[18] The sheer variety of these risks suggests that a piecemeal, siloed, approach—in which we hope that each risk will be dealt with separately by the relevant community —becomes increasingly hard, and a more unified approach is needed.

The anthropogenic risks are inherently more speculative than the natural risks, since it is impossible to acquire evidence of them having happened before. But this does not make them smaller. We saw that natural risk almost certainly totals less than 1 in 300 per century. How confident would we be that humanity could expect to survive 300 centuries like the 20th century? Or like the 21st? Using the fossil record, we can be more than 99.7 percent confident we will survive the natural risks of the next 100 years. How confident can we be that we survive the human-made risks? While we cannot be sure, reflections such as this make it seem likely that anthropogenic risks are now the greater threat to our future, posing an unsustainable level of risk (box S1.3.1).

Analysis

The world is only just beginning to understand the scale and severity of existential risk. The substantial work on the risks of nuclear war and climate change still pales in comparison with the importance of the topics. And little of this work has been directed to the parts of these problems most relevant to existential

Box S1.3.1 Existential risk as sustainability

Protecting humanity's long-term potential is a key form of sustainability. The current period of heightened anthropogenic risk is unsustainable—we can get lucky for a while, but eventually the odds are going to catch up with us. In many other cases people can do well by taking calculated risks, but here our entire bankroll is on the line, so if we eventually lose—even once—there is no coming back.

We could thus think of our accumulated existential risk over humanity's future as a kind of risk budget—a budget that has to last for our entire lifespan, the ultimate nonrenewable resource. Responsible stewardship of humanity's potential would involve lowering this risk as quickly as possible and setting in place the safeguards to keep it low in order to allow humanity to flourish for as long as possible.

risk (such as better understanding nuclear winter or extreme climate feedbacks).

It is helpful to look at why existential risk is so neglected.

First, protection from existential risk is an intergenerational global public good. Standard economic theory thus predicts a market failure in which individual nations cannot capture more than a small fraction of the benefits and are tempted to free-ride on each other, undersupplying this protection.

Second, many of the risks are inherently international—beyond any individual nation's ability to solve, were one even prepared to do so. International cooperation and coordination are thus required but move much slower than technology. If we remain in a paradigm in which a new agreement is required for each new risk and can be achieved only decades after the risk rises to prominence, we might forever be playing catchup.

Third, minimizing existential risk just feels like too big a task for most nations—something that is outside the scope of their usual responsibilities or "above the pay grade" of their leaders. Yet nations have not officially passed this responsibility up to the international level, entrusting an international institution with key tasks relating to monitoring, assessing or minimizing existential risks. Responsibility for protecting humanity's long-term potential thus falls through the cracks between the national and international spheres.

Fourth, the whole idea of existential risks to humanity is very recent. We have been exposed to anthropogenic existential risks for only 75 years, most of which was spent in the grip of a Cold War. Our ethics and our institutions have not had time to catch up.

As we begin to wake up to the present situation, we will face great challenges. But there will also be new opportunities. Responses that first seemed impossible may become possible—and in time even inevitable. As Ulrich Beck put it, "One can make two diametrically opposed kinds of assertion: global risks inspire paralysing terror, or: global risks create new room for action."[19]

We have seen that the rise in anthropogenic risk means that most of the existential risk we face likely arises from our own actions. While this is a disturbing trend, there is a flip side that should give us hope: Humanity's future is largely within humanity's control. If a 10 kilometre across asteroid were on a trajectory to hit the Earth in 10 years, there might truly be nothing we could do to stop it. But the risks from nuclear war, climate change and engineered pandemics arise from activities that humans perform—and thus that humans can stop.

There are serious challenges to doing so—challenges of international coordination, verification and policing—as well as the overarching challenge of creating the political will for action. But these are not insurmountable.[20] If we fail, it will not be because there was no way through but because we were distracted by other issues or were not willing to do the necessary work. If we set our minds to it, taking the risks with due seriousness and adopting the protection of humanity's long-term potential as one of the overarching missions of our time, then our generation could very well be the one that sets humanity on a path towards a long, secure future.

NOTES

1 Ord 2020.

2 The idea of existential risk was introduced by Bostrom (2002). Earlier work on the ethics of human extinction includes Leslie (1996), Parfit (1984), Sagan (1983) and Schell (1982).

3 Longrich, Scriberas and Wills 2016.

4 Stokes and others 2017.

5 See also Snyder-Beattie, Ord and Bonsall (2019).

6 Sagan 1983.

7 Robock, Oman and Stenchikov 2007.

8 For example, Richard Turco (Browne 1990): "My personal opinion is that the human race wouldn't become extinct, but civilization as we know it certainly would." And Alan Robock (Conn, Toon and Robock 2016): "Carl [Sagan] used to talk about extinction of the human species, but I think that was an exaggeration. … But you wouldn't have any modern medicine. … You wouldn't have any civilization."

9 Hertsgaard 2000; Reagan 1985.

10 See Ord 2020.

11 See Ord 2020.

12 See Ord 2020.

13 Taubenberger and Morens (2006) estimate 50 million deaths, which would be 2.8 percent of the 1918 world population of 1.8 billion.

14 Snyder-Beattie, Ord and Bonsall 2019.

15 Trevisanato 2007.

16 Kelly 2006.

17 Countries that are confirmed to have had bioweapons programmes include Canada (1940–1958), Egypt (1960s–?), France (1915–1966?), Germany (1915–1918), Iraq (1974–1991), Israel (1948–?), Italy (1934–1940), Japan (1934–1945), Poland (?), Rhodesia (1977), South Africa (1981–1993), Soviet Union (1928–1991), Syrian Arab Republic (1970s?–?), United Kingdom (1940–1957) and United States (1941–1971). See Carus (2017).

18 For more on existential risk from artificial intelligence, see Bostrom (2014) and Russell (2019). For existential risk from nanotechnology, see Drexler 2013.

19 Beck 2009, p. 57.

20 For a list of concrete policy and research proposals that would make a difference, see Ord (2020).

Conversations on rethinking human development: Ideas emerging from a global dialogue

The global dialogue was co-organized by the International Science Council and the United Nations Development Programme

In collaboration with the International Science Council, the United Nations Development Programme and the Human Development Report Office launched a platform to seek views, inputs and aspirations about what human development means today and how it can evolve in the future. Rethinking human development is not a one-off exercise. It is a continuing process requiring dialogue, a journey towards new understandings that hears a wide diversity of voices from the natural and social sciences, humanities, decisionmakers and wider public. This spotlight synthesizes inputs reflecting multiple perspectives on nine topics.

A fresh start for rethinking the meaning of development

Several contributions noted that the term "development" is loaded with history, values, politics and orthodoxies. The term has also become entrenched with ideas and ideologies that obscure important elements, such as the value of people's inner lives or the role of power relations in perpetuating poverty and vulnerability. Many argued for decolonizing development, which requires actively challenging these power relations, while recognizing development as positive change for everyone everywhere, nuanced by diverse societal priorities. Some further alternative meanings of the term emerging from evolutionary biology and social psychology were invoked. Others relate to its distinctive meaning in medicine and the human sciences, with passages from conception to birth to childhood to adulthood to old age and death. From the human sciences perspective the development and maintenance of good physical and psychological health are central. Indeed, concepts of personal, family and social wellbeing and happiness are closely linked to mental wellbeing, with the foundations created early in the life course.

Visionary rethinking of our humanity

As with the term "development," several contributions argued for the need to rethink "human," our humanity. Moving beyond the assumption that economic production is the primary driver of wellbeing to a deep dive into the conditions that make us humans living in diverse cultures who each need to be valued and that provided each of us with an identity that is key to our wellbeing. Rethinking our humanity includes recognizing the co-construction of human and nonhuman natures and the intimate connectedness, for our individual and collective wellbeing, with the natural environment, with all living things and their dynamism and agency, whether in our bodies, homes, communities, ecologies or planet. Connectedness to one another across societies in multicultural settings and the connectedness created by transnational webs leading to a global community of humans are fundamental elements of shaping human development in the 21st century.

Strengthening institutions and accountability

Moving to implementation, the contributions emphasized how institutions and accountability are central for operationalizing human development as freedom. Institutions work for humanity but also protect all the nonhuman elements that make humanity possible—functioning socioecological systems, including climate and biodiversity—and address the challenges of rapid technological change. Moreover, the measures to adapt to unavoidable climate change impacts and roll out the needed mitigation strategies to prevent catastrophic tipping points would be possible only with accountable institutions that create the needed incentives. These incentives require international, transnational and global institutions that take the world towards collective action, countering aggressive nationalism and revitalizing multilateralism, ensuring that global responsibilities are assumed in addressing global challenges.

Human development is possible only within planetary boundaries

The tendency to pit economic development against the environment has led the world towards a dead end. Several voices called to reinterweave them, just as humanity is interwoven with the health of nonhuman natures and ultimately the planet. The notion of responsible wellbeing was suggested as being cognizant of the implications of consumption and accountability and the ways to factor in the interests of future generations. Responsible wellbeing for people and planet is about internalizing environmental and social costs in the true value of goods and services, recognizing that the value extends well beyond the monetary. It is about conceptualizing the systems underpinning humanity as socioecological or socionatural systems—and development as positive change in those systems. If we wish to celebrate another 30 years of human development, attention must extend to all societies and to the behaviour of citizens who have already achieved high levels of human development on traditional measures.

Social cohesion and mitigating inequalities are enablers—not just prerequisites—for human development

It was frequently emphasized that a reconceptualization of human development that addresses cohesion across and within society—relations between countries or across generations and relations with nonhuman natures and ecologies—is threatened by a grossly unequal world and by the narratives, technologies and processes that perpetuate inequalities. Social cohesion requires vertical and horizontal trust within societies while respecting diversity of beliefs and worldviews. Enhancing social cohesion, mitigating inequalities and restoring the value of social and socionatural relations require the inclusion of multiple voices and perspectives. We have to seriously attend to the structural conditions and violence creating and perpetuating inequalities—and listen to and include the experiences and priorities of those most marginalized. Rethinking human development is an open journey for all, beyond governments and agencies, beyond experts and academics. It thus demands democratic deliberation.

Democratic deliberation is needed for resilient socioecological systems

Individual and community empowerment allowing for democratic deliberation—local, national and transnational—is a critical channel to get us there, many emphasized. This does not always or necessarily mean democracy, as defined by particular formal representative institutions and practices, or political and historical traditions, while recognizing that healthy institutions are necessary for us to live in large social and socioecological networks. Moreover, the broad rethinking of our humanity by and for all its members and recognizing our interconnectedness with nonhuman natures in legitimate democratic processes are key for generating the consensus and the institutions capable of doing the very difficult work of avoiding dangerous planetary change. The connectedness between people and planet and among societies—and the many other global interdependencies that have emerged in the past three decades—call for cultures of global cooperation and structures of global governance that enable transnational democratic deliberation.

Making the digital age work for human development

Big Data has become the new oil. As with fossil fuels, it has led to great advances and great harm, particularly threatening individual, social and institutional wellbeing. And as with fossil fuels, there is a need to address these matters in a way that transcends national boundaries. Yet just a few private companies dominate the digital sphere, driven by competitive short-term market gains, in a governance vacuum, without appropriate public and private regulation. Furthermore, human enhancement approaches, such as synthetic biology, genome research and digital technologies are coming together, which opens the possibility of transforming not just the planet but ourselves as humans, posing fundamental ethical and broader challenges. Hence the importance of moving towards fair and sustainable value chains for technology components, while redressing the huge technical and knowledge gaps. For many, even access to the internet is a challenge, and digital technologies and the capabilities to create, use and deploy them are still limited. But investments and innovation driven by a new conception of value can put technologies to work for human development.

Value—a new narrative

When GDP growth and macroeconomic stability are considered the key signposts of development, they are often presented as value-free concepts, desirable because of their efficiency in bringing about other positive outcomes. Yet GDP is used as a proxy for anything valuable while being presented as a measurement devoid of any normative context. This contradiction is a true sleight of hand. Our economies and public policy solutions are skewed against human development precisely because of the way we tend to understand "value," giving GDP growth a central role, discounting the future and any social and environmental harm. This misguided view of value, which considers activities harmful to people and to the environment as creating value, also fails to account for the true value of social services, social protection mechanisms or public goods.

The role of scientific knowledge

Science, in relation to human development, can be conceptualized broadly to include not just natural, health and technical sciences but also knowledge from the social sciences, arts and humanities. Several voices emphasized the need to learn to readjust and rebalance the interactions among the three major systems that shape our civilization: human systems, earth systems and technological and infrastructure systems. Science is not well prepared. There still is far too little cooperation between the natural and the social sciences and between the humanities and the medical sciences. Nor do all those sciences interact well with technology and engineering. Dominant scientific traditions must become more prepared to question their categories, languages and assumptions, including the relationship between human and nonhuman natures, and more open to dialogue with diverse scientific and other knowledge cultures. Transdisciplinary approaches must be promoted to break down the institutional barriers and reconcile the different logics of public and private research and innovation to progress in badly needed dialogue.

NOTE

For more information and a full account of the contributions, see https://stories.council.science/stories-human-development/. The global dialogue's steering group comprised Peter Gluckman, President-elect, International Science Council; Melissa Leach, Director, Institute of Development Studies; Dirk Messner, President, German Environmental Agency; Elisa Reis, Vice President, International Science Council; Binyam Sisay Mendisu, Program Officer, United Nations Educational, Scientific and Cultural Organization–International Institute for Capacity Building in Africa, Associate Professor of Linguistics, Addis Ababa University, Member of the Global Young Academy; Asunción Lera St. Clair, Program Director, Digital Assurance, DNV GL – Group Technology and Research; Heide Hackmann, Chief Executive Officer, International Science Council; Pedro Conceição, Director, Human Development Report Office, United Nations Development Programme.

SPOTLIGHT 2.1

A tale told to the future

David Farrier, author of *Footprints: In Search of Future Fossils,* Professor of Literature and the Environment at the University of Edinburgh

Imagine you could tell a story that would last for nearly 40,000 years.

The Gunditjmara people of southeastern Australia have a tale of four giants, creators of the early Earth, who arrived on land from the sea. Three strode off to other parts of the country, but one stayed behind. He lay down, and his body took the form of a volcano, called Tappoc in the Dhauwurd Wurrong language, while his head became another, called Budj Bim. When Budj Bim erupted, so the story goes, "the lava spat out as the head burst through the earth forming his teeth."[1]

The story occurs in the Dreaming, the mythic time in which the world was made, according to indigenous Australian cultures. But we can also place it in geological time. The discovery of a stone axe beneath tephra layers deposited when Budj Bim erupted around 37,000 years ago suggests that humans were living in the area and therefore could have witnessed the eruption. It would have been sudden; scientists think the volcano might have grown from ground level to tens of metres high in a matter of months or even just weeks.[2] Other Gunditjmara legends describe a time when the land shook and the trees danced. Budj Bim could be the oldest continually told story in the world.[3]

Many indigenous Australian peoples are thought to have lived on the same land for almost 50,000 years.[4] It is difficult to imagine that life in the developed world, governed by the propulsion of technological innovation and the spasms of election cycles, is as deeply embedded in time. Yet the cumulative effect of our occupation will be a legacy imprinted on the planet's geology, biodiversity and atmospheric and oceanic chemistry that will persist for hundreds of thousands of years—and in some cases even hundreds of millions.

Nearly 1,500 generations separate us from the people who first told the story of Budj Bim 37,000 years ago. In 100,000 years, or 4,000 generations from now, the Earth's atmosphere might still bear a trace of the carbon dioxide added to it since the Industrial Revolution.[5] The biologist Edward O. Wilson observed that it took tens of millions of years for biodiversity to recover following each of the last five major extinctions. Recovery from the most recent, the Cretaceous, which saw off the dinosaurs along with 75 percent of plant and animal species, took 20 million years.[6] If the current extinction crisis reaches the same pitch of ruin, 800,000 human generations would pass before our descendants live in a world as rich in life as the one we are destroying.

The ancient Gunditjmara story tells of the land remaking itself; ours will tell of the world remade by human action, a presence written so deeply in time that it will far outstrip the Gunditjmara's oldest tale.

The incredible extent of our reach through deep time is perhaps best illustrated by contemplating the fate of our cities. The world's megacities are dense concentrations of durable, artificial materials such as concrete, steel, plastic and glass. These are some of the largest cities that have ever existed, and they are threatened by seas that could rise by up to a metre by the end of the century and continue to rise for several centuries more. Shanghai, home to 26 million people, has sunk by more than 2.5 metres in the last 100 years, due to groundwater extraction and the weight of its immense skyscrapers, built on soft, boggy ground.[7]

Some megacities lie in regions being uplifted by geological processes. Over time they will be worn away just as hills and mountains are eroded. But others stand on ground that is sinking. If the waters rise to cover these cities, they will begin a long descent into the Earth, and a slow, patient process of fossilization. Thick mud will wash through the streets and the ground floors of buildings, coating them in preserving sediment. For thousands of years, abandoned towers will slowly crumble until there is nothing left above the surface. Anything beneath the ground, however, will submit to pressure and time, condensing over millions of years into what geologist Jan Zalasiewicz calls "the urban stratum," a layer of artificial materials in the geologic record.[8] In the foundations of tall buildings, concrete and brick will demineralize, glass will devitrify and iron reacting with sulphides will acquire the golden sheen of pyrite. The remains of subterranean shopping malls will be punctuated by the fossil outlines of countless everyday objects, from bottle caps to bicycle wheels; miles of subway tracks, perhaps even the twisted remains of a train carriage, will be preserved. Much will be lost, but even a fraction of this abundance will be enough to give the precise outlines of city life as it was once lived.

Life today will become the palaeontology of the future. One hundred million years from now, a city like Shanghai could be compressed into a metre-thick layer in the rock, hundreds of kilometres down.[9]

However, we do not need to peer this far ahead in order to glimpse the world to come. The future is hurtling towards us, and it looks to be a lot like the deep past. There is nothing that resembles the coming climate in all of human history; the nearest analogue would be the mid-Pliocene, 3 million years ago, when atmospheric carbon last exceeded 400 parts per million. The current emissions trajectory could render climates more like the Eocene by 2150, "effectively rewinding the climate clock by approximately 50 My [million years], reversing a multimillion year cooling trend in less than two centuries."[10]

Global warming is "scrambling our sense of time," writes David Wallace Wells.[11] It both accelerates and unwinds history, compressing millennia of change into decades and stretching time so that carbon burned to serve a moment of convenience will linger in the atmosphere and influence the climate for thousands of years.

Even as things accelerate, the present contains much more time than we tend to think. The situation calls us to cultivate a deep time perspective. We need long-term thinking in how we use resources, how we design our cities, how we trade and travel; intergenerational minds that accept the claim of the unborn on how we live now. To do this, we need to think about the stories we tell, and those we listen to. In fact, to really develop a frame of mind that spans generations, we need to change how we think about stories altogether.

In *Transcendence,* her account of the evolution of human culture, Gaia Vince writes that the first stories were exercises in time travel, as the very first storytellers found it was to their advantage to direct the attention of the group to a threat or an opportunity that lay beyond the here and now.[12] Stories gave us time, shaping our capacity for narrative, which in turn shaped how we came to perceive the world, providing our ancestors with both a cultural memory bank and a predictive tool.

Stories provide both an inheritance and a window onto possible futures. What if we were to think of our material traces—our plastic waste or carbon emissions—not as the byproducts of a developed way of life, or even as the pollution that future generations will be forced to contend with, but as stories, as tales told to the future? Embracing this way of thinking would mean we were better placed to choose the kind of world we will pass on.

For too long we have listened to a single story, one in which land is only ever tap or sink and growth overthrows balance. It is essentially the story of a minority who, in pursuit of a particular way of life, put all life on the planet at risk. In *Braiding Sweetgrass,* botanist and member of the Citizen Potawatomi Nation Robin Wall Kimmerer recounts the Anishinaabe legend of the Windigo, who was transformed from a man into a creature of pure appetite. Ten feet tall, with lips chewed ragged and bloody by his insatiable hunger, the Windigo stalks people through "the hungry time" of winter. The more he eats, the greater his hunger becomes, Kimmerer says, so that the Windigo represents a kind of positive feedback. Today he walks wherever we find feedback loops, from melting permafrost accelerating warming by releasing methane, to melting ice darkening the poles and absorbing more heat. But perhaps the greater feedback loop is in the developed world's growth-driven economic model. "Windigo," Kimmerer writes, "is the name for that within us which cares more for its own survival than for anything else."[13]

Climate change confronts us with a fundamental truth: that our individual stories are braided with the stories of every living thing on the planet and of countless lives yet to be born. Decisions taken in the next decades will shape the story of life on Earth for generations to come. Like the graphs that plot different warming trajectories, 1.5, 2, 3 degrees Celsius or more, the threads of many different future Earths spool out from this moment. The thread we follow will connect us to people living decades, generations, even millennia in the future. It will determine whether our descendants will be riding in a tourist boat through the drowned streets of an abandoned Venice, fighting in water wars caused by the loss of Himalayan glaciers or fleeing with millions of others from storm, drought and flood or whether they will live in cities designed to be sustainable, in a world that is damaged but moving closer each day towards balance, in which fossil fuels, rather than megafauna, are a distant memory.

Climate change is also a matter of temporal equality. The human climate niche—the narrow climate window that permitted human societies to develop and flourish since the end of the last ice age—is closing, but not for all; or at least, not at the same time. Without action to arrest emissions, over the course of the next 50 years 1–3 billion people (overwhelmingly in the Global South) could be "left outside the climate conditions that have served humanity well over the past 6,000 years,"[14] as large parts of the planet would become uninhabitable. Already, the very worst effects of global warming are focused on some of the poorest nations.[15] By 2070 we could see a situation of global temporal apartheid, as the Global North continues (although probably only temporarily) to enjoy something like the world as human societies have always known it, while the Global South is exiled to a version of the planet unlike anything that humans have ever experienced before.[16]

Unheeding consumption cannot be the only story. Kimmerer also recounts the Mayan creation myth: When the gods set out to populate the Earth, they made a people of mud, who melted in the rain. Next the gods made a people of wood and reed, whose cleverness filled the world with made things but who lacked compassion in their hearts. So the gods made a people of light, who were so beautiful, and proud of their beauty, that they thought they could do without the gods altogether. Finally, the gods made a people from corn. These people could sing praise and offer gratitude to the world that sustained them; "and so," Kimmerer says, "they were the people who were sustained upon the earth."[17]

Indigenous peoples' creation stories, Kimmerer writes, imagine time as a lake rather than a river—a pooling of past, present and future. The story of the people of corn is both history and prophecy: which people are we, the people of wood or the people of corn, and which could we become?[18] It invites us to contemplate a different relationship to time; to realize that moment by moment the present in which we live is accompanied by the deep past and the distant future. Facing this reality is the first step to deciding which story we want to tell.

We enter this crucial period with life reconfigured by the Covid-19 pandemic. The human cost has been intolerable, and much of the world has yet to truly reckon with the challenge of living in the long term with the virus. But the disruption of the pandemic has also emphasized the scale of the environmental challenge. Despite the massive drop in heavy industry, air traffic and consumption, global greenhouse gas emissions will have declined by only 8 percent by the end of 2020,[19] roughly equivalent to the annual reduction we need to achieve between now and 2050 if we are to limit global mean temperature rise to 1.5 degrees Celsius.[20]

Still, the window has been opened, just a crack, on a world driven by care for the most vulnerable rather than by the illusion of infinite growth. "If a New World were discovered now, would we be able to *see it?*" Italo Calvino once asked.[21] We cannot help but acknowledge the new world before us. We are stewards of a story we did not begin, and we have no choice but to carry it forward. Yet we can also have a say in how the story goes.

Walter Benjamin writes of an Egyptian king, Psammenitus, who, according to Herodotus, was defeated by the Persians and made to watch as his people were led into slavery. He remained impassive even while first his daughter, then his son were led past. Only when he saw an old man, a former servant, stumble along at the procession's tale, did king's grief break over him. Successive generations have wondered why Psammenitus wept at the suffering of the old man and not at those closest to him, Benjamin recounts.[22] Future generations might also wonder how we could be unmoved by the procession of disaster, as the waves engulf low-lying nations, crops fail and whole regions become uninhabitable. Or might they tell the story of how, finally, we were shaken from our inertia by those at the tail end of the procession of development but at the frontline of climate change?

The world is a gift that we can only pass on. Every material and chemical trace, each remade landscape and coastline, is a tale told to the future, so long lasting it will resemble a kind of continuous occupation like that of the Gunditjmara. But the world does not stand still. Stories can be changed in the telling.

NOTES

1 Gunditjmara People and Wettenhall (2010), quoted in Matchan and others (2020, p. 390).

2 Gunditjmara People and Wettenhall (2010), quoted in Matchan and others (2020).

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14 Xu and others 2020, p. 11350.

15 UNFCCC 2018.

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Developing humanity for a changed planet

Gaia Vince, science writer and author of *Transcendence: How Humans Evolved through Fire, Language, Beauty and Time* and *Adventures in the Anthropocene: A Journey to the Heart of the Planet We Made*

For the endangered olive ridley sea turtle, life is a challenge faced alone. From the moment a clutch of eggs is deposited in a sandy beach pit, each embryo faces its own private battle for survival. The odds are stacked against it even surviving long enough to be born. During the turtle's 50-day gestation, the eggs are frequently damaged or dug up by dogs and birds or harvested by people for their value as a delicacy. Any hatchling that emerges undisturbed must then unbury itself and cross the open beach to reach the ocean—all without being eaten. Only a tiny percentage of turtle eggs will go on to become adults that live as long as 50 years.

What counts as a good life for the solitary olive ridley turtle? Perhaps, living long enough to successfully mate with one of the vanishingly few others of its type and producing living descendants. Perhaps it is to be pain-free; to escape boat damage, plastic pollution and fishing net entanglement; to be able to satisfy its hunger in overfished and depleted seas. Its existence is driven entirely by its biology and environment, a lifestyle of swimming, feeding and occasionally mating, that remains almost unchanged since the species evolved more than 30 million years ago.

Humans, though, are different. We, who wonder about the life lived by a turtle, want more for our own lives. We have become exceptionally good at survival, but this is not enough—it has never been enough for our species. Humans have needs and desires that go far beyond receiving an adequate number of calories. We want these needs to be met for ourselves and our families, but we also want this for strangers in distant lands whom we will never meet.

The needs, rights and desires of humans have changed and evolved over time, unlike those of the olive ridley turtle. But for both species, at its most fundamental, a good life rests on having a safe environment in which to thrive. For humans this includes not just the physical environment but also the social environment. We want people to be able to live a good life with their basic needs met, such as clean water and sanitation, and their human rights respected, such as access to education. We hope to achieve this and more for every human on Earth through "development."

What does human development mean? What does it mean to develop as a person? These are two different but entwined questions, and they go to the heart of what it means to be a human rather than, say, a turtle, on this rapidly transforming planet.

All life evolves as biology adapts to environmental pressures. This is how the turtle got its hard shell and we got our sweating skin. Over billions of years, a great diversity of life forms has evolved, each adapted for its niche within complex ecosystems in the grander biosphere. Deep in our ancestry, hominins diverged from the evolutionary path taken by all other creatures and pioneered a new type of development driven by cumulative culture. Just as genetic information is passed down through generations of families, humans also pass a whole suite of cultural information through societies and down the generations, including knowledge, behaviours, tools, languages and values. By learning from each other, teaching each other and relying on each other for resources, human culture ratchets up in complexity and diversity over generations to produce increasingly more efficient solutions to life's challenges.

In this way human cultural evolution allows us to solve many of the same adaptive problems as genetic evolution, only faster and without speciation. Our societies of cooperating, interconnected individuals work collectively, enjoying great efficiencies in the way they harvest energy and resources. It is our collective culture, even more than our individual intelligence, that makes us smarter than the other animals, and it is this that creates the extraordinary nature of us: a species with the ability to be not simply the objects of a transformative cosmos, but agents of our own transformation.

Our cumulative culture relies on an exceptional degree of cooperation and our ability to communicate and learn from each other. We are not just stronger together; we are utterly dependent on each other from birth. Human development took an evolutionary path that prioritized cooperation and group reliance instead of individual strength, as a way of getting the most energy and resources from our environment for the least individual effort.

Humans do not operate within their ecosystems in the same way as other species, even other top-level predators. We do not have an ecological niche; rather, we dominate and alter the local—and now, global—ecosystem cumulatively to suit our lifestyles and make it safer, including though habitat loss, introduction of invasive species, climate change, industrial-scale hunting, burning, planting, infrastructure replacement and countless other modifications. It means that while other species do not naturally cause extinctions, humans currently threaten 1 million of the world's 8 million species.[1]

Over tens of thousands of years, this has helped make us the most successful big species. Humans now operate as a globalized network of nearly 8 billion hyperconnected individuals. We have effectively become a superorganism in our interactions with the natural world. We now dominate the planet and have pushed it into the Anthropocene, the Age of Humans. No part of Earth is untouched by human activity. About four-tenths of the planet's land surface is used to grow our food.[2] We have interfered with most of the world's major river systems.[3] We have harnessed more than a quarter of the entire biological productivity of the planet's land.[4] Our material changes alone—including roads, buildings and croplands—weigh an estimated 30 trillion tonnes[5] and allow us to live in an ultraconnected global population that is heading for 9 billion.

In changing the Earth we have been able to live longer and healthier than ever before. Through human development, a 72-year-old Japanese man today has the same chances of dying as a 30-year-old caveman.[6] The chance of a child dying before age 5 has declined five-fold since 1950, and the number of women dying in childbirth has been almost halved globally since 1990.[7] In many ways the world is becoming safer for a human to live and grow up in, due largely to harnessing energy, modern medicine and affordable, plentiful food.

We have made the planet safer for humans in a number of ways, but we have also made it worse: depleting its resources, killing its biodiversity, polluting it with waste and straining its capacity to support us. We have added hundreds of billions of tonnes of carbon dioxide to the atmosphere since industrialization—we currently add at least 36 billion tonnes a year[8]—progressively heating the planet, producing stronger storms, with extreme and erratic weather (including droughts and floods), sea level rise, melting ice caps, heatwaves and wildfires, all of which directly threaten the safety of humans or the ecosystems we rely on.

In 2019 nation-sized wildfires blazed across the northern hemisphere and Australia. Summer heatwaves produced temperatures above 45 degrees Celsius in Europe[9]—and above 50 degrees Celsius in Australia,[10] India and Pakistan[11]—breaking temperature records and killing hundreds of people. Heatwaves and intense rains boosted giant swarms of locusts, the size of New York City, which have since devastated crops from Kenya to Iran. Meanwhile, Arctic sea ice has melted to its second lowest extent in the 40-year satellite record,[12] alongside alarming melting of Greenland's ice sheet. A crippling drought coupled with poor infrastructure in Chennai, India—home to 10 million people—caused water shortages so severe that there were street clashes.[13] Meanwhile, the heaviest monsoon in 25 years produced catastrophic floods and the loss of at least 1,600 lives across 13 Indian states; in Kerala more than 100,000 people had to be evacuated. In September Hurricane Lorenzo became the largest and most powerful hurricane to make it so far east in the Atlantic that it reached Ireland and the United Kingdom,[14] just weeks after Hurricane Dorian devastated the Bahamas. This is the best scenario we can hope for if we reduce our carbon emissions to net-zero; if they continue to climb, it will only get worse.

No one decided to heat the planet and degrade our natural environment; it emerged from our collective cultural evolution. Human development has made us healthier and wealthier but also ushered in a global social system that constrains us. The environmental problems we face are systemic: a mixture of physical, chemical, biological and social changes that all interact and feed back on each other. Trying to understand how our impacts in one area, such as river extraction, affect another, such as food provision, is a complex task. But while our problematic practices in one area can impact many other areas, the good news is that so can our restorative ones: improving biodiversity in a wetland ecosystem can also reduce water pollution and soil erosion and protect crops against storm damage, for instance.

Earth's biosphere operates systemically, but so does human culture. Our numbers, how we are networked and our position in this network of humanity as individuals and societies, all produce their own effects. This is important because human interactions with their ecosystems are culturally driven. We attach subjective values to things of no or little survival value, such as gold, mahogany and turtle eggs. And we spread these invented values through our networks, just as we spread our resources, genes and germs. We are each individuals with our own motivations and desires, and yet much of our autonomy is an illusion. We are formed in our society's cultural "developing bath," which we will ourselves then help fashion and maintain—a grand social project without direction or goal that has nevertheless produced the most successful species on Earth.

In some societies humans are understood as part of the ecosystem they inhabit, an integral player like the fish or turtle. In others humans are part of an economic and social system that is seen as separate and external to nature. Many economic and development models, including the Human Development Index, do not factor in the environment or nature at all. Meanwhile, many societies measure progress or development with the gross domestic product metric, which does not value the biodiversity of the river or the cleanliness of the beach, only the price the fish or eggs obtain in a formal market. In reality the human economy is a wholly owned subsidiary of the environment, not the reverse.

Human development is ongoing, of course. It is possible for people in prosperous countries to order food from an app in air-conditioned comfort only because their recent ancestors developed by exploiting the natural wealth of other places and people. Rich nations continue to import resources from poorer nations, offloading the environmental damage of global consumption onto the people with the least power. As each generation of nation develops, this pattern has been followed, with richer Asian countries importing materials at the environmental expense of poorer Asian and African nations. But the poorest nations will have nowhere else to exploit. Earth, we are realizing, is finite.

Thus far, a key feature of human development has been inequality. By contrast, for most of our ancestry, the evidence suggests we lived as equals—today's hunter-gatherer communities are notable for their lack of social or gender-based hierarchies. However, as people began settling, and it became possible to own and store more resources, and the land itself, hierarchies developed, and people became valued according to the amount of stuff they possessed. Although the numbers living in extreme poverty have fallen, today's global inequality is at record levels, with 40 percent of total wealth in the hands of billionaires and nearly half of humanity living on less than $5.50 a day.[15]

This matters because the richest people in the world are doing the most to damage the environment that we all rely on for clean air, water, food and other resources. Yet they experience few consequences and the least danger from this environmental damage. The richest 10 percent of the world's population are responsible for half of carbon emissions, while the poorest 50 percent are responsible for just 10 percent.[16] At the same time the wealthiest people contribute less socially, paying in the least to the collective pot. In relatively equal Scandinavia the richest 0.01 percent illegally evade 25 percent of the taxes they owe, far higher than the average evasion rate of 2.8 percent.[17] In the United States the richest 400 families pay a lower effective tax rate than any other income group.[18] An estimated $9–$36 trillion is stored in tax havens around the world.[19] Delivering social justice and protecting the environment are closely linked: How poor people get rich will strongly shape the Anthropocene.

A useful thought experiment is to imagine you are in an antechamber waiting to be born, but first you must create the global society in which you will live. You do not know who you will be born as (what sex, skin colour, wealth, or nationality you will be or what skills or intelligence you will possess) or where you will be born (with rich soils and clean rivers or with toxic ponds and filthy air). Would you design today's world with its palaces and slums, knowing you are far more likely to end up in a slum with no sanitation than with a gold-plated toilet bowl?[20]

In 2015 UN Member States agreed to 17 Sustainable Development Goals (SDGs) for 2030 in a plan to achieve a better future for all, recognizing that all our needs are intertwined with each other's and with our environment. The SDGs seek to address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. We are a third of the way to 2030, and despite progress in some areas, progress in others has been too slow or has even been reversed. For instance, even though extreme poverty has reached its lowest point since monitoring began, we are still not on track to end it by 2030; meanwhile, malnutrition rates are creeping upwards again for the first time in years, even as the amount of food produced per capita increases. The unequal impacts of the Covid-19 pandemic may push a further 100 million people into extreme poverty, effectively wiping out progress made since 2017 and exacerbating child hunger.[21]

So perhaps we should now ask what does it mean to develop as a person? Every human life begins small, vulnerable and dependent on others, as we slowly mature physically, cognitively and socially throughout our lives. For a human to thrive, she needs a safe physical environment that does not risk her health and a safe social environment that does not constrain her potential. The two are linked: Life-path studies suggest that socioeconomic circumstances are embedded in our biology—disadvantage does not just make life worse; it makes it shorter. Humans are now the main driver of planetary change, and human systems must be targeted to do something about it. That means addressing societal systems, including populism, finance and information transmission, alongside the practices and technologies that emit polluting gases, from fossil fuel burning to food production.

As individuals there is little we can do about glaring inequalities of opportunity, climate change and environmental degradation—these are systemic issues that will be solved only through large-scale structural change. But even such major reformations of how society functions start with the individual agency of voters, consumers, gardeners, parents and witnesses. We are a vast global population facing unprecedented environmental challenges, yet we still have the time and capability to prevent extreme outcomes, such as runaway climate change and wildlife extinctions. Even if some environmental changes feel too locked in or overwhelming to reverse, we have the power to change the social justice systems that underlie and manage their impacts on us.

We cannot protect our environment unless we also protect the needs of the humans that rely on it. Take the illegal trade in wildlife, which is worth an estimated $19 billion a year[22] and threatens the stability of governments as well as human health—some 75 percent of infectious diseases have zoonotic origins,[23] including Covid-19.[24] This trade is often conducted by well organized criminal networks that undermine government efforts to halt other illegal trades, such as arms and drug trafficking, and help finance regional conflicts.

In the past 20 years the population of olive ridley turtles has fallen by a third. Around the world females are slaughtered on the beach for their meat, skins and shells, and their eggs are traded as a valuable delicacy. One of the species' few remaining nesting sites is Ostional beach in Costa Rica, home to a poor village wedged on the coast between mountains and rivers and entirely cut off during seasonal floods. The villagers once subsisted on fishing and turtle eggs but stopped after egg-harvesting was prohibited by international conservation laws. Many villagers deserted Ostional to find work in the cities; those who remained lived in fear as it became besieged by poachers and violent criminal gangs.

In desperation, women from the village banded together to form the Ostional Development Association and approached biologists studying the turtles to see whether there was a way to legalize egg collecting within sustainable parameters. A plan was drawn up with the government to allow families to harvest a limited number of eggs, and as part of the agreement, the community cleans the beach, protects the turtles and their eggs from poachers and manages the many tourists that now descend on Ostional during monthly egg-layings. The eggs harvested are licensed for sale at the same price as chicken eggs to deter the black market, and the proceeds are used for community development projects. Egg licencing has given people a living wage and paid for training, maternity cover and pensions. Residents have a vested interest in protecting eggs and turtles,[25] and the population of baby turtles has risen, while other wildlife has returned.[26] People, too, are returning to the village and making new lives for themselves.

As we negotiate a path between the needs of the human and natural worlds, Ostional shows us that resilience relies on recognizing the interdependence of the two. To protect wildlife, you must also protect human life. Our environmental crisis is a test of our uniquely human development, of our ability to come together, cooperate and adapt to a different way of sharing this one planetary home. We live in our own small local environments that we can ourselves defile, restore or enhance. Each is a part of the bigger whole, just as we are part of a bigger humanity.

NOTES

1 United Nations 2019c.
2 Ramankutty and others 2008; World Bank 2016a.
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7 Roser, Ritchie and Dadonaite 2013.
8 Friedlingstein and others 2019b; Ritchie and Roser 2020.
9 Pacorel 2019.
10 Government of Australia 2019.
11 NASA Earth Observatory 2019.
12 Witze 2020b.
13 Yeung and Gupta 2019.
14 Fortin 2019.
15 Oxfam 2020.
16 See spotlight 7.2. See also Chakravarty and others (2009), Kartha and others (2020) and SEI (2020).
17 Alstadsæter, Johannesen and Zucman 2019.
18 Saez and Zucman 2019.
19 Shaxson 2019.
20 Rawls 1971.
21 On poverty, see World Bank (2020c); on child hunger, see Fore and others (2020).
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SPOTLIGHT 3.1

The future we want—the United Nations we need

Perspectives from commemorations of the 75th anniversary of the United Nations

Across this anniversary year, we have engaged in a global conversation. And the results are striking. People are thinking big—they are also expressing an intense yearning for international cooperation and global solidarity. Now is the time to respond to these aspirations and realize these aims. In this 75th anniversary year, we face our own 1945 moment. We must meet that moment. We must show unity like never before to overcome today's emergency, get the world moving and working and prospering again, and uphold the vision of the Charter.

UN Secretary-General António Guterres

In January 2020 UN Secretary-General António Guterres launched the UN75 initiative, not as a celebration but as the world's largest conversation about current global challenges—and the gap between the future we want and where we are headed if current trends continue.

Through formal and informal surveys and dialogues held around the world, the exercise took stock of global concerns and gained views on what sort of global cooperation is required. It was also intended to reimagine the UN role in addressing global challenges.

To date, more than 1 million people in all UN Member and Observer States have taken the one-minute survey, and more than 1,000 dialogues have been held in 82 countries. In addition, 50,000 people in 50 countries took part in independent polling by Edelman and the Pew Research Center, and artificial intelligence analysis of social and traditional media was conducted in 70 countries, along with academic and policy research mappings in all regions.

Together, they represent the most ambitious attempt by the United Nations to undertake a global reality check and hear from "we the peoples" on their priorities and suggested solutions to global challenges, providing unique insights into the future we want and the United Nations we need.

The key findings align with the main topics of the 2020 Human Development Report, including people's concern for both climate and social issues such as poverty and inequality as well as the importance of multilateralism and global cooperation. The findings identify some optimism for the future and belief that we can improve current social and planetary trajectories though stronger global leadership, innovation and inclusiveness in the multilateral arena.

Ten key findings

1. Amid the Covid-19 pandemic the immediate priority of most respondents everywhere is improved access to basic services: health care, safe water and sanitation, and education.

2. The next main priority is greater international solidarity and increased support to the places hardest hit by the pandemic. This includes tackling poverty, reducing inequalities and boosting employment.

3. Respondents were hopeful about progress in access to public health services. They also believe access to education and women's rights will improve.

4. Respondents' priorities for the future corresponded to the areas they believe will worsen. Most participants across all regions are worried about the future impact of climate change. The most overwhelming medium- and long-term concern is our inability to stem the climate crisis and the destruction of the natural environment.

5. Other major priorities for the future include ensuring greater respect for human rights, settling conflicts, tackling poverty and reducing corruption.

6. Younger participants and participants in developing countries tended to be more optimistic about the future than older participants and participants in developed countries.

7. Some 87 percent of respondents believe international cooperation is vital to deal with today's challenges. And the majority of respondents believe the Covid-19 pandemic has made international cooperation even more urgent.

8. About 60 percent of respondents believe the United Nations has made the world a better place, and 74 percent see the United Nations as essential in tackling global challenges. At the same time over half see the United Nations as remote from their lives and say they do not know much about it. Moreover, while just under half currently see the United Nations as contributing somewhat to advancing key global challenges, only about a third see it as contributing a lot in this regard. The United Nations is perceived to be contributing most to upholding human rights and promoting peace.

9. Dialogue participants overwhelmingly called for the United Nations to be more inclusive of the diversity of actors in the 21st century. They identified in particular the need for greater inclusion of civil society, women, young people, vulnerable groups, cities and local authorities, businesses, regional organizations and other international organizations.

10. Dialogue participants also called for the United Nations to innovate in other ways, with stronger leadership and more consistency in exercising its moral authority to uphold the UN Charter. There were calls for increased accountability, transparency and impartiality, including through better engagement and communication with communities, as well as strengthening implementation of programmes and operations.

NOTE

The UN75 initiative gathered the data synthesized here through five channels between January and August 2020. This spotlight reflects the analysis of more than 800,000 survey responses collected between 2 January and 1 September 2020. It also analyses more than 1,000 dialogues in 82 countries with groups representing street children, indigenous peoples, grassroots activists, youth networks, nongovernmental organizations, schools and universities, cities and local authorities, and businesses. It also includes an analysis of a survey by Edelman, a global communications firm, of 35,777 people in 36 countries as well as a Pew survey of 14,276 adults ages 18 and older.