CHAPTER

6

Building nature-based human development

Building nature-based human development

So far, the focus has been on norms, incentives and regulation.

But what can the flourishing of nature itself contribute to advancing human development in the Anthropocene?

As this chapter argues: a lot. It makes the case for nature-based human development and for the cumulative impacts that local initiatives can have at global levels. It highlights the contributions indigenous communities around the world are making every day to protect the planet.

Social norms and incentives can be harnessed for transformational change, and so can a new generation of nature-based solutions—actions to protect, sustainably manage and restore ecosystems while simultaneously promoting wellbeing.[1] These are a manifestation of people empowered in ways that enhance equity, foster innovation and are rooted in a sense of stewardship of nature (figure 6.1).

Nature-based solutions are typically bottom-up, with a proliferation of new initiatives in different contexts. They often rely on the participation and initiative of indigenous peoples and local communities. They are implemented across countries at all levels of human development and are nested in social and economic systems, complementing human-made engineered solutions.

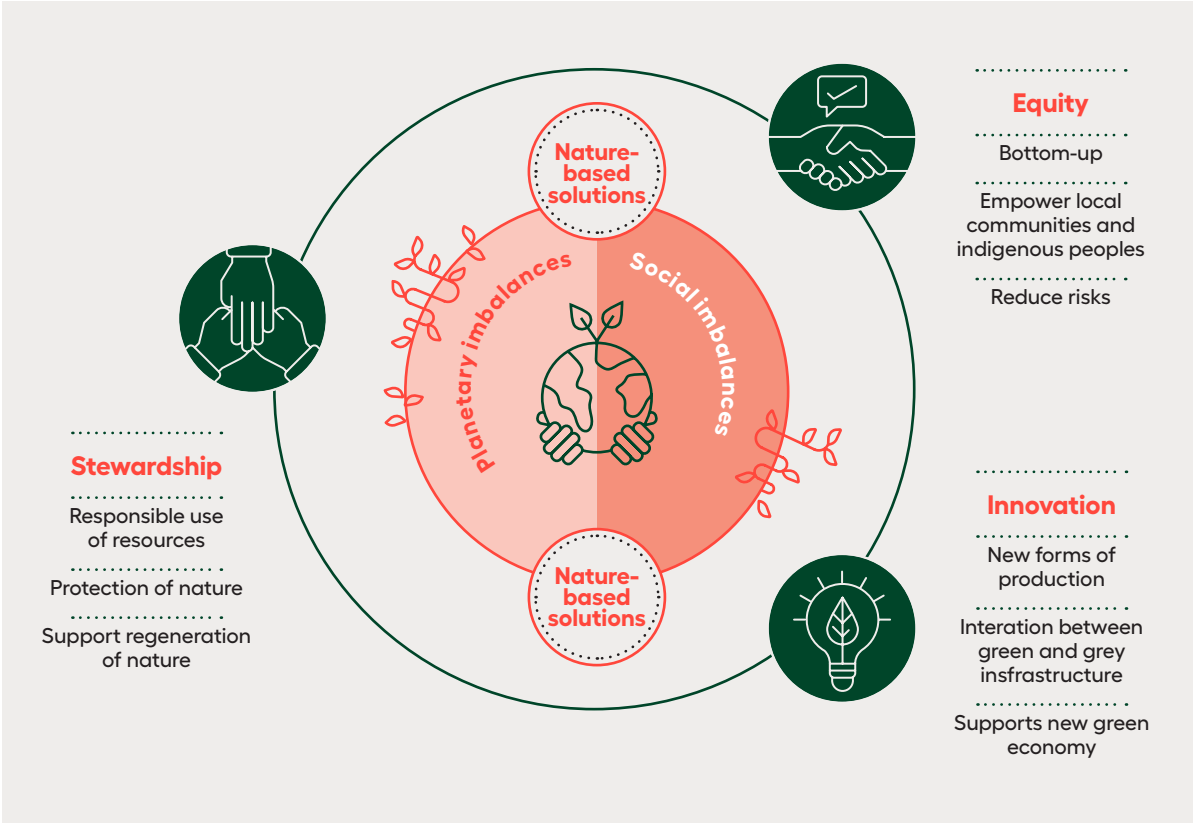
When local becomes global

Local nature-based solutions have the potential to contribute to transformational change, even at the global level—for two reasons. First, many local and community decisions can add up to substantial global impact. Second, planetary and socioeconomic systems are interconnected, and local decisions can have impacts elsewhere and at multiple scales.

As an illustration of the first effect, consider how a set of 20 cost-effective actions across global forests, wetlands, grasslands and agricultural lands can provide 37 percent of the mitigation needed through 2030 to keep global warming below 2 degrees Celsius above preindustrial levels and 20 percent of the mitigation needed through 2050 (figure 6.2).[2] About two-thirds of that mitigation potential is linked to forest pathways.[3]

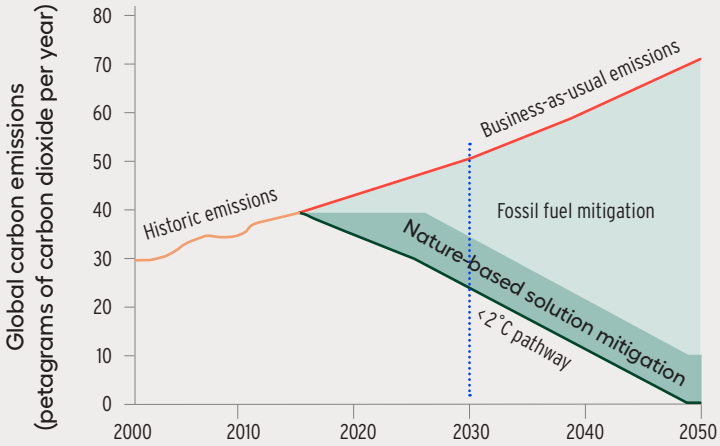
And for the second effect, consider the decisions in small-scale, coastal aquaculture—perhaps the world's most vibrant food sector today, especially in Southeast Asia (figure 6.3).[4] Coastal aquaculture puts stress on land (due to the need for terrestrial crops for feed) and on the local environment (destroying coastal vegetation—mangroves, in particular) in ways that scale up to the national or even global level (by incubating diseases that may spread to other species

Figure 6.1 Nature-based solutions and the potential for a virtuous cycle between people and planet



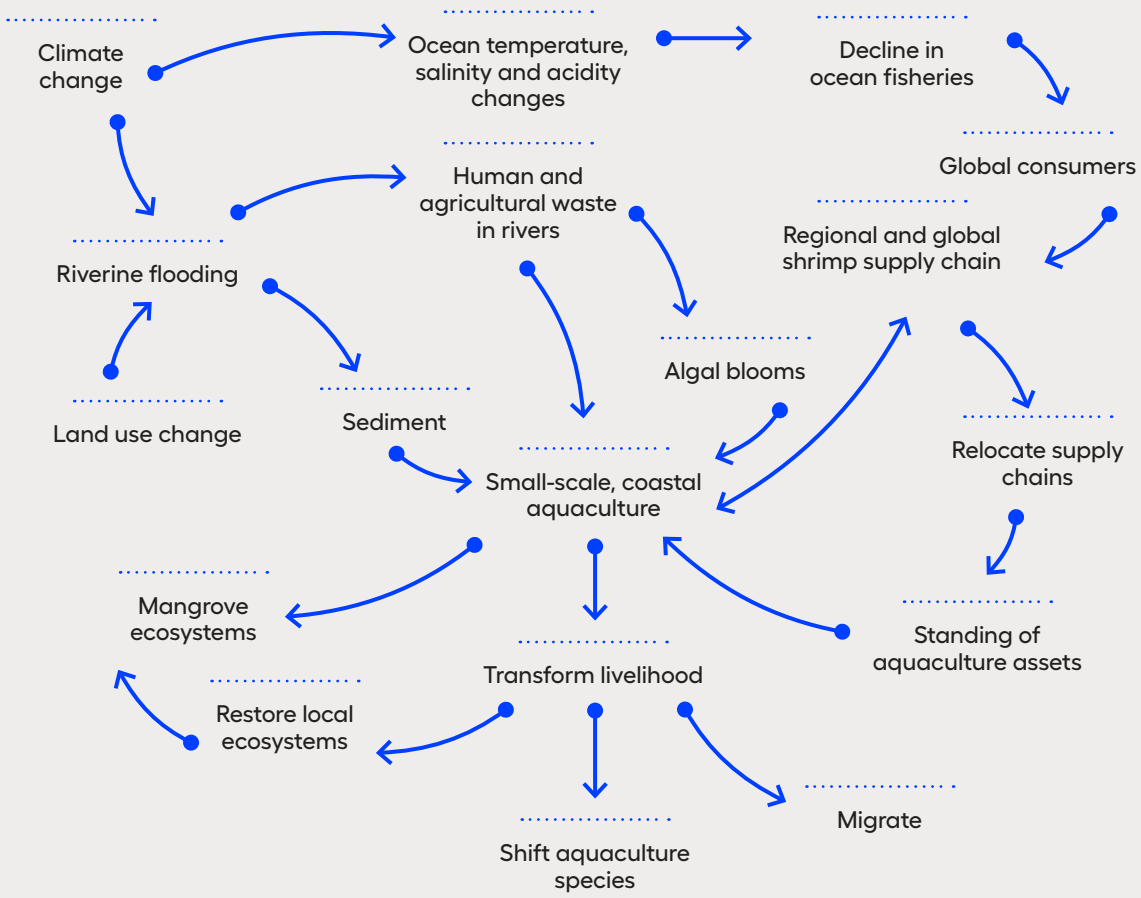
Source: Human Development Report Office.

Figure 6.2 Twenty nature-based solutions can provide some of the mitigation needed to restrain global warming



Source: Griscom and others 2017, figure 2.

Figure 6.3 The local and the global are deeply interconnected



Source: Keys and others 2019, figure 3b.

and by using antimicrobials in ways that cause resistance). But aquaculture practices that provide livelihoods and better address these risks can have regional and global benefits. This is part of the more general pattern of telecoupling: the global interconnection of ecological and social systems (box 6.1).

A systematic approach to nature-based solutions can leverage their potential for large-scale transformative change—what this chapter calls "nature-based human development."

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The next section provides evidence on how nature-based solutions are being implemented and the ways they advance human development while protecting ecosystem integrity. The final section addresses the potential to turn a cloud of fragmented solutions into an integrated system of nature-based human development, underscoring the role of indigenous peoples and local communities. This systemic integration requires structural support, involving the coordination and contributions of various actors and institutions so that nature-based solutions not only provide multiple benefits to multiple stakeholders but are also harnessed for transformative change at the global scale.

Box 6.1. Telecoupling between Indian farmers and rainfall in East Africa

How do the agricultural practices of farmers in India affect rainfall in East Africa? The link is atmospheric moisture recycling, the process of evaporation in which water enters the atmosphere, travels along prevailing winds and falls as rain elsewhere. Farmers in India rely on groundwater for irrigation. This water then evaporates into the atmosphere, where it is carried to East Africa to fall again as rain. This process could be interrupted if groundwater were unexpectedly and rapidly drained. In other words, Indian farmers might unexpectedly discover that their groundwater pumps cannot reach the water table any longer, leaving them unable to irrigate their fields. This could eliminate the supply of evaporated water and lead to a substantial decline in rainfall in East Africa, with corresponding consequences for the productivity of local ecosystem services—for example, water for animals, agriculture and trees. Such an interruption in rainfall could also have regional impacts: It might trigger migration and conflict over resources. An unexpected outcome could be the loss of livestock in Somaliland.

Source: Galaz, Collste and Moore 2020.

Avoiding biosphere integrity loss, empowering people

Nature-based solutions show that human development can be advanced while safeguarding the integrity of ecosystems. This section describes how nature-based solutions are helping manage risks from natural hazards, improve water availability and quality and enhance food security.

Managing risks from natural hazards

Natural hazards such as heat waves, severe flooding, storms, landslides and droughts drive risks that affect migration, urbanization, inequality and the degradation of ecosystems, including soil erosion.[5] A hazard combined with exposure and vulnerability becomes a risk that can cause loss, damage and death.[6] Worldwide the number of disasters linked to natural hazards has increased by 75 percent over the past 20 years.[7] In the past two decades these disasters have affected more than 4 billion people, claiming 1.23 million lives and causing close to $3 trillion in economic losses.[8] Disasters are one of the main triggers of displacement, with almost 23 million people displaced on average every year as a result of natural hazards in 2009–2019.[9] Actions for national and local disaster risk reduction strategies are thus crucial, as called for by the Sendai Framework (box 6.2).

The role of ecosystems in reducing risks from disasters has been widely recognized in recent years as climate change has increased the frequency, intensity and magnitude of natural hazards.[10] In this context, maintaining ecosystem integrity can provide cost-effective measures that, if complemented by other policies, can enhance community preparedness and resilience.[11] It is an investment: In the United States every $1 spent on preparedness saves $4 in natural

Box 6.2 The Sendai Framework

Disaster risk reduction has been as a global policy priority since the late 1980s. In March 2015 in Sendai, Japan, UN member states adopted the Framework for Disaster Risk Reduction, laying out a voluntary pathway for reducing risks from natural hazards during the following 15 years. The framework, following the Hyogo Framework for Action 2005–2015, was signed in the same year as the Sustainable Development Goals. Although the Hyogo Framework led to more proactive and coordinated international efforts to reduce disaster risk, the achievements were uneven across countries. The Sendai Framework renewed the sense of urgency with seven targets: reduce global disaster mortality, reduce the number of affected people globally, reduce direct disaster economic loss as a share of global GDP, reduce disaster damage to critical infrastructure and disruption of basic services, increase the number of countries with national and local disaster risk reduction strategies, enhance international cooperation to developing countries and increase the availability of and access to early warning systems and disaster risk information.[1]

In the first five years of the agreement, countries were to shape national and local strategies to implement in the next 10 years. This year, 2020, is the deadline, requiring immediate and focused action to reduce natural disaster risk. The main challenge for the next 10 years revolves around international coordination, since the framework's targets are collective.

The Covid-19 pandemic adds another layer to the challenges but can also be used as an example of country capacities in risk management. The Sendai Framework mechanisms and strategies for disaster resilience can complement and enhance current responses to the Covid-19 pandemic.[2] The Sendai Framework treats epidemics and pandemics explicitly as biological hazards that can lead to disaster. Several aspects of the framework can be used in responding to biological hazards, such as risk assessment (to have stronger knowledge of the crisis), multistakeholder and regional coordination mechanisms, the resilience of critical infrastructure and the preparation of inclusive recovery plans. Finally, social systems and links shape community perceptions of risk,[3] so community-based models for disaster risk reduction can be applied for Covid-19 assessment, preparedness and management, important in reducing deaths and losses from natural hazards.

Notes
1. Mysiak and others 2016. **2.** Djalante, Shaw and DeWit 2020. **3.** Scherer and Cho 2003.

disaster costs,[12] and the ratio is higher for flooding and hurricane-related disasters.

Green areas to manage extreme temperatures risk

Heat waves, a dangerous natural hazard, killed more than 166,000 people between 1998 and 2017. About 125 million more people faced exposure to heat waves in 2016 than in 2000.[13] Besides being lethal, heat waves can cause fatigue, nausea, dehydration and heat stroke and aggravate chronic respiratory diseases. Patients with mental health issues could be at higher risk of heat-related morbidities and undesirable effects of psychiatric medications.[14] Risks are also expected from vectorborne and waterborne diseases and through malnutrition, given the expected impacts on food security.[15]

> "Nature-based solutions can mitigate the health impacts of extreme weather.

Extreme heat events are particularly severe in cities because they become urban heat islands. Buildings, roads and other structures absorb and re-emit the sun's heat typically more than natural landscapes do. Areas with a higher concentration of these structures and limited greenery become islands of greater heat than other areas.[16] Due to urban heat islands, urban populations, particularly more vulnerable social groups, face greater health risks from heat exposure than rural populations do.[17] Nature-based solutions can mitigate the health impacts of extreme weather.

Cooling systems, such as air conditioning, are often used to cope with extreme temperatures, especially during heat waves. Since parts of the population cannot access or afford air conditioning systems

(which can triple annual energy costs for heating and cooling), this solution can exacerbate inequalities in exposure to heat waves. And air conditioning aggravates the underlying cause of extreme temperatures by releasing heat energy into the outdoor environment of the city and hindering the natural cooling that happens after sunset. It creates a vicious cycle in which the mechanism to cope with heat waves contributes to extreme temperatures.[18]

A viable and effective nature-based solution to mitigate the effects of urban heat islands is to create, restore and protect vegetation within cities. Evapotranspiration draws heat from the air, naturally decreasing the temperature of surrounding areas. Plants and trees absorb solar radiation and shade the ground beneath, and trees affect wind and can reduce heating energy in winter by shading wind. Vegetation also assimilates carbon dioxide and produces oxygen, lowering greenhouse gas concentration in the atmosphere.[19] Thus, green spaces such as urban parks and forests are an effective way to both cope with the effects of urban heat islands and mitigate anthropogenic planetary pressures.

> "Conserving forests and other vegetation can help with both rapid- and slow-onset disasters, since vegetation reduces the risk of landslides after earthquakes and during droughts.

Multiple studies have documented the effects of urban green areas on cooling cities. In Nagoya, in central Japan, temperatures were up to 1.9 degrees Celsius higher in urban areas than in green areas. Differences were larger during the day than at night, and greater during the summer. In the winter temperature differences fell due to the loss of tree foliage, which reduces shading and evapotranspiration, causing a relative increase in green space air temperature and a decrease in differences with urban area temperatures. The cooling effect of green areas appeared to extend 200–300 metres from the green area into urban areas at night and 300–500 metres during the day.[20] A study in London assessing the cooling effects of a large urban green space found that the mean temperature difference between urban and green spaces was about 1.1 degrees Celsius in the summer—and as much as 4 degrees on some nights—with the estimated cooling reaching 20–440 metres into the urban area.[21] Studies of the physiological equivalent temperature, which describes human thermal perceptions and is used as an indicator of human comfort under temperature variation,[22] showed considerable impacts of urban green spaces. In the Yunan Dynasty City Walls Relics Park in Shanghai, China, the physiological equivalent temperature fell by 2 degrees Celsius on average and by up to 15.6 degrees at 14:00 on a hot summer day in August. The biggest factor reducing the physiological equivalent temperature was the presence of high trees.[23]

Ecosystems for disaster risk reduction

Ecosystem-based disaster risk reduction is the sustainable management, conservation and restoration of ecosystems to reduce disaster risk.[24] Conserving forests and other vegetation can help with both rapid- and slow-onset disasters, since vegetation reduces the risk of landslides after earthquakes and during droughts.[25] Wetlands are critical to regulating and controlling floods and drought.[26] Coastal vegetation such as sand dunes and mangrove forests can prevent damage to crops by coastal storms.[27]

Sustainably managing ecosystems in seas, wetlands and rivers can boost fish stocks, support livelihoods dependent on fisheries, reduce the risks of flooding and benefit tourism and the economy. Oyster and coral reefs, salt marshes, dunes, barrier islands, floodplains, wetlands, forests and mangroves are natural defenders and can reduce the risk of a hazard turning into a disaster by protecting the shoreline against storms, winds and erosion; bolstering food security; and providing a high level of carbon storage.[28] For example, in the Gulf of Nicoya in Costa Rica, where 34 percent of the mangrove forests are threatened by agricultural expansion,[29] Conservation International started a mangrove restoration project, building capacity and creating an education programme so local stakeholders could replant mangroves.[30] Other countries have recently implemented innovative approaches to manage risks, expanding the use of insurance mechanisms (box 6.3).

Ecosystem-based disaster risk reduction can be leveraged by empowering women, drawing on their risk awareness, social networking practices, extensive knowledge of their communities and tasks related to managing natural environmental resources and

Box 6.3 The first reef insurance policy to protect coastal communities in Mexico

Hurricanes Emily, Stan and Wilma hit the Caribbean coast of Mexico in 2005, causing about $8 billion in damage, closing restaurants and hotels in an area whose income depends mostly on tourism.[1]

But one of the ports, Puerto Morelos, protected by its coral reef, suffered less damage. A healthy coral reef can reduce the energy of a wave by 97 percent (the reef crest alone reduces it by 86 percent),[2] so waves are much less destructive when they reach the shoreline. Coral reefs can provide similar or better wave attenuation than artificial defences such as breakwaters.

But coral reefs can also be damaged or destroyed by natural hazards such as storms and by pollution, overfishing and bleaching—as of 2018, 50 percent of Mexico's reefs were in poor or critical condition.[3] Since this destruction compromises the safety of coastal communities and their livelihoods, in 2018 the Nature Conservancy, the insurance company Swiss Re and Mexico's state governments partnered to protect the coral reefs in the Yucatan Peninsula.[4] Several reefs were at risk of dying because of pollution and storm damage.

The partnership offers an insurance solution. The state of Quintana Roo established the Coastal Zone Management Trust in 2018 to manage funds collected for coral reef maintenance and reconstruction. In 2019 the trust purchased the first coral reef insurance policy in the world.[5] The policy will ensure the repair of coral reefs after severe storms, providing the community the financial resources to manage the reefs and prevent erosion to coastlines. The policy covers six municipalities and 160 kilometres of coastline, including the city of Cancún and the municipality of Puerto Morelos.

Key lessons of this experience are the opportunity to use financial mechanisms to protect nature and the importance of different stakeholders collaborating. Such initiatives have important implications for the 840 million people around the world who live with the risk of coastal flooding and for economies that rely on tourism (coral reef tourism generates $36 billion a year).[6] Similar partnerships are being considered in Asia, Australia, the Caribbean and the United States.

On Mexico's Caribbean coast, volunteer squads of divers are learning to repair the coral reefs that shield the shore. The Nature Conservancy gathered fishers, researchers, hotel owners, tour operators, local government representatives and coral specialists and designed a training course for volunteers to repair reefs and the surrounding infrastructure. The divers learned skills such as using pneumatic drills underwater and inserting metal rods to keep larger pieces of reattached coral in place, setting them like broken bones. They practised with cement and marine epoxy on pieces of dead coral and learned to inflate nylon lift bags to move large pieces of coral and storm debris.[7]

Notes
1. Healthy Reefs 2020. **2.** Ferrario and others 2014. **3.** Healthy Reefs 2020. **4.** Swiss Re Group 2019. **5.** The Nature Conservancy 2019b. **6.** The Nature Conservancy 2019b. **7.** Smith 2018.

caring for the community. In Nepal climate change is associated with rainfall variability that has increased the risk of floods, affecting water and food scarcity. The US Agency for International Development, in partnership with the World Wildlife Fund and CARE International, started the Hariyo Ban Program in 2011 to help the government work with civil society to use existing ecosystems to build resilience to floods and landslides through natural resource management groups.[31] More than 12,000 women were supported and empowered to ensure their meaningful representation in decisionmaking, and the groups' internal governance was led mostly by women (70 percent).[32]

Biodiversity contributes to resilience

Biodiversity has a role in reducing disaster risk, fostering ecological resilience and enhancing ecosystem protective functions and community resilience. For instance, seagrass ensures the generation of oxygen, affects fisheries' efficiency and captures sand, dirt and silt particles, thus improving water quality. Its roots trap and stabilize sediment, reducing erosion and buffering the coastline against storms. Indonesia is home to the world's largest concentration of seagrass—more than 30,000 square kilometres, 10 percent of the world's seagrass.[33] But only 40 percent of Indonesian seagrass is healthy.[34] In

2013 researchers from the University of California, Davis, and Hasanuddin University started a pilot programme for restoring seagrass in Sulawesi, Indonesia, by transplanting different combinations of seagrass species to determine which performed best.[35] The survival and coverage of seagrass increased with the number of species transplanted, signalling that species richness can be important for restoration.[36]

Africa is home to crop diversity that reduces the potential impact of climate stressors and is adaptive,[37] as different genotypes create more resistance to changing conditions.[38] But diversity losses have been reported in crop varieties, mainly because of improved varieties displacing local ones. In Burkina Faso and Mali sorghum and millet face genetic erosion given high rainfall variability, among other factors.[39] Bioversity International partnered with local governments and universities in Burkina Faso, Mali and Niger in a project to encourage farmers to experiment with and evaluate diverse crop varieties. The project trained farmers in producing quality seed to adapt to local conditions.[40] Several farmers have formed their own seed production groups and set up community seedbanks.[41] In Mali the project continued without external financial support, and local community leaders have integrated the approach into development plans.[42]

Improving water availability and quality

While water covers 70 percent of the Earth's surface, less than 1 percent is available as freshwater.[43] This vital resource is under increasing pressure from households and productive activities.[44] Global water use has risen sixfold over the past 100 years,[45] and 80 percent of wastewater is released back into the environment without treatment,[46] while about half of accessible freshwater is appropriated for human use each year.[47] Water pollution in rivers rose more than 50 percent between 1990 and 2010 in Africa, Asia and Latin America, driven by agriculture, economic activity, population growth and an increase in untreated sewage discharge.[48] Since 1900, 64–71 percent of natural wetland area worldwide has been lost due to human activity.[49] As a result, about 4 billion people—60 percent of the world's population—live in regions with nearly permanent water stress,[50] and 3 billion people lack basic handwashing facilities at home.[51] By 2030 global demand for water is expected to exceed supply by 40 percent,[52] and about 6 billion people might face clean water scarcity by 2050.[53] Enhancing water's availability and quality is thus a major challenge.

> "The integrated management of hydric resources can often offer multiple benefits to different communities. Bearing this in mind is important to shape innovative collective financing mechanisms being used to scale up nature-based solutions.

Neither nature nor human-built infrastructure alone will address this challenge.[54] Nature-based solutions for water security benefit from ecosystem processes and functions for providing and managing water. In some cases, rather than building infrastructure to manage water, relying on such ecosystems as grasslands, mountains and rivers would be better for water management.[55] Some nature-based approaches provide the main or only viable solution, such as landscape restoration to combat land degradation and desertification. Still, infrastructure will always be required for some purposes, such as supplying water for households through pipes and taps.

Green infrastructure watershed banks or a global water ecosystem services observatory could support the adoption of more efficient and sustainable water futures.[56] A global assessment that mapped the water catchments and watersheds supplying water for more than 1.7 billion people across 4,000 of the world's largest cities estimated that source water conservation and restoration could reduce sediment pollution in at least 70 percent of watershed areas in Africa, Asia, Europe and Latin America.[57] That could benefit 780 million people who live in urban watersheds in countries in the bottom decile of the Human Development Index (as of 2014). The integrated management of hydric resources can often offer multiple benefits to different communities. Bearing this in mind is important to shape innovative collective financing mechanisms being used to scale up nature-based solutions (box 6.4).

Managing water availability

Nature-based solutions focused on water availability address water supply by managing water

Box 6.4. Using collective financing mechanisms to scale up nature-based water management

In Ecuador the Fund for the Protection of Water was created in 2000 to preserve the watershed that provides water for the Metropolitan District of Quito, where almost 15 percent of the country's population resides. The fund, a collective financing mechanism, gathers public and private resources and prioritizes investment in green infrastructure as the core of water management. It has recovered and restored more than 15,000 hectares through diverse projects in water management, sustainable hydric conservation, green cover restoration and environmental education.[1] One of the first funds created for sustainable management of watersheds, the fund today operates with an annual budget of $2 million.[2] The strategy has been replicated throughout Ecuador, and in 2015 a fund was set up for the conservation of the Daule River, which feeds the city of Guayaquil. The fund also works as a participatory multisector financial tool dedicated to conserving hydric resources and the watershed that supplies the population.[3]

A regional alliance for water funds was set up to scale up this initiative. The Alianza Latinoamericana de Fondos de Agua provides seed capital and technical assistance for the creation of water funds, mostly in Latin America and the Caribbean. At least 25 funds exist throughout the region in Argentina, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador and Guatemala.[4] Water funds build evidence on water security, help develop a shared and actionable vision for water security, gather diverse stakeholders and encourage political will for positive change. They influence water governance, promote green infrastructure projects and offer an attractive and cost-efficient investment opportunity.[5]

Another organization, Rare, uses blended finance and reciprocity arrangements as innovative ways to promote conservancy. For example, in the Cauca Valley in Colombia, a programme was set up for downstream users to fund incentives for upstream farmers to set aside some of their land for conservation. This helps farmers transition to more sustainable practices and protects the quality of the water that reaches downstream users.[6]

Notes
1. FONAG n.d. **2.** The Nature Conservancy 2019a. **3.** Alianza Latinoamericana de Fondos de Agua 2020a. **4.** Alianza Latinoamericana de Fondos de Agua 2020b. **5.** Alianza Latinoamericana de Fondos de Agua 2018. **6.** National Geographic 2014.

storage, infiltration and transmission to improve the location, timing and quantity of water for human needs. For instance, natural wetlands, improvements in soil moisture and groundwater recharge are ecosystem-friendly methods of storing water that are cheaper and more sustainable than building and maintaining dams.[58]

In China the per capita availability of water resources is just a fourth the world average.[59] Nationally, 83 percent of surface water and 28 percent of ground water do not meet standards for safe water.[60] A partnership between Chinese government institutions and the International Union for Conservation of Nature developed a project to use natural infrastructure to secure long-term supplies of drinking water. By rehabilitating and protecting the Miyun and Jiaquan Watersheds, the project aimed to ensure sustainable water supplies in 30–50 Chinese megacities. It created long-term management and financing mechanisms to protect drinking water sources and enhanced local capacities by teaching 500 farmers safe pesticide and fertilizer use and water source protection to prevent pollution.[61]

Urban settlements are another area for water management. Although cities account for only 2 percent of global land,[62] they will absorb most of the population growth in the coming years, and their water demand will also grow, putting pressure on supplies.[63] Nature-based solutions for cities include catchment management, water recycling and green infrastructure. Catchment measures are traditionally used to improve water supply, but they can also store water and control regular water flows to a city. Urban green infrastructure is incorporated in infiltration, bioretention, permeable pavements, designing new areas, constructing wetlands and connecting rivers and floodplains.

Revitalizing and restoring riverbanks can provide water for cities and urban areas. Revitalizing the Ślepiotka River valley in Katowice, Poland, reestablished natural habitats on the riverbanks and in

the river basin. By bringing together multiple actors, including individuals, engineers and planners, the project was planned to store water and mitigate flood risks. Previously abandoned spaces along the riverbanks were regenerated with citizens' help.[64] In the Netherlands the sealed surfaces of urban riverbanks of Boompjes Promenade were restored to a green riverfront area. The promenade was part of the country's "Give space back to the river" programme and its implementation in Rotterdam. As in Poland, the riverbank was used for water retention as well as for green urban recreation space.[65]

Ensuring water quality

While water availability considers the quantity of demand and supply, water quality relates to pollution and health. Protecting water sources through nature-based solutions can improve water quality. The process can reduce water treatment costs for urban suppliers and improve access to safe drinking water, mainly for rural communities.

Agricultural pesticides and wastewater from food processing and livestock add considerably to water pollution. Wetlands and grasslands can be managed to enable soils and crops to reduce sediment loading, capture and retain pollutants, and recycle nutrients that improve water quality and reduce demand for fertilizers.

Of Peru's 32 million people, 2.5 million lack access to safe water, and 5 million lack access to improved sanitation facilities.[66] In 2015 the water utility serving Lima approved Latin America's largest investment in natural infrastructure, funded by monthly tariffs.[67] The project is restoring wetlands and grasslands and rehabilitating and replicating infiltration channels in the Chillon, Rimac and Alto Mantaro Rivers, which provide water to Lima. It has also developed a tool, Cuantificación de Beneficios Hidrológicos de Intervenciones en Cuencas (Quantification of Hydrological Benefits of Interventions in Watersheds), to estimate the impacts of the most common nature-based solutions, such as grassland, forest or wetland conservation and restoration, infiltration trenches, riparian buffers and permeable reservoirs. The tool allows practitioners and decisionmakers to know what they are getting for their investments in nature and to compare it with alternatives.

As with water availability, green infrastructure in new spaces in cities can reduce urban pollution. For instance, through green walls, roof gardens, vegetated infiltration and drainage basins, nature-based solutions support the treatment and recycling of wastewater. Urban water pollution control is mostly an "end of pipe" solution with intensive wastewater treatment, but nature-based solutions offer alternatives. Constructed wetlands are among the solutions that can be incorporated into urban design to manage polluted water from rainfall, by biodegrading or filtering pollutants.[68]

"Protecting water sources through nature-based solutions can improve water quality. The process can reduce water treatment costs for urban suppliers and improve access to safe drinking water, mainly for rural communities.

Constructed wetlands are engineered systems built to use natural processes mimicking natural wetland systems that filter runoff before it reaches open water. Used for rainwater treatment, they combine sewer overflow treatment, cleaning outflows from water treatment plants and greywater treatment.[69] They typically can remove up to 88 percent of suspended solids, 92 percent of organic matter, 46–90 percent of phosphorus and 16–84 percent of nitrogen,[70] and they can remove pathogens.[71] Constructed wetlands have become a common nature-based alternative to help obtain clean and reusable water, safeguarding human health and preserving hydric resources.

Studies in water-stressed areas in the Arab States region have shown the potential for constructed wetlands to treat wastewater and polluted water and to preserve freshwater by producing reusable effluents for irrigation. In Oman constructed wetlands treat the wastewater from workers' camps at oil production facilities. In the United Arab Emirates a constructed wetland serves a residential area of 100 villas, producing effluent water reused to irrigate green areas.[72] The solutions are used across the region for wastewater from sludge, residential areas, and oil and gas activities, which are among the largest industrial sources of wastewater worldwide. Implementing such solutions in water-stressed environments has additional challenges, including increased evapotranspiration due to high temperatures and higher plant biomass production.[73] But the benefits come in areas where

water scarcity and quality are obstacles to human development.

Enhancing food security

Biological diversity—including soil microbial diversity; genetic seed diversity; pollinator diversity; crop, livestock and fish diversity; and more—underpins food security at all levels. Although humans have evolved to eat more than 7,000 species, just three—wheat, rice and maize—now provide more than half our calories,[74] and just 12 plant crops and 5 animal species account for 75 percent of our entire planetary food system.[75] We are losing genetic diversity within species. For example, seed growers in 1900 offered 3,879 varieties of 10 common vegetables in the United States, but in 1983 that number was reduced more than tenfold to 310.[76] We are losing the populations of wild crop and livestock relatives, plants and animals.[77]

The sharp decline of pollinators due to pesticides and habitat loss threatens food security and nutrition around the world.[78] Of the leading global food crops consumed directly by humans and traded on the global market, 85 percent rely on animal pollination. Without pollinators, production would fall by more than 90 percent for 12 percent of leading global crops.[79] The decline of pollinators affects both production and nutrition. Pollinated crops account for 35 percent of global food production, more than 90 percent of available vitamin C and more than 70 percent of available vitamin A.[80]

"We are losing genetic diversity within species. For example, seed growers in 1900 offered 3,879 varieties of 10 common vegetables in the United States, but in 1983 that number was reduced more than tenfold to 310.

Forests are essential to global food security. More than 1.25 billion people depend directly on forests for shelter, livelihoods, water, fuel and food security.[81] Wild foods harvested from forests provide a wide range of nutrients and micronutrients,[82] especially important to the more than 2 billion people who experience micronutrient malnutrition.[83] Wild animals, or bush meat, provide more than 6 million tonnes of food a year to communities in the Congo and Amazon Basins alone.[84] Yet tropical forest loss has been accelerating, taking more than 60 million hectares since 2002.[85]

Pastoralist activities are carried out by more than 200 million people worldwide and are essential to food security, especially in dryland areas such as the Horn of Africa. But they are also some of the most vulnerable to climate change.[86] As the demand for animal products keeps increasing,[87] climate-related phenomena such as droughts and climate variability put pressure on pastoralist systems, causing losses of livestock and poor reproductive performance, partially hindering their adaptive capacity.[88]

Farming is the occupation that engages the most people on the planet.[89] But rural farmers disproportionately face the brunt of agrobiodiversity loss, especially soil microbial diversity loss. More than 1.3 billion people live on degraded agricultural land with limited fertility,[90] and more than half of agricultural land worldwide is moderately or severely affected by land degradation and desertification.[91] Poor farmers, when trapped in a vicious cycle, are forced to use ever-increasing inputs of chemical pesticides and fertilizers, further degrading microbial diversity and in turn undermining long-term crop productivity and requiring even more inputs, causing more degradation.[92] The next section reviews options to improve agricultural practices on and off the farm and provides examples related to fisheries. Both farming and fishing are key to enhancing food security.

Improving agricultural practices

Nature-based solutions to improve agricultural practices while enhancing food security include regenerative agriculture, agroforestry, silvopasture, habitat protection for pollinators, protection of crop wild relatives and promotion of agrobiodiversity.

Regenerative agriculture—farming that increases soil fertility and productive capacity over time—provides substantial long-term gains for farmers by releasing them from the land degradation trap. Farmers save money by spending less on chemical inputs and see increased crop productivity.[93]

Agroforestry—growing crops on land interspersed with trees—provides many benefits for food and reduces inequality. Agroforestry improves crop yields by increasing soil fertility and providing pollinator

habitat. It strengthens farmers' economic resilience by diversifying the type and timing of their crops and reducing the risk of crop failures, and it improves farmer nutrition by offering a wider range of foods, especially protein from nut trees. Forest and grassland protection provides a range of benefits. Many pollinators depend on forest habitat, while strips of forest, as well as large forest blocks, have multiple benefits for many crops, such as coffee.[94]

> "Regenerative agriculture, agroforestry and silvopasture—yield many of the same benefits, including increased diversity of farmer income, improved nutrition, enhanced resilience to climate change, more carbon sequestration and greater biodiversity.

Silvopasture integrates trees, forests, forage and grazing livestock in mutually beneficial ways. It yields multiple benefits, including more efficient use of mixed woodlands, greater wildlife abundance and diversity, increased carbon sequestration, improved animal health and nutrition, better weed and vegetation control and reduced labour inputs. Farm productivity can be enhanced by planting fruit and nut trees on pasture lands.[95]

All three approaches—regenerative agriculture, agroforestry and silvopasture—yield many of the same benefits, including increased diversity of farmer income, improved nutrition, enhanced resilience to climate change, more carbon sequestration and greater biodiversity.[96] They provide an alternative approach to today's most common agricultural practices, which favour high-chemical fertilizers and pesticides, crop monocultures, simplified seed genetic diversity, mechanized equipment that prevents trees growth, and high tillage and other practices that reduce soil microbial health and fertility. A broad array of tax incentives, market and pricing structures, land use policies and perverse agricultural subsidies inhibit agricultural nature-based solutions around the world and can keep farmers trapped on degraded lands.[97]

Preserving fisheries

More than 90 percent of the world's fisheries have been fully exploited, have been overexploited or have collapsed altogether.[98] Overfishing has profound impacts on the world's food systems. About 3.1 billion people rely on fish for 20 percent of their daily protein intake.[99] Globally, consumption of seafood per capita is over 15 times higher in indigenous coastal communities than in nonindigenous communities.[100]

Sustainable fisheries and protected marine areas ensure that fish populations can regenerate and provide sustainable yields. Protecting coastal and marine areas such as mangroves, coral reefs, seagrass beds and seamounts—particularly the sites of fish spawning, nursery and aggregation—is crucial to various parts of fish lifecycles. Fish biomass can be as much as 670 percent higher in effectively managed marine protected areas than in unprotected areas, providing a source population for local fisheries.[101] Expanding marine protected areas by 5 percent could yield at least a 20 percent increase in future catch.[102]

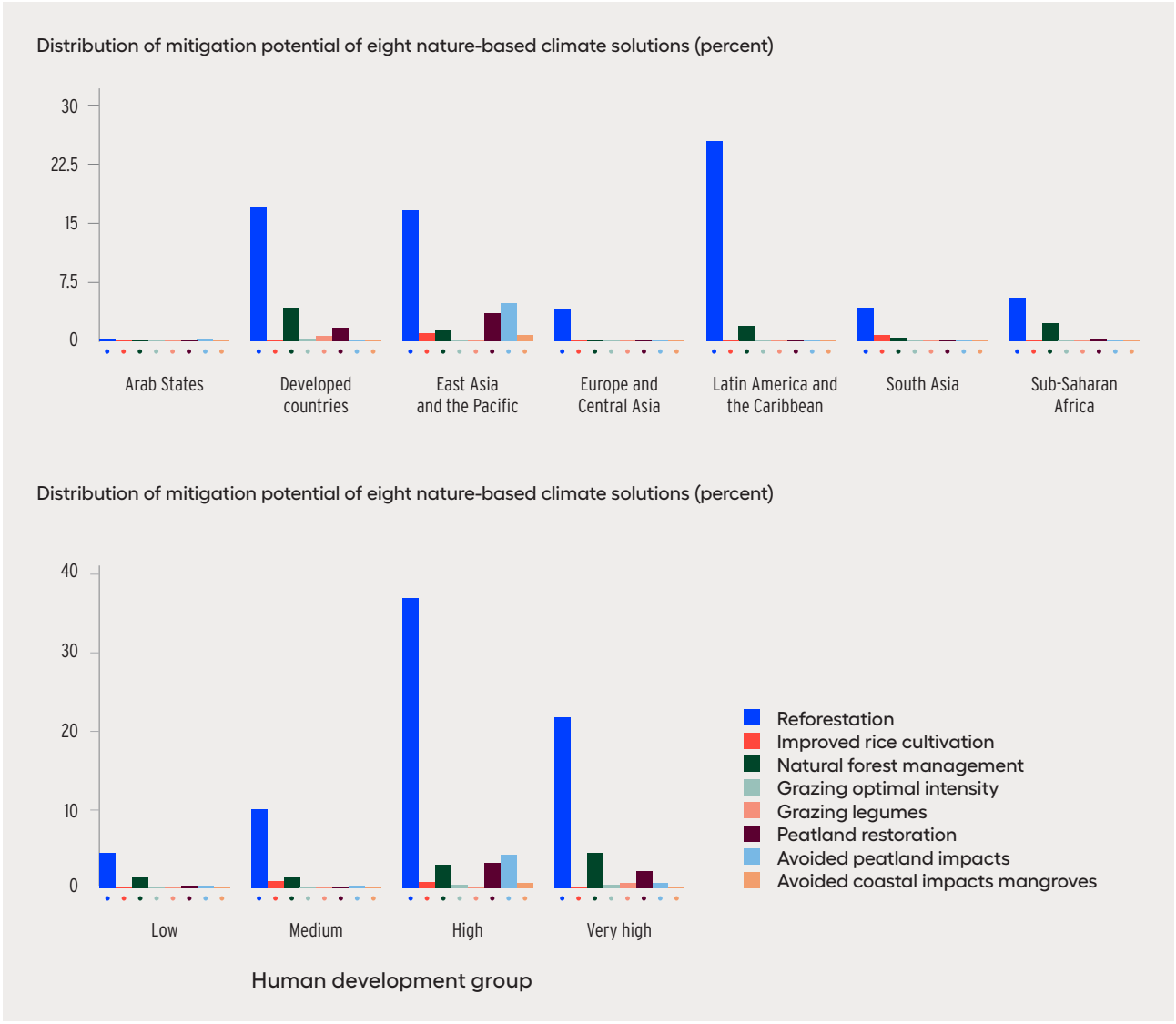
Towards nature-based human development

Nature-based solutions can add up to a substantial impact. For instance, reforestation and land neutrality can curb climate risks, with several mitigation actions potentially adding up to a considerable reduction in net greenhouse gas emissions. Those mitigation actions are heterogenous across regions and levels of development, depending largely on geographic characteristics (figure 6.4), with several of the globally relevant ecosystems transcending national borders.[103]

Even though mitigation actions are cost-effective, implementing them is challenging because they contribute to global benefits (climate change mitigation) but have local costs. And with ecosystems shared across countries, action by one country alone does not ensure ecosystem integrity. Moreover, multiple interests are at play. Large differences in wealth and power have been operating for centuries, distorting incentives and often biasing decisions towards overexploiting forest resources. With the individuals interested in protecting the forest, such as indigenous peoples and local communities, historically disempowered, large business interests typically enjoy more power.

Forest area has been decreasing over the past few decades in developing countries, reflecting national or local development priorities. This underlying

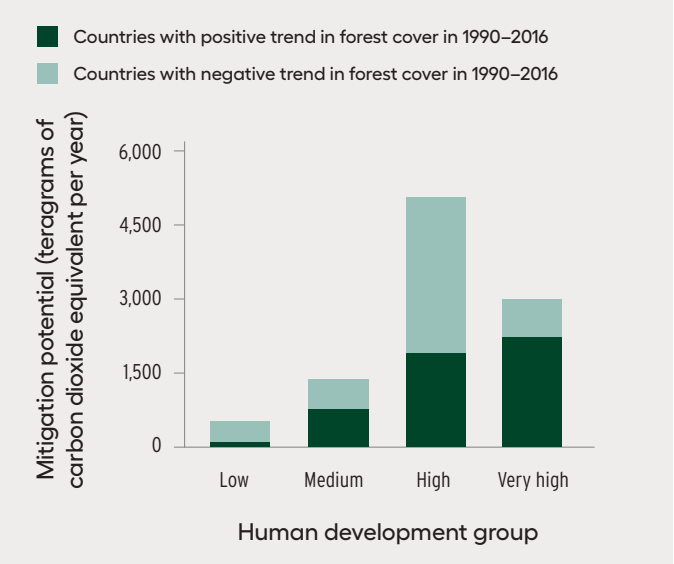
Figure 6.4 The mitigation potential of eight climate change interventions is widely distributed across countries in different regions and at different levels of development



Note: This is a subset of the 20 cost-effective solutions that are geolocalized.
Source: Human Development Report Office based on Griscom and others (2017).

reality presents a challenge for the mitigation potential offered by nature-based solutions (figure 6.5). To enhance human development, reforestation or large-scale afforestation cannot be dissociated from socioeconomic development of forest- and grassland-dependent communities.[104] Instead, reforestation must be part of a broader social and economic development effort, supporting local communities and supported by them, with socioeconomic empowerment and the protection of nature coming together. There is great potential for this, as close to 295 million people live on tropical forest restoration opportunity land in the Global South.[105] But global incentives also matter. If reforestation is pursued only locally, carbon leakage is a risk: Market interests might simply finance deforestation in a different location. Aligning incentives would be easier with actions towards reducing the need for pasture, which in turn depend on systemic support for improving beef production efficiency or changing dietary preferences to reduce beef consumption.[106] In fact, achieving land degradation neutrality goes beyond reforestation; it also depends on combatting desertification and restoring degraded land and soil.[107]

Figure 6.5 The decrease in forest area in developing countries presents a challenge for the mitigation potential offered by nature-based solutions



Source: Human Development Report Office based on FAO (2020b) and Griscom and others (2017).

This discussion of the potential and challenges of land use illustrates a broader point: how a systemic approach that considers asymmetries of power and incentive structures at multiple scales is crucial to unleash the potential of nature-based solutions for transformational change. The rest of this chapter explores how to do so through nature-based human development, which shifts the focus from specific solutions towards human agency and to the broader determinants of local empowerment to advance human development and preserve the integrity of the biosphere.

Leveraging interventions for transformational change

The value of nature-based solutions goes beyond their contributions to local communities. If their effects are scaled up, they can contribute to transformational change. Promoting innovative ideas and diffusing knowledge of existing nature-based solutions are first steps. But only a systemic approach will enable nature-based solutions to have impacts at larger scales. Creating systemic conditions that provide the socioeconomic support for this to happen is referred to here as nature-based human development.

Having plausible and cost-effective nature-based solutions is not enough to ensure their implementation. Despite the overwhelmingly compelling social, economic and ecological case for these solutions, only about $120–$150 billion a year is spent globally on biodiversity conservation. There is an estimated gap of about $600–$820 billion a year to increase protected areas,[108] improve the productive management of landscapes and seascapes and protect biodiversity in areas of high human impact.[109] The benefits of this investment might outweigh the costs by a factor of five,[110] with many of the benefits accruing to those who need it most—often poor rural communities that depend directly on nature for their livelihoods. Yet nature-based solutions have been largely ignored by governments, firms and investors alike. This is not new, as countries' natural resource endowments have often been associated with a "curse" obstructing human progress.[111]

A systemic approach would ease constraints that limit the adoption of nature-based solutions, including the fact that the social value (typically widely shared across communities) is larger than the private value that accrues to direct beneficiaries, leading to underinvestment. Moreover, extant interests in managing natural resources are encoded in regulations, subsidies and taxes that reflect current distributions in wealth and power, with a bias to preserving the status quo of resource overexploitation for larger private gains. The political economy challenge is compounded because developing countries and poor communities lack resources—the origin of environmental poverty traps[112]—and because the compounding negative impacts of human pressures on the planet further erode their agency.[113]

Nature-based human development complements the mechanisms of change discussed in chapters 4 and 5 by highlighting the importance of placing the preservation of ecosystem integrity at the core of multiple economic and social processes.

Leveraging business and finance

This means using regulations and incentive mechanisms to hold financial institutions accountable for their impacts on nature. A key step to increase transparency and accountability is a new task

force—the Informal Working Group for the Taskforce on Nature-related Financial Disclosure[114]—that will be launched in 2021 to steer finance towards nature-positive outcomes. It also means reducing business-related risks from nature losses. As noted in chapter 5, nearly half of global GDP might already be at risk as a result of degrading nature.[115] But by prioritizing nature, businesses could unlock $10 trillion in financial opportunities and create 395 million jobs by 2030.[116] Placing nature at the heart implies phasing out governments' nature-harmful incentives, which present an enormous barrier to transformative change, such as the fossil fuel subsidies discussed in chapter 5 as well as many agricultural subsidies.

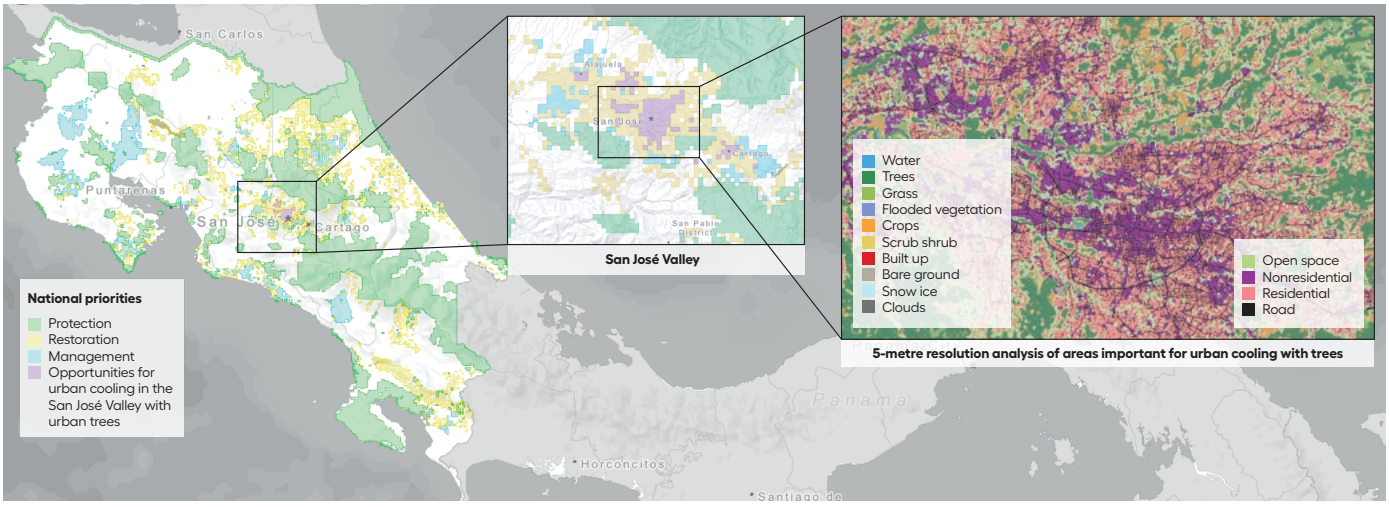
Embedding ecosystem integrity into sustainable development policymaking

Rather than being treated as an isolated sector in national development priorities, nature-based solutions can be integrated into prioritization efforts, such as those related to national climate commitments, and policies related to water security, food security, disaster risk reduction, economic growth and jobs. Investing in nature- and climate-aligned Covid-19 stimulus packages can yield returns of $2–$10 per $1 invested.[117] To achieve this, multiple government sectors can align their policies and priorities around a coherent framework, as Costa Rica and Uganda have done.[118] For instance, Costa Rica recently undertook an extensive mapping of essential life support areas, identifying opportunities for protecting, restoring and managing nature through nature-based solutions in both rural and urban areas (figure 6.6).

"Rather than being treated as an isolated sector in national development priorities, nature-based solutions can be integrated into prioritization efforts, such as those related to national climate commitments, and policies related to water security, food security, disaster risk reduction, economic growth and jobs.

There is no blueprint for nature-based solutions governance, and each country's economic, institutional, social and political context will present different opportunities and barriers. But high multisector participation and incentives for nature-based solutions implementation at scale are important everywhere.[119] The International Institute for Applied Systems Analysis has identified three governance enablers for implementing nature-based solutions: polycentric governance (echoing the discussion in chapter 4), participatory codesign (for example, at the municipal level in Costa Rica, constant stakeholder involvement and technical knowledge transfer have been vital)[120] and financial incentives (as noted above).[121]

Figure 6.6 Costa Rica's high-resolution mapping of national nature-based solutions priorities



Source: Maps provided by the United Nations Biodiversity Lab.

Increasing awareness to shape social norms

People's values in relation to nature can shape the attitudes of stakeholders towards nature-based solutions. There is evidence that people who value stewardship or the conservation of nature have a higher preference for nature-based solutions than for conventional approaches.[122] Education also seems to have a positive association with perceptions of nature-based solutions[123]—stressing the importance of knowledge in the Anthropocene.[124] The mechanisms for changing social norms described in chapter 4 can be harnessed by increasing awareness and education of nature-based solutions to catalyse transformational change.

Elevating efforts to the regional and global levels

Internationally, actors ranging from UN agencies to multilateral development banks have developed collaboration tools and made financial resources available for interested countries. The International Union for Conservation of Nature has launched the first-ever global standard for nature-based solutions and has facilitated communication between governments and civil society organizations, providing key knowledge, research and tools, in addition to carrying out its own projects in more than 160 countries. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, established in 2012, works on assessments and identifies policy-relevant tools to build capacity and knowledge for its 94 member states.[125] Several UN agencies work on nature-based solutions. The United Nations Environment Programme works to implement nature-based solutions and coleads the United Nations Decade on Ecosystem Restoration 2021–2030, together with the Food and Agriculture Organization (which has produced substantive work on nature-based solutions focused on agricultural practices, water and food). The United Nations Development Programme's Equator Initiative highlights nature-based solutions among indigenous peoples and local communities and has produced toolkits and research to support the implementation of nature-based solutions.

International efforts have also aimed to protect agents of change that have been historically disempowered, specifically through international agreements to protect indigenous peoples. The Indigenous and Tribal Peoples Convention, adopted in 1989 by the International Labour Organization and ratified by most of Latin America and a few other countries worldwide, is an important international law on indigenous peoples' rights (chapter 3). Among multilateral development banks, the World Bank has had a nature-based solutions programme since 2017 to inform its operations, advice and investments.[126] Regional development banks have also become active promoters. In 2018 the Inter-American Development Bank launched the Natural Capital Lab, a platform to bring government and businesses together to create high-risk, high-reward approaches for preserving natural capital.[127] The African Development Bank has funded several initiatives prioritizing the restoration of damaged ecosystems, the conservation of biodiversity and integrated natural resources management.[128] The Asian Development Bank has partnered with the International Centre for Environmental Management and the Nordic Development Fund to build capacity for green infrastructure across Asian cities and to share knowledge for implementation from international good practices.

"The Indigenous and Tribal Peoples Convention, adopted in 1989 by the International Labour Organization and ratified by most of Latin America and a few other countries worldwide, is an important international law on indigenous peoples' rights.

Closing gaps in empowerment: Indigenous peoples as shapers and defenders of nature

As part I of this Report argues, the Anthropocene compels a reimaging of the human development journey in which our embeddedness in nature is brought to the fore. Doing so by expanding human agency implies empowering people by enhancing equity, fostering innovation and instilling a sense of stewardship for nature. Complementing social norms and incentives, this chapter argues for a systemic approach to nurture and expand nature-based solutions to deliver transformational change. Over human history and in many places around the world today, those systemic approaches have emerged, providing social benefits while preserving ecosystems. One example is the

contribution of many indigenous peoples and local communities to preserving nature

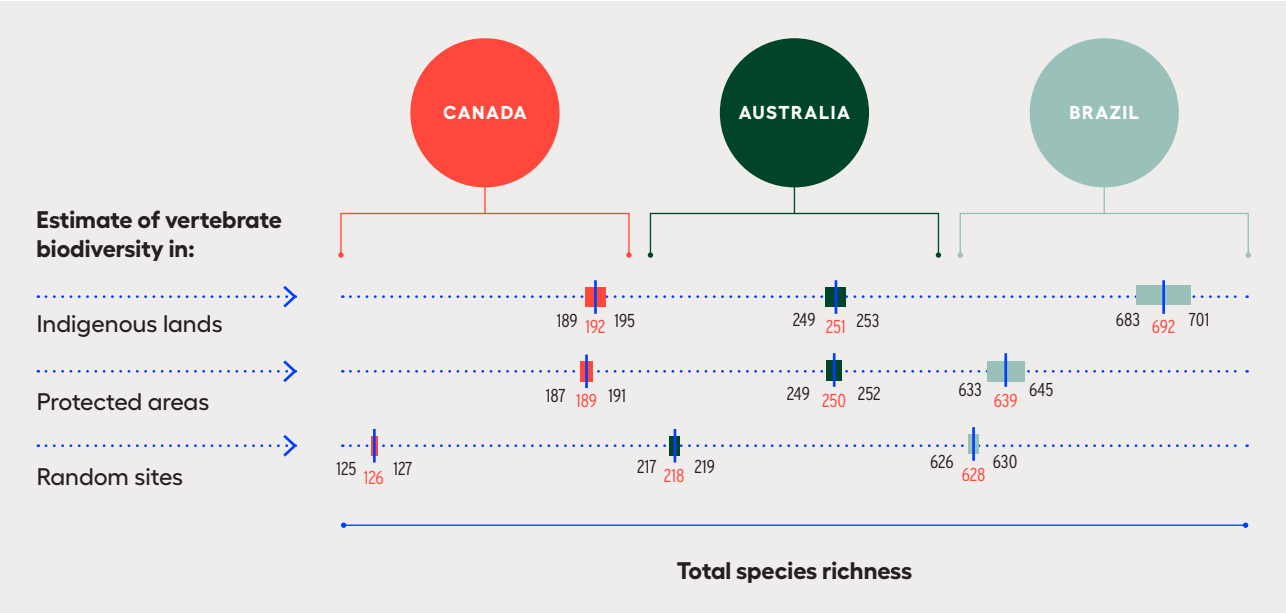
For example, biodiversity richness has a higher estimated value in indigenous lands than in protected areas, despite differences across indigenous peoples' contribution in the same country (figure 6.7).[129] This is the result of interactions between people and nature that have evolved over millennia and are tied to biocultural diversity (chapter 1).[130] Thus, supporting the practices of indigenous peoples that sustain biodiversity is key, especially since lands managed by indigenous peoples—around 25 percent of global land area—host an estimated 80 percent of global biodiversity.[131]

Consider Colombia, one of the world's most biodiverse countries. It is home to more than 50 million ethnically and linguistically diverse people, and it has a leading regional and global role in environmental stewardship and climate change leadership. Deforestation continues to be the largest source of greenhouse gas emissions in Colombia, accounting for 27 percent of annual emissions, equivalent to 69 megatonnes of carbon dioxide. Despite sustained efforts to set aside large portions of the country's lands for environmental protection, key carbon sinks are under severe stress. Colombia has drafted detailed plans to reduce carbon emissions 20 percent by 2030, primarily through reduced deforestation, which also protects biodiversity and natural watersheds and secures a future for communities that depend directly on the forest. Success will require the participation of a multitude of indigenous peoples across the country.[132]

"Supporting the practices of indigenous peoples that sustain biodiversity is key, especially since lands managed by indigenous peoples—around 25 percent of global land area—host an estimated 80 percent of global biodiversity.

Over the past few decades indigenous peoples have been on the front line of defending the Amazon rainforest. Territories across nine countries sharing the Amazon Basin and managed by indigenous peoples barely lost stored carbon between 2003 and 2016 (a fall of 0.1 percent), reflecting minor forest loss. Protected areas not managed by indigenous peoples experienced a loss of 0.6 percent.[133] The rest of the Amazon experienced a loss of 3.6 percent.[134] Translating indigenous peoples' contribution to forest preservation in terms of its impact on climate change mitigation—a rather narrow and limited

Figure 6.7 Biodiversity richness is greatest under indigenous peoples' management regimes



Note: Regression-based estimates. Boxes represent 95 percent confidence intervals.
Source: Schuster and others 2019.

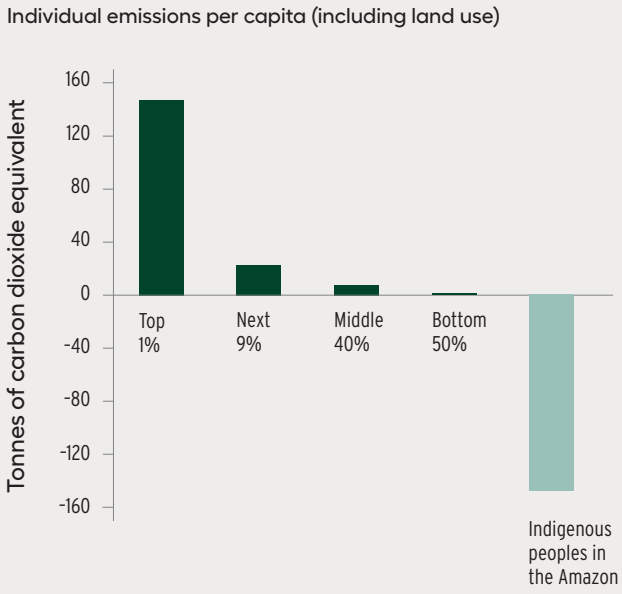
exercise, in that it does not account for many other contributions, including avoiding biocultural diversity loss—suggests that indigenous peoples' per capita contribution as a carbon sink through forest preservation in the Amazon is roughly equal to the average per capita emissions by the top 1 percent of the income distribution (figure 6.8).

The large-scale indigenous peoples' contribution to carbon storage is an example of how local decisions and nature-based solutions can add up to substantial easing of planetary pressures. Where the role of indigenous peoples supports ecosystem preservation, it provides a useful template for how to think about systemic approaches for nature-based human development. In those instances, every single leverage point recently identified by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services seems to be at play (figure 6.9).

The behaviour of indigenous peoples and local communities is not only about a single solution but also about wellbeing while preserving ecosystem integrity in coupled social and ecological systems. Understanding the drivers of behaviour—which work outside formal market-mediated incentives—has the potential to inform the system approach to nature-based solutions that can unleash transformational change (table 6.1 and box 6.5).

Despite numerous well documented instances of the multiple benefits of indigenous peoples' actions, their perseverance and contributions are hugely undervalued by most societies. As the United Nations Declaration on the Rights of Indigenous Peoples sets out, self-determination lies at the heart of

Figure 6.8 The per capita contribution by indigenous peoples preserving forest storage capacity in the Amazon is roughly equal to per capita greenhouse gas emissions by the top 1 percent of the income distribution



Source: Human Development Report Office based on data in spotlight 7.2 with estimates for 2020 of individual distribution of carbon dioxide emissions. Estimates of contributions of indigenous peoples are based on data for 2003–2016 from Walker and others (2020).

Figure 6.9 Indigenous peoples and local communities move the leverage points to build global sustainability

Source: Human Development Report Office based on Brondizio and others (2019).

Table 6.1 Examples of nature-based solutions by indigenous peoples and local communities

Solution	Contributions to human development	Preservation of ecosystem integrity	Examples in indigenous and local communities
Agroforestry	→ Food security → Sustainable livelihoods for small-scale farmers → Higher productivity of trees, crops and livestock → Greater product diversity for farmers	→ Preserving biodiversity and increasing diversity → Reducing soil erosion → Reducing loss of water, soil material, organic matter and nutrients → Reducing insect pests → Maintaining soil fertility → Increasing carbon sequestration	→ Bolivia, Consejo Indigena del Pueblo Tacana[a] → Cameroon, Riba[b] → Cameroon, Gender and Environment Watch[c] → Jamaica, Jeffrey Town Farmers Association[d] → Mexico, Koolel-Kab/Muuchkambal[e] → Nigeria, Environmental Management and Development Trust[f] → Phillipines, Camalandaan Agroforestry Farmers' Association[g]
Protection of coastal ecosystems for disaster risk reduction	→ Safeguarding lives, homes and livelihoods by mitigating the impacts of tsunamis, typhoons and other hydrometeorological disasters on human settlements → Supporting livelihoods through timber and nontimber product availability	→ Protecting and stabilizing coastal zones → Supporting unique and rich ecosystems and biodiversity → Storing carbon	→ Federated States of Micronesia, Tamil Resources Conservation Trust[h] → Indonesia, West Kalimantan[i] → Thailand, Community Mangrove Forest Conservation of Baan Bang La[j]
Sustainable land management	→ Optimizing social and economic benefits from nature's ecosystem services → Increasing community resilience and ensuring the continued availability of food, water and other natural products → Establishing practices and knowledge that can be replicated and inherited through changes in administration and across generations → Participatory management of natural assets	→ Protecting and conserving ecosystems → Safeguarding nature's ecosystem services and species' ability to regenerate	→ Bolivia, La Paz[k] → Ghana, Greater Accra Region[l] → Northwestern Nicaragua[m]

Notes
a. See UNDP (2015a). **b.** See UNDP (2010a). **c.** See UNDP (2019a). **d.** See UNDP (2014c). **e.** See UNDP (2014d). **f.** See UNDP (2019b). **g.** See UNDP (2008). **h.** See UNDP (2019d). **i.** See UNDP (2017b). **j.** See UNDP (2017a). **k.** See UNDP (2010b). **l.** See UNDP (2014b). **m.** See UNDP (2012).
Source: Human Development Report Office literature review.

development for and by indigenous peoples. Achieving self-determination requires the transformation of governance and law as well as space to enable indigenous peoples to articulate, pursue and realize lives they value.[135] Indigenous peoples remain notably disempowered, and the 1.3 billion indigenous people living in areas endowed with forests have some of the highest poverty rates in the world.[136] Moreover, they are victims of violence, with several of their leaders killed in connection with their environmental activism (box 6.6).

Degradation of nature and biodiversity loss have resulted largely from disempowering many seeking to preserve natural resources, often indigenous peoples (chapter 2). Indigenous communities managing their territories typically have limited power to face extractive industries, and their livelihoods and well-being are threatened by the expansion of infrastructure that strains local ecosystems.[137]

> "The behaviour of indigenous peoples and local communities is not only about a single solution but also about wellbeing while preserving ecosystem integrity in coupled social and ecological systems.

Greater recognition and support are due to indigenous peoples and local communities, in line with their past and current contributions to conserving nature and easing planetary pressures. Support starts with basic respect for their human rights and ensuring their freedom from violence. Yet the opposite has been the

Box 6.5 Holistic approaches to nature can deliver multiple impacts

The Lashihai Watershed, in the southwestern province of Yunnan, China, is home to about 10,000 indigenous people, mostly Naxi and the Yi peoples. Lashihai Lake, also part of the watershed, plays a vital role in sustaining biodiversity in the area because it has the greatest bird diversity in the country and is an important migration passage, breeding ground and wintering habitat for many goose and duck species.

In 1998 a dam was built in the area, flooding farmland and displacing communities, who moved to hillsides to farm and began to overfish the lake using illegal nets. This, in turn, led to mudslides, soil erosion and the depletion of fish populations, increasing poverty and tensions between the communities and local governments.

In 2000 the Green Watershed organization began working with the local governments and established an indigenous peoples' watershed management model to include local indigenous communities in the management of resources while also considering economic development objectives. The initiative founded indigenous peoples' autonomous organizations, included participatory methods to promote self-management of resources and generated positive results.

Water security. The initiative ensured the irrigation of surrounding farmland during five consecutive years of drought. Agroforestry and ecological cultivation were promoted, curbing soil erosion and reducing wetland sediment deposition. The Fishermen's Association restored the ecological balance of the wetlands, which guaranteed food for 100,000 wintering birds of more than 76 species.

Food security. The Yi people could ensure only about four months of food into the future. High-quality potato seeds were introduced to Yi households, and production increased fivefold in the span of a year. Moreover, a ban on the use of illegal nets by the Fishermen's Association protected fish populations, resources and related livelihoods, restoring fish to numbers last seen 20 years before.

Sustainable livelihoods. The Naxi community built slit dams to control soil erosion, planted forests, implemented household methane biodigesters and developed agroforestry. The Yi villages developed animal husbandry, cultivated Chinese herbal medicines and opened an ecotourism enterprise to diversify their livelihoods in the face of natural and market risks. The average income per capita of both groups increased tenfold.

Disaster risk reduction. Water storage ponds mitigated the effects of droughts. Fortified houses were built to withstand earthquakes. Afforestation was encouraged to mitigate flooding and mudslide risks. And livelihood diversification was encouraged to help the communities face the potential losses of livelihood due to disaster.

Source: Human Development Report Office based on UNDP (2015c).

norm. Between 2002 and 2017, 1,558 people across 50 countries were killed for defending their environment and lands.[138] The loss is tragic for the community but no less so for all of us and our descendants. We miss taking full advantage of learning from their knowledge and principles, precisely when a sense of stewardship for nature is becoming paramount to ease planetary pressures. A greater space for indigenous peoples and local communities adds voices that have often been silenced or unheard in public deliberation and that tend to be marginalized by other ways of knowing based on technologies and the advancement of science.[139]

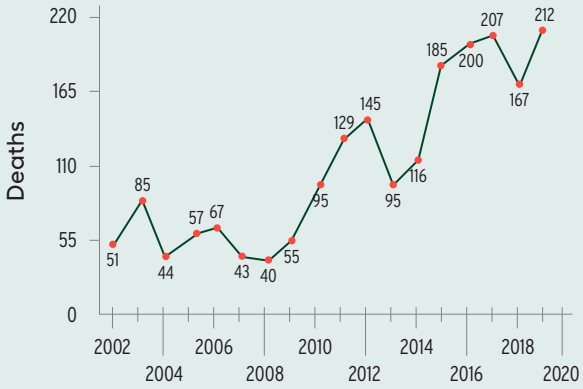
Recognizing and supporting the direct contributions of indigenous peoples and local communities in the preservation of biosphere integrity are key to easing planetary pressures.[140] Just as important is recognizing the ongoing injustices suffered by these communities and the ways these injustices shape their agency and ability to thrive in ways valuable to them.[141] Only then might we begin to learn with humility from what they and many others over our 300,000 year history have done. That is the aspiration—and promise—of nature-based human development.

Box 6.6 Environmental activists are being killed

In 2019 a record 212 people—more than four a week—were killed defending their land and environment.[1] Violence against environmental activists has increased, with the annual death toll more than tripling since the early 2000s (see figure).

Indigenous peoples have an important presence in environmental activism, and they are disproportionately at risk of violence, attacks and killings for their activism. In 2019, 40 percent of murdered defenders belonged to indigenous communities, and more than a third of fatal attacks between 2015 and 2019 targeted indigenous peoples.[2] In 2018 the United Nations Special Rapporteur on the rights of indigenous peoples expressed grave concern at the targeting of indigenous peoples through attacks and violence in the context of large-scale projects of extractive industries and mounting competition to exploit natural resources.[3]

The number of killings of environmental activists has more than tripled since the early 2000s



Source: Human Development Report Office based on data from Global Witness's annual land and environmental defenders reports 2002–2019, accessed on 23 November 2020.

Notes

1. Global Witness 2020. **2.** Global Witness 2019. **3.** UN Human Rights Council 2018.

Source: Human Development Report Office based on data from Global Witness. Data from Global Witness on environmental defenders' killing has been cited in studies by Butt and others (2019), Scheidel and others (2020) and the UN Special Rapporteur on the situation of human rights defenders (Forst and Tognoni 2016) and in media such as CNN (Guy 2020b), *The Guardian* (Watts 2019) and *Time* magazine (Godin 2020).

Implications of climate change for financial and monetary policy

Joaquín Bernal, Advisor to the Governor of Banco de la República (Central Bank of Colombia), and **José Antonio Ocampo,** Professor at the School of International and Public Affairs, Columbia University, and Chair of the United Nations Committee for Development Policy

Climate change generates widely known physical risks, particularly disasters associated with hydrometeorological events such as hurricanes, tornadoes, cyclones, monsoons, floods and avalanches—and, conversely, desertification and increasing aridity. These impacts are wide ranging and affect all agents and sectors of the economies in all geographies of the planet—though in an uneven way. These major events, as well as more gradual but persistent changes in temperatures, have structural impacts on economic activity, labour productivity and people's wellbeing. In addition, the process of adjustment towards a lower carbon economy—prompted by climate-related policies, technological disruptions and shifts in consumer preferences—generates what in the literature are called transition risks.[1]

These risks have major macroeconomic and financial implications that have been recognized in the Paris Agreement (article 2, c), which states that, in order to strengthen the global response to the threat of climate change, it is essential to make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate resilient development." Financial policies play a key role in mobilizing mainstream finance to move towards the needed large-scale transformation in the productive structure of the economy. It is also key to generate a concomitant change in the underlying financial asset structure by leveraging market mechanisms to increase efficiency in allocating resources for and costs of mitigating climate change.[2]

Financial policies encompass macroprudential, financial regulation and supervision, governance and financial market development policies. They include policies aimed at redressing possible underpricing and the lack of transparency of climate risks in financial markets and regulatory prudential frameworks. They are also intended to develop a taxonomy of economic activities to advance markets for green financial instruments. And they help reduce the short-term bias and improve the governance frameworks of financial institutions. Monetary policy can also contribute to these goals. It may include instruments related to the central bank balance sheet—such as collateral policy, asset purchases and commercial bank access to the central bank balance sheet—and in some countries credit allocation.[3] These financial and monetary policies to promote green investments should complement—but not substitute for—tax and fiscal policies and government investment responsibilities.

Financial policies

A first group of financial policies standardizes climate-related risks disclosures and makes them mandatory. These policies can support and improve the pricing and transparency of these risks.[4] Gathering and disseminating relevant climate-related financial data could also enhance risk assessment in financial regulation and stress tests. In addition, laying solid foundations is instrumental in defining an adequate taxonomy of "green" and sustainable assets in relation to climate and other environmental considerations and for the development of green bonds and markets, as well as carbon pricing.

In this regard, the efforts of the Task Force on Climate-related Financial Disclosure should be particularly highlighted. Its recommendations, developed by the market for the market, aim to ensure that climate-related risks are understood and discussed at a broad level, considered in risk management and investment decisions and embedded into firms' strategies. The recommendations may allow investors and external stakeholders to better value assets and investment projects and to mobilize financial resources to facilitate the transition to more sustainable and resilient activities.

Supervisors should verify that individual institutions under their purview identify exposures to

climate-related risks, assess the potential losses should those risks materialize, ensure adequate management of the risks and take mitigating action where appropriate. Authorities should set supervisory expectations based on a prudent approach to climate-related and environmental risks.[5]

In addition, central banks and supervisors should gradually develop tools to map the transmission channels of physical and transition risks within the financial system and conduct quantitative climate-related risk analysis to size the risks across the financial system and how the impact of climate change can be included in macroeconomic modelling, forecasting and financial stability monitoring.[6] Some leading central banks—those in Brazil, the United Kingdom (Bank of England), France and the Netherlands—are also preparing to apply these tools on stress test scenarios for the financial firms they supervise.

A second group of policies support the development of a taxonomy of economic activities and the advancement of markets for green financial instruments. Financial regulators and supervisors can take a leading role in bringing together relevant stakeholders and experts to develop a taxonomy that enhances the transparency around which economic activities contribute to the transition to a "green" (low-carbon and environmentally sustainable) economy and in which others are more exposed to climate-related risks ("brown"). Such a taxonomy[7] would facilitate financial institutions' identification, assessment and management of climate and environment-related risks and mobilize capital for green and low-carbon investments.[8]

For prudential regulation some analysts have proposed adapting micro- and macro-prudential policies to explicitly consider climate-related risks and internalize systemic climate risk. "Tools could include reserve, liquidity and capital adequacy requirements, loan-to-value ratios, and caps on credit growth, as well as sectoral capital buffers targeting credit to particularly climate-exposed sectors."[9] Similarly, green supporting and brown penalizing factors could be included in capital requirements, and regulation could determine that minimum amounts of green assets should be held on financial institutions' balance sheets.[10]

There is controversy, however, over the effectiveness of these climate-related prudential regulations, as they "may only very partially contribute to hedging financial institutions from 'green swan' events."[11] Other analysts consider that "lowering capital requirements on bank loans to green sectors could undermine macroprudential policy goals and financial risk mitigation. The Basel Committee has consistently adopted an approach in which prudential rules are based only on risk considerations, to shield them from influences like industrial policy goals or political interference in banks' lending practices."[12]

In this respect, a recent survey by the Basel Committee on Banking Supervision found that "The majority of authorities considered it appropriate to address climate-related financial risks within their existing regulatory and supervisory framework.[...] However, it is important to note that the majority of members have not factored, or have not yet considered factoring, the mitigation of such risks into the prudential capital framework."[13]

The third group of financial policies can reduce financial institutions' short-term bias and improve their governance. This can be done through prudential and corporate governance reforms and by adopting environmental, social and governance standards in the financial sector, especially among pension funds and other asset managers. Depending on a country's institutional framework, some central banks and regulators can also be catalysts for sound scaling up of green finance.[14]

Private sector moves towards long termism and supporting the values of sustainable finance are also under way. Some of the largest wealth managers have publicly announced a series of initiatives to place sustainability at the centre of their investment approach, liquidate investments that present a high risk to sustainability and commit to disclosure guidelines in accordance with the Task Force on Climate-related Financial Disclosure, among others.[15]

According to the Institute of International Finance, "with the Covid-19 pandemic serving as a real-life "stress test" for ESG [environmental, social and governance] investing strategies, the relative performance of sustainable assets has been remarkable" during the atypical first half of 2020."[16]

Monetary policy

Climate-related physical and transition risks will most likely progressively have an impact on prices, actual and potential economic growth, and financial

stability, all of which are core objectives of most central banks. Increasingly, therefore, central banks have to analyse and discuss whether and what they can and should do to confront climate change in order to efficiently and successfully safeguard price and financial stability.[17]

As mentioned above, central banks can use the valuable arsenal of policy tools at their disposal to respond to the challenges arising from climate-related shocks, even within a restricted interpretation of their mandates. These tools include adjusting interest rates, expanding balance sheets through bond purchases and extending loans to companies via banks. They also include providing funding schemes for banks that invest in low-carbon projects and even allowing credit allocation policies to favour low-carbon investments (either directly or indirectly through guarantees).

Other more specific aspects of the discussion on ways central banks could proactively support the transition to a low-carbon economy relate to how they can reflect climate risks in monetary policy frameworks. They can integrate climate risk analytics into collateral frameworks—for instance, by adjusting haircuts and valuations on brown assets and even excluding them from the pool of eligible collateral. They can use sustainability criteria in their large-scale asset purchases and refinancing operations to exclude carbon-intensive assets and favour green assets (also referred to as green quantitative easing). And they can implement parallel asset purchase programmes focused on low-carbon assets.[18]

However, the mainstream literature does not consider monetary policy best suited for long-term climate change mitigation efforts and believes it should remain focused on short-term stabilization. And the use of central bank balance sheets to tackle "green swan" events or to further green investments and markets is highly controversial. It may imply stretching central banks' mandates, raising questions of governance, and may risk distorting markets.[19]

Other actions that central banks can consider are coordinating macroeconomic policies and prudential regulations to support an environmental transition.[20] To do so, central banks need to coordinate their own actions with a broad set of fiscal, prudential and carbon regulations to be implemented by other players (governments, private sector, academia, civil society and the international community), keeping in mind that this is a collective action problem.

Finally, central banks and supervisors have a role in leading by example by incorporating sustainability and environmental, social and governance criteria into their own investment portfolios and operational activities. Examples are managing corporate portfolios and pension funds, integrating green requirements into their management framework, targeting green financing, reducing their carbon footprint as companies and publicly disclosing their engagement regarding the previous items.[21]

NOTES

1 Batten and others 2016; NGFS 2019a, 2019b.

2 Krogstrup and Oman 2019.

3 Krogstrup and Oman 2019.

4 Krogstrup and Oman 2019.

5 NGFS 2020a.

6 NGFS 2019a, 2020a.

7 China and the European Union have outlined green taxonomies. There are also some market-driven taxonomies, such as the Climate Bonds Standards (released by the Climate Bonds Initiative) and the International Capital Market Association's Green Bond Principles.

8 NGFS 2019a.

9 Krogstrup and Oman 2019, p. 26.

10 Dikau and Volz 2019.

11 Bolton and others 2020, p. 53.

12 Krogstrup and Oman 2019, p. 29.

13 BCBS 2020, p. 1.

14 Krogstrup and Oman 2019.

15 Fink 2020; *The Economist* 2020a.

16 IIF 2020, p. 1.

17 Bolton and others 2020; Dikau, Robins and Volz 2020; Dikau and Volz 2019; NGFS 2019b, 2020b.

18 Dikau, Robins and Volz 2020; Krogstrup and Oman 2019.

19 Bolton and others 2020; Krogstrup and Oman 2019; Pereira da Silva 2020.

20 Bolton and others 2020.

21 These are considered under workstream 3 (mainstreaming green finance) of the Network for Greening the Financial System (NGFS 2019c).

SPOTLIGHT 5.2

The role of carbon pricing in climate change mitigation

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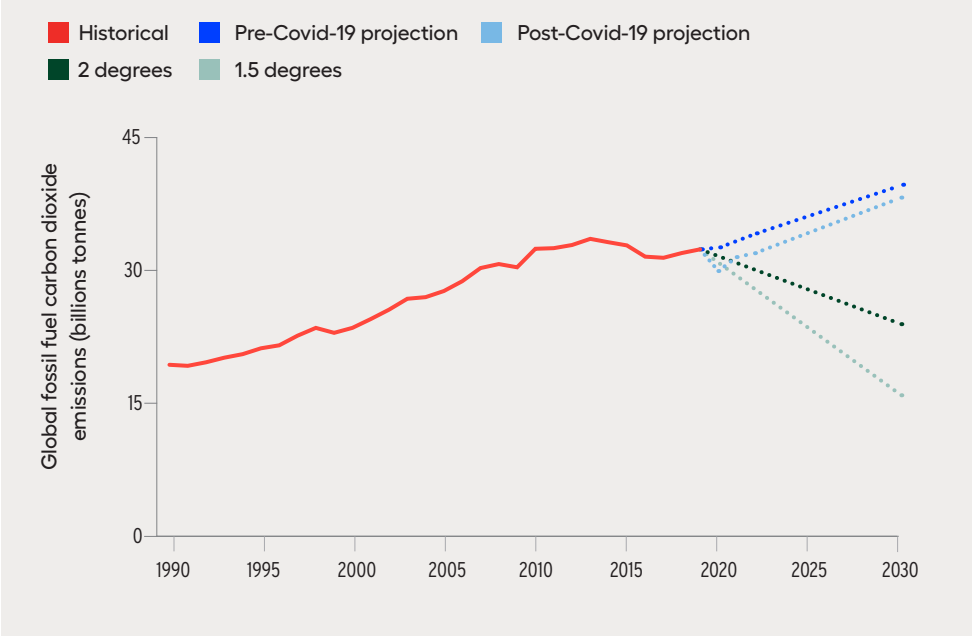
The public health and economic crisis precipitated by the Covid-19 pandemic has not altered the basic need for transitioning to clean energy systems by mid-century to contain the risk of dangerous and irreversible instability in the global climate system. Indeed, with governments likely to bring forward investment plans to help boost their economies, the pandemic has added to the urgency of ensuring that this new investment is appropriately allocated to low-carbon technologies rather than locking in emissions-intensive capital. Carbon pricing provides a critical incentive in this regard, and the revenue it yields can also help meet fiscal needs—needs that are especially pressing because of the crisis and in the wider context of meeting the Sustainable Development Goals. But to maximize effectiveness, pricing needs to be part of a comprehensive policy package and coordinated across large emitters.

Emissions trends and the Paris Agreement

An emissions pathway consistent with limiting future global warming to 1.5–2 degrees Celsius would require cutting fossil fuel–based carbon dioxide and other greenhouse gas emissions to 25–50 percent of their 2018 levels by 2030,[1] with continued rapid reductions thereafter. Emissions are projected to be about 8 percent lower in 2020 than in 2019,[2] due to both lower GDP and structural shifts in the economy, such as increased remote working. However, this dent in the flow hardly affects the stock of carbon dioxide in the atmosphere, which continues to rise precipitously. And emissions are likely to start rising again in 2021 as economies recover and some of the structural shifts are partially reversed (figure S5.2.1).

Figure S5.2.1 Emissions are likely to start rising again in 2021 as economies recover and some structural shifts are partially reversed



Source: International Monetary Fund staff calculations and IEA (2020b) and IPCC (2018).

The 2015 Paris Agreement provides the international framework for meaningful action on climate mitigation. The heart of the agreement is commitments by 188 parties to reduce their emissions. These pledges are due to be revised ahead of the 26th UN Climate Change Conference of the Parties (COP26), in November 2021. Although the immediate challenge is for countries to implement current pledges, ambition at the global level needs to be scaled up considerably. Even if current pledges are fully achieved, the emissions gap in 2030 to the 2 degrees Celsius target would be cut by only a third.[3]

The case for carbon pricing

As argued in the chapter, carbon pricing can play a pivotal role in mitigation strategies by providing a critical price signal for redirecting investment and consumption towards low-carbon technologies. A carbon price of, say, $50 per tonne of carbon dioxide emissions in 2030 could increase projected prices in Group of 20 (G20) countries by about 140 percent for coal, 45 percent for natural gas, 30 percent for electricity and 10 percent for gasoline.[4]

The carbon prices consistent with countries' mitigation pledges vary widely due to both differences in the stringency of commitments and the responsiveness of emissions to pricing (for example, emissions are more price responsive in countries using a lot of coal, such as China, India and South Africa). For example, a $25 carbon price would exceed the level needed to meet mitigation commitments in China, India, South Africa and the United States, but $75 per tonne would fall short of what is needed in Canada, France, Italy and the Republic of Korea (figure S5.2.2).

Carbon pricing could also raise significant revenue, typically 0.5–2 percent of GDP in G20 countries for a $50 tax in 2030. That revenue can be used productively to offset the harmful macroeconomic effects of higher energy prices—for example, by funding general or green public investments or lowering taxes on work effort and investment.

Many studies suggest that carbon pricing has a small overall impact, or perhaps even a positive impact, on GDP.[5] The economic efficiency costs of carbon pricing—the value of foregone benefits to fuel users minus savings in supply costs—are also not that large, typically around 0.5 percent of GDP or less for a $50 carbon price in 2030 (figure S5.2.3). Moreover, for many countries these efficiency costs are more than offset by the domestic environmental benefits, such as reduced mortality due to local air pollution. In short, many countries can move ahead unilaterally with some level of carbon pricing that makes them better off, before even counting the global warming benefits.

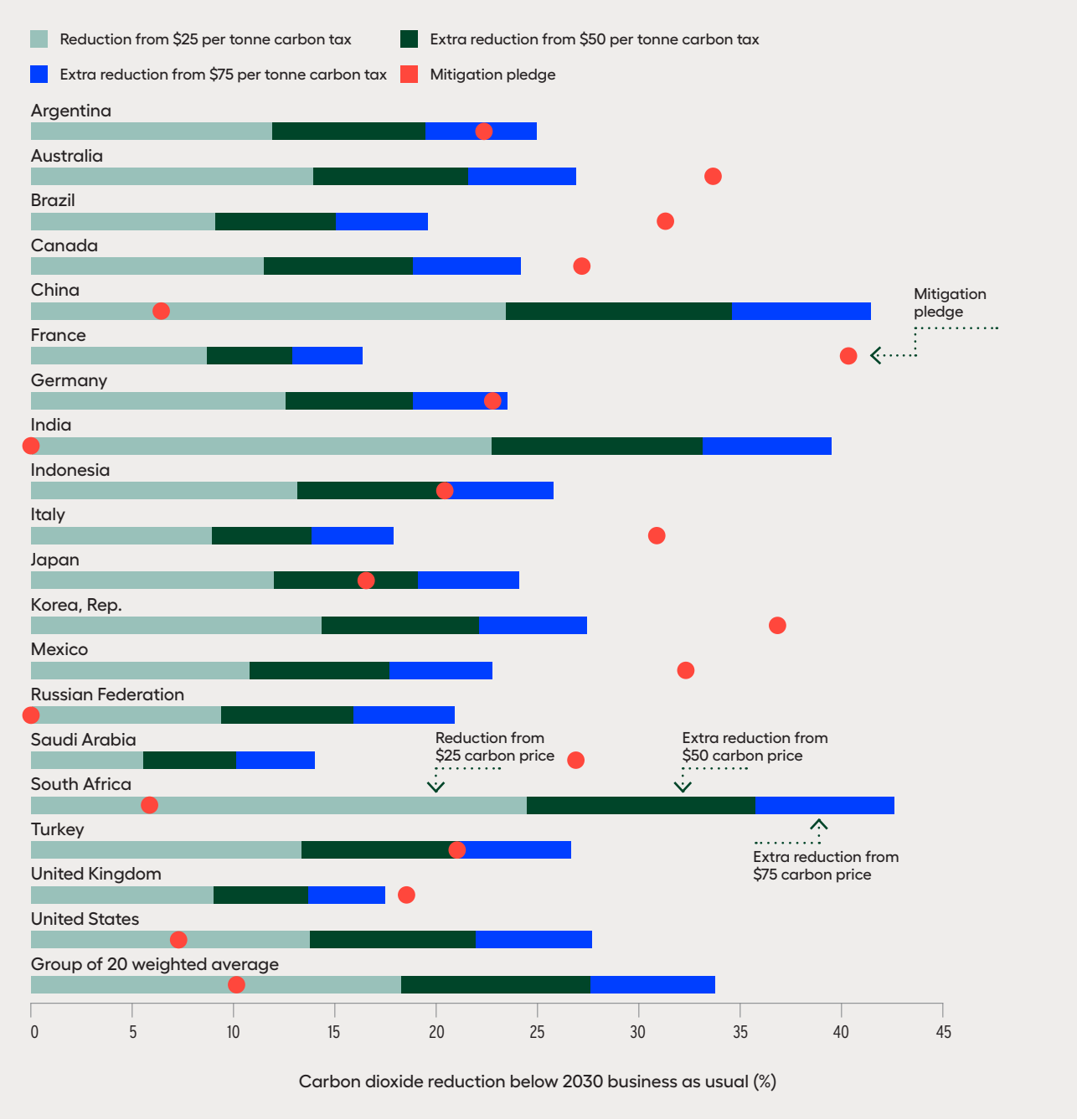
Although more than 60 carbon tax and trading systems are in operation at the national, subnational and regional levels in various countries, the average price on emissions worldwide is only $2 per tonne.[6] The International Monetary Fund has called for measures equivalent to a global carbon price of at least $75 per tonne by 2030 to keep global warming below 2 degrees Celsius.[7] The difference between current and needed prices underscores the political difficulty of ambitious pricing, as elaborated in the chapter. Where carbon pricing is politically constrained, policymakers could reinforce it with other approaches that do not impose a new tax burden on energy and therefore avoid large increases in energy prices.

One flexible and cost-effective approach of this kind is (revenue-neutral) "feebates," which provide a sliding scale of fees on products or activities with above-average emissions intensity and a sliding scale of rebates for products or activities with below-average emissions intensity. Feebates are especially valuable for sectors that are difficult to decarbonize through carbon pricing alone, such as the transport sector. By altering the relative price of vehicles with high- and low-emissions rates, feebates could provide powerful incentives for consumers to buy electric or other zero-emissions vehicles without a new tax burden on the average motorist or the fiscal costs associated with tax rebate or subsidy programmes for zero- or low-emissions vehicles. Several countries, including France, the Netherlands and Norway, have introduced elements of feebates for the vehicle sector.

Broader components of green recovery programmes

In addition to carbon pricing and reinforcing mitigation instruments, as well as developing a new and ambitious climate plan for COP26, there are several other potential ingredients to a green recovery programme.

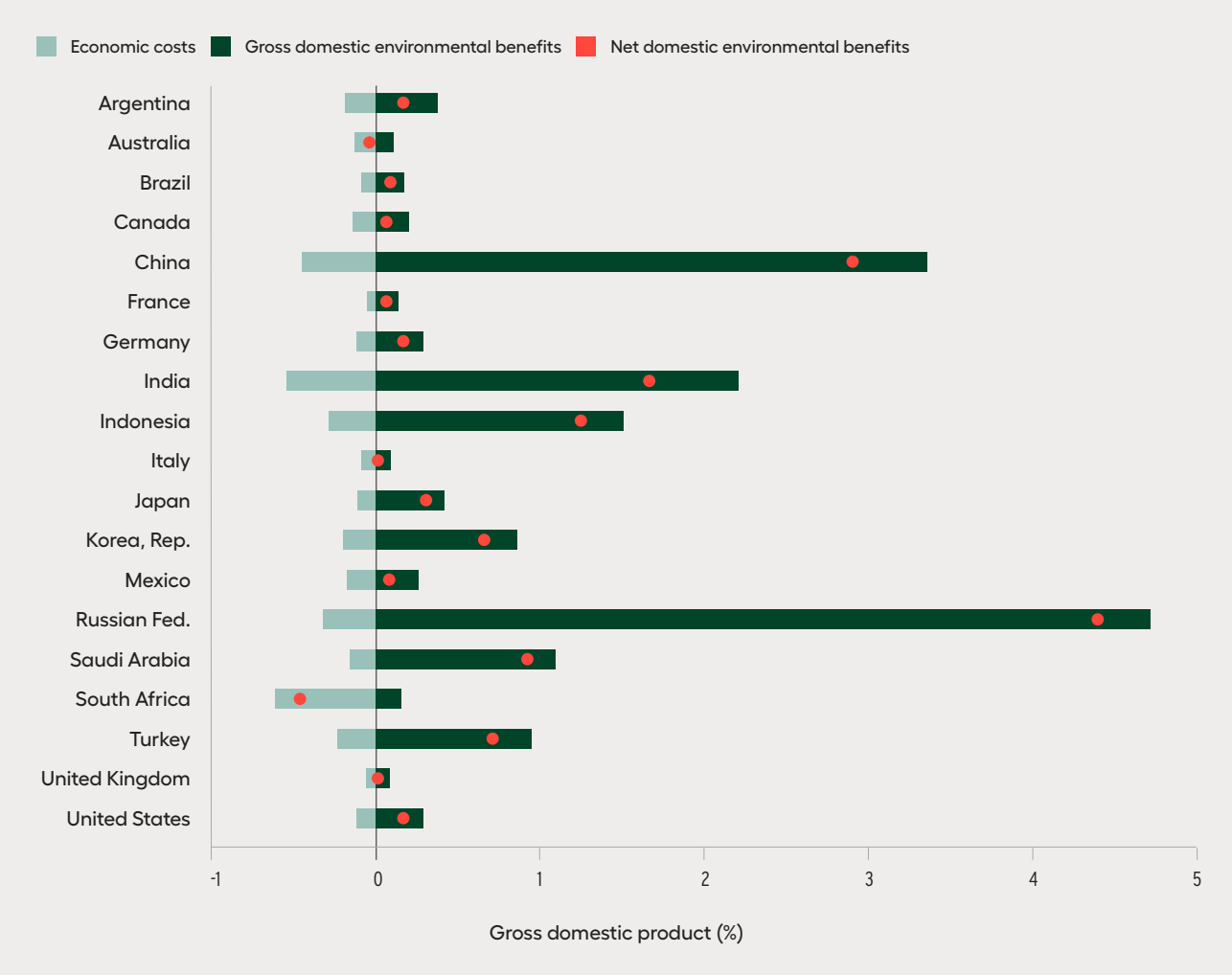
Figure S5.2.2 The carbon prices consistent with countries' mitigation pledges vary widely



Note: Mitigation pledges are from the Paris Agreement or subsequent national pledges.
Source: Updated from IMF (2019b).

One is measures to enhance the effectiveness and credibility of carbon pricing. These include public investment in clean energy infrastructure (grid extensions to link renewable generation sites, pipelines for carbon capture and storage, charging stations for electric vehicles), instruments to promote the development and deployment of clean energy technologies (prizes for energy storage technologies, fiscal incentives to encourage deployment of immature technologies) and instruments to lubricate climate finance from financial markets (carbon disclosures, futures markets for carbon pricing, loans for residential retrofitting). Carbon pricing or feebates can also be extended to other emissions sources as monitoring

Figure S5.2.3 The economic efficiency costs of carbon pricing are more than offset by domestic environmental benefits



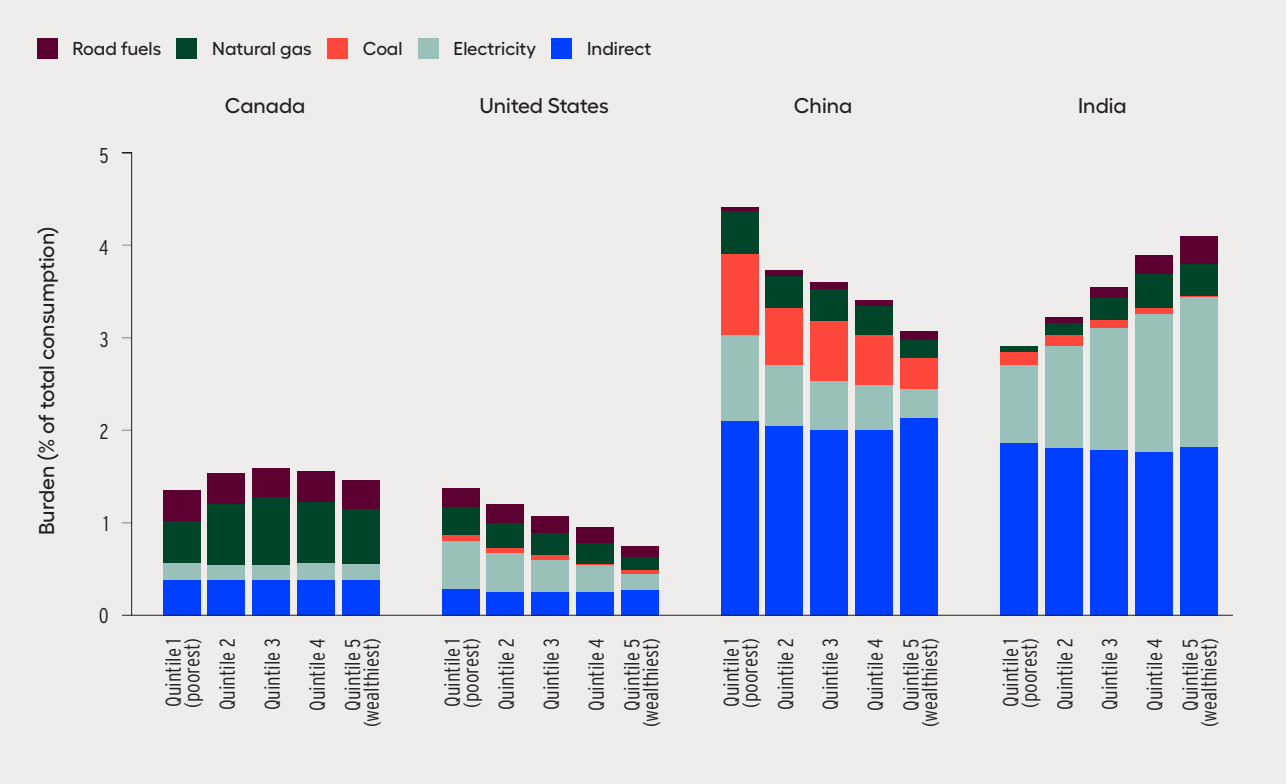
Source: Updated from IMF (2019b).

capacity is developed (for forestry, industrial process emissions, fugitive emissions from extractive industries). Where monitoring is inherently difficult, as in agriculture, proxy emissions fees or feebates might be based on farm-level inputs to promote less emissions-intensive methods (poultry or crop farming instead of cattle and pig farming) and "sin taxes" at the consumer level might discourage meat consumption.

Besides prioritizing climate investments in national budgeting procedures, government support might also be greened, where appropriate, by making business loans conditional on environmental improvement (for example, emissions reductions for airline companies).

The overall carbon mitigation package needs to be equitable within countries—both for its own sake and to enhance the acceptability of reform. Incidence analyses suggest that carbon pricing can be anything from moderately regressive (China, the United States), to distribution-neutral (Canada) to moderately progressive (India, where wealthier households have greater access to electricity; figure S5.2.4). The recycling of carbon pricing revenues should be tilted towards lower income households in the former cases to keep the overall policy reform fair from a distributional perspective. Adverse impacts on displaced workers (from coal mining) and regions (rural areas lacking access to public transport) are also a major concern. An upfront package of targeted assistance measures (stronger social safety nets, worker retraining programmes, tax relief for commuters) is

Figure S5.2.4 Carbon pricing can be moderately regressive, distribution-neutral or moderately progressive



Note: "Indirect" refers to the increased price of consumer goods from higher energy costs. Burdens are estimated prior to the use of carbon tax revenue; a full passthrough of taxes to consumer prices is assumed.
Source: Updated from IMF (2019b).

important and need only use a small fraction of the revenue from carbon pricing.

The appropriate timing of carbon pricing will vary with international conditions (reform may be easier when oil prices are low) and national circumstances (reform may be delayed until recovery is well under way for countries able to finance stimulus packages through debt). And consultations with business interests and labour organizations, as well as an extensive public communications programme, may help to overcome opposition to the reform.

Advancing policy internationally —a carbon price floor

At the international level the Paris Agreement mitigation process could be strengthened and reinforced with a carbon price floor arrangement among large-emitting countries. This arrangement would guarantee a minimum level of effort among participants and provide some reassurance against losses in international competitiveness from introducing carbon pricing. Coordination over price floors rather than price levels allows countries to exceed the floor if this is needed to meet their Paris Agreement mitigation pledges. And the floor could be designed equitably, with stricter requirements for advanced countries, and flexibly, to accommodate different approaches at the national level if they achieve the same emissions outcome as would have occurred under the floor price. There are some monitoring challenges—for example, countries would need to agree on procedures to account for possible exemptions in carbon pricing schemes and changes in pre-existing energy taxes that might offset, or enhance, the effectiveness of carbon pricing. But these analytical challenges should be manageable.

The price floor could be strikingly effective. For example, if advanced and developing G20 countries were subject to (relatively modest) carbon floor prices of $50 and $25 per tonne of carbon dioxide respectively, mitigation effort by 2030 would still be twice

as much as reductions implied by meeting current mitigation pledges.[8] The prospective border carbon adjustment in the European Union could be a potential mechanism for promoting participation in such an arrangement, through exemptions for those with adequate carbon pricing.

NOTES

1 IPCC 2018.
2 IEA 2020b.
3 UNEP 2019a.
4 IMF 2019b.
5 For example, Metcalf and Stock (2020).
6 World Bank 2020d.
7 Georgieva 2020.
8 IMF 2019b.

SPOTLIGHT 5.3

How do governments' responses to the Covid-19 pandemic address inequality and the environment?

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Around the globe the Covid-19 pandemic has exacerbated several forms of health, social, gender and racial inequality. The worse-off, with less access to health care, have been hit particularly hard.[1] The consequences of the pandemic for the environment are more ambiguous. The Great Lockdown led to a temporary drop in global greenhouse gas emissions, but it is still unclear whether environmental protection will increase thanks to the pandemic. So to what extent do Covid-19 economic policy responses integrate inequality reduction and environmental protection, two central dimensions of the Sustainable Development Goals?

Colourless stimulus packages hide polarized endeavours for green transition

The global Covid-19 pandemic has imposed unprecedented constraints on social and economic activity—particularly mobility—with severe impacts on energy use. Global energy demand is expected to contract by 6 percent in 2020, the largest drop in more than 70 years. The decline in greenhouse gas emissions in the short term is a mechanical scale effect of the economic contraction and physical lockdown—particularly limited surface transport. Globally, greenhouse gas emissions are expected to fall by 8 percent in 2020,[2] roughly the cut needed every year from 2020 to 2030 to be on track for the Paris Agreement on climate change objective to keep global warming below 1.5 degree Celsius.[3]

This expected reduction in greenhouse gas emissions is the highest relative to major historical wars and epidemics.[4] Annual carbon dioxide emissions dropped by 3 percent during World War II (1939–1945) and by 4 percent during the 1980–1982 recession.[5] They fell by only 1 percent during the 1991–1992 recession and the 2009 global financial crisis. Despite the dip in emissions seen in 2020, the sector with the highest emissions—electricity—had one of the smallest changes in activity,[6] making decarbonizing the power sector a burning emergency. In addition, there was a postlockdown rebound in countries such as China, where fossil and cement emissions were higher in May 2020 than a year before.[7]

In one study of more than 300 policies in Group of 20 countries, only 8 percent were deemed green or brown (4 percent green and 4 percent brown), while 92 percent were deemed colourless.[8] Although lockdown measures and particularly restrictions on mobility have reduced greenhouse gas emissions in 2020, the overall climate impact will be driven by investment choices and the greenness of recovery packages, when existing. Climate experts warn that pollution and emissions could bounce back after the Covid-19 pandemic due to a carbon-driven recovery[9] and the relaxation of environmental regulation.[10]

A limited number of policy responses targeted the environment. Take Kenya, where $8 million was spent to enhance the provision of water facilities, $9 million for flood control measures and $5 million for a Greening Kenya Campaign.[11] Barbados announced a massive environmental cleanup program.[12] Some measures actually harmed the environment in the short term. In Viet Nam a deduction of 30 percent of the current environmental protection tax was allowed for jet fuel between August and December 2020.[13] In Fiji the government cut the environmental tax but at the same time eased credit for renewable energy businesses.[14]

The greenness of emergency rescue packages should be much higher than the documented 4 percent share. Clean physical renovations and retrofits, education and training, natural capital and ecosystem resilience, and clean research and development are pinpointed as key investment priorities.[15]

Screening the policy responses collated by the International Monetary Fund Policy Tracker,[16] a few of these normative policy types turn up in actual recovery packages. Limited in number, the green recovery packages and financial measures encompass investment in green infrastructure, incentives for consumer purchases, support to green jobs and credit facilities for green sectors or activities, including research and development. Strikingly, they are found almost exclusively in a few high-income countries; Fiji, Kenya and Uganda are exceptions (table S5.3.1).

There is a marked difference between the haves and the have nots—governments having the financial and institutional capacity to plan and green their long-term economic pathway in the follow-up to the Covid-19 pandemic, and the others.

How social can green recovery policies be?

It is unclear whether green policies will affect socioeconomic inequalities—and in which direction. Infrastructure investment can turn out to be pro-poor environmental policies. In Sweden investments in urban renewable heating networks in the 1970s and 1980s made it possible for households to reduce their energy bill and shift to low-carbon energy technologies.[17] A carbon tax in the 1990s with support schemes for households (followed by a tax reduction for low-income households in 2004) made Sweden one of the rare industrialized countries to have reduced its carbon dioxide emissions between 1990 and the early 2010s, while sustaining growth and keeping inequalities under control. However, other forms of low-carbon investments may favour the better-off: high-speed trains connecting large urban centres may benefit urban elites more than rural communities. On a similar reasoning, credit facilities for green sectors or research and development subsidies can be critical to develop green innovation and jobs. And yet, in dual economies with formal and informal sectors, such policies may deepen the gap.

The economic transformation sparked by the Covid-19 pandemic and its diverse responses will

Table S5.3.1 A breakdown of green recovery measures

Country or economy	Investment in green infrastructure	Incentives for consumer purchases	Support to green jobs	Credit facilities for green sectors or activities, including research and development
Australia	✔			
Barbados	✔			
Canada (British Columbia)				✔
France	✔	✔		
Germany	✔	✔		
Kuwait				✔
Ireland				✔
Italy				✔
Korea, Rep.	✔			
Luxemburg	✔	✔		
Norway	✔	✔		
Spain				✔
Sweden			✔	
United Kingdom	✔		✔	
Euro Area	✔	✔		
Fiji				✔
Kenya				✔
Uganda				✔

Source: Authors' creation based on the International Monetary Fund Policy Tracker.

move some countries closer to the Sustainable Development Goals pathway, while pushing others farther away from it. As in any crisis, the drivers of positive societal change are playing out. The expansion of social registers is part of it, as in Angola and Nigeria, and the same holds for higher public health spending, including capital spending, partly because of long-lasting scrutiny of Covid-19's resurgence, as in Senegal and Tunisia. A structural transformation is under way in Uganda, where the government provided additional funding to the Uganda Development Bank, recapitalized the Uganda Development Cooperation and accelerated the development of industrial parks while boosting funding for agriculture.[18] Fiji raised its Import Substitution and Export Finance Facility by FJ$100 million to provide credit to exporters, large-scale commercial agricultural farmers, public transportation and renewable energy businesses at concessional rates.[19]

Making the Covid-19 recovery an opportunity for countries to harness the transformation called for by the 2030 Agenda for Sustainable Development and the Sustainable Development Goals is a crying emergency. Lack of financial resources, policy coordination and knowledge put the fragile momentum for building back better at risk. In order to maximize policies' effectiveness at reaching interdependent sustainable development goals, we must increase understanding of how social and environmental impacts of stimulus and recovery packages are playing out and could be magnified.

To this aim, we propose a socioenvironmental policy assessment matrix, narrowing environmental policy to sustainable energy for all, and identify from the deep decarbonization literature three broad pathways to achieving sustainable energy for all: increasing energy access and efficiency, decarbonizing existing energy carriers and switching to low-carbon energy carriers (table S5.3.2).[20] To design the matrix, each pathway considers whether specific environmental policies might affect inequality by looking at the incidence of impacts at the bottom, middle and top of the income distribution, following the economic inequality literature.[21]

The matrix enables mapping of what transformative decarbonization measures were taken or planned in Covid-19 responses, what kind of inequality is affected and, as important, what complementary measures could be envisaged to ensure that the recovery phase genuinely supports the Sustainable Development Goals. Our takeaway from the Covid-19 response trackers is that, the Euro Area/European Union aside, most green measures fall in the energy access and efficiency pathway (in bold). Progressive funding measures are still not considered at this stage. This leaves ample room to innovate and experiment with recovery packages in meeting the sustainable development challenges of our times.

Table S5.3.2 A matrix of environmental and inequality reduction policies, with a focus on energy transition in developing countries

		Pathway to low-carbon and inclusive energy systems		
		Increase energy efficiency and access	**Decarbonize energy supply**	**Large-scale switch in end uses (building, transport, industry)**
What kind of inequality is impacted?	**Bottom**	→ **Cash transfers** → Clean cooking solutions → Rural electrification (solar)	→ Decentralized off-grid/mini-grid	→ Green bus rapid transit
	Middle	→ Overhaul of power distribution → Energy-efficient buildings → **Electricity bill relief**	→ On-grid renewable energy deployment	→ Railway development → Circular economy
	Top	→ Wealth taxes (to finance the above) → **Removal of fossil fuel subsidies**	→ Carbon-based corporate taxes → Wealth taxes (to finance the above)	→ Energy-positive buildings → Electric vehicles subsidies → Carbon-based flight (business) ticket taxes → Wealth taxes (to finance the above)

Source: Authors' creation.

NOTES

1 See, for instance, evidence from Opportunity Insights data (at https://tracker.opportunityinsights.org). In the United States low-wage employment (below $27,000 a year) dropped by 35 percent in April, while high-wage employment (above $60,000 a year) fell by close to 13 percent in the same month. Employment rebounded by the end of August to pre-Covid levels for high-wage earners, while they remained significantly lower for low-wage earners.

2 IEA 2020b.

3 UNEP 2019a.

4 Boden and other 2017; Liu and others 2020; Pongratz and others 2011.

5 Boden and others 2017.

6 Le Quéré and others 2020.

7 Myllyvirta 2020.

8 Hepburn and others 2020.

9 Liu and others 2020.

10 Le Quéré and others 2020.

11 SET 2020

12 KPMG 2020.

13 IMF 2020b.

14 IMF 2020b.

15 Hepburn and others 2020.

16 IMF 2020b.

17 Chancel 2020.

18 Cases of Angola, Nigeria, Senegal, Tunisia and Uganda are based on SET (2020).

19 IMF 2020b.

20 Energy Transitions Commission 2018; Waisman and others 2019.

21 Particularly Blanchard and Rodrik (forthcoming) and World Inequality Lab and World Inequality Database (2018).

SPOTLIGHT 5.4

Policymaking for sustainable development 2.0

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As policymakers around the world strive for global sustainability, research in support of this goal is racing ahead, driven by new and exciting innovations. Advances in data collection and computing capabilities and the integration of science with economics are transforming how we think about managing the planet.

A key step is to focus our attention on critical sustainability issues rather than trying to answer interesting but impractical questions. A large body of research has focused on pricing the total annual value produced by the world's natural systems—for example, how much the world values the totality of global rainforests or all biodiversity on the planet (see also chapter 7 and spotlight 7.3).[1] These tasks are both ambitious and inspiring, but they are almost impossible, from both a practical and a theoretical standpoint—and more important, they are unnecessary for guiding the world towards achieving sustainability.

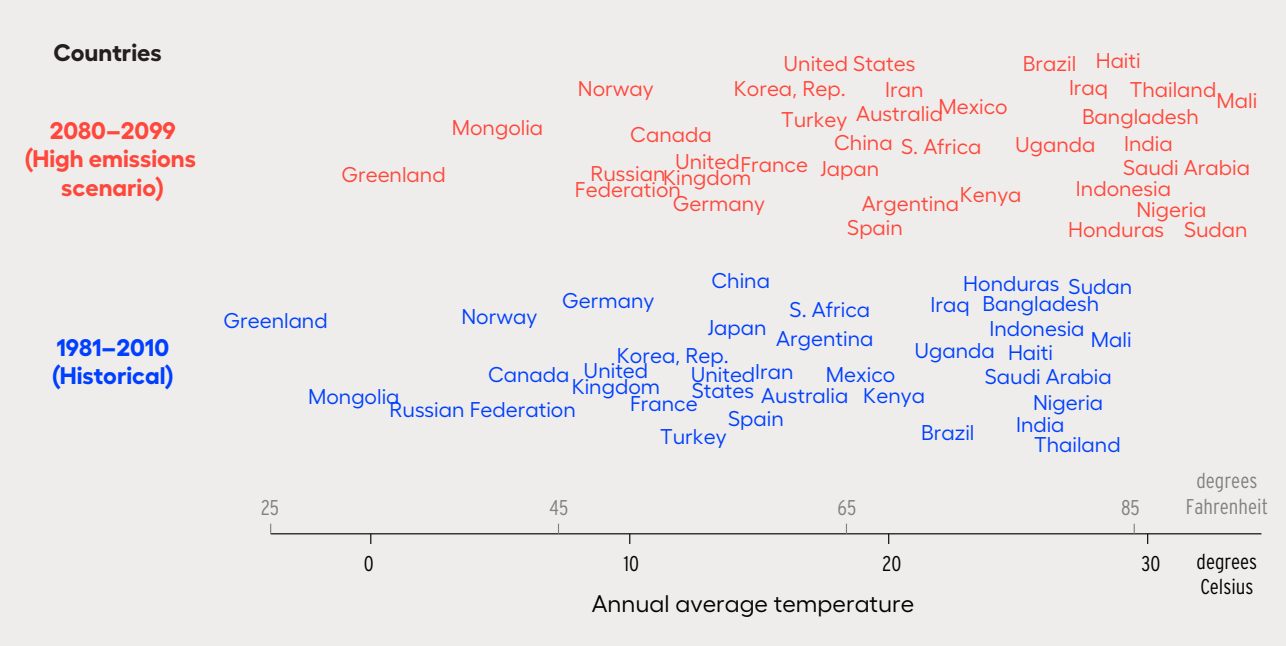
What is essential for achieving sustainability is properly valuing natural resource assets that might be affected by decisions today. In the language of economics, we need to think about planetary resource management "on the margin." If a resource might be used or polluted by humans, we need to ask whether the benefits of that decision outweigh the costs, both direct and indirect. If we can ensure that we satisfy this sustainability criterion at every decision point, we are guaranteed to achieve long-term sustainability as a global society.[2] In this way achieving sustainability is like following a compass on a journey: Each time you choose a path, if you check that you are traveling north, you are guaranteed to keep moving northward. Similarly, if we ensure that each economic project is increasing the wellbeing of future generations, we will achieve sustainability.

New empirical research is illuminating how environmental conditions affect economic outcomes. If human activities alter the environment, the environment may in turn alter the economy. For example, recent findings illustrate how industrial pollution lowers the productivity of workers,[3] how changes in sunlight—either by pollution or intentional geoengineering—affect crop yields,[4] how living forests increase the value of real estate,[5] how fisheries provide labour opportunities for would-be pirates,[6] how groundwater depletion drives poverty,[7] how windblown dust increases child mortality,[8] how El Niño droughts increase the risk of civil conflict,[9] how rainfall during early life improves women's long-term health outcomes[10] and how hurricanes slow GDP growth.[11] All these data-driven insights result from innovations in how environmental science is integrated with more traditional economic analyses.

Among these findings the role of temperature has stood out as a major environmental factor influencing human development around the world.[12] High temperatures have been found to cause crop failures;[13] increase violence,[14] suicide,[15] all-cause mortality[16] and asylum applications;[17] reduce cognitive performance,[18] learning,[19] industrial productivity[20] and economic growth;[21] and strain the basic functioning of governance systems[22] and infrastructure.[23] Taken together, this collection of findings suggests that climate change, through its direct effect on increasing temperature alone, may be a major obstacle to future development. For context, in a high greenhouse gas emissions scenario, temperatures are projected to climb to unprecedented levels throughout the developing world by the end of the century, with future Mexico hotter than historical Iraq and future Bangladesh hotter than historical Mali (figure S5.4.1). Future Sudan will be so hot that there is no historical country it can be compared to. Figure S5.4.2 depicts the projected global mortality consequences of this warming.

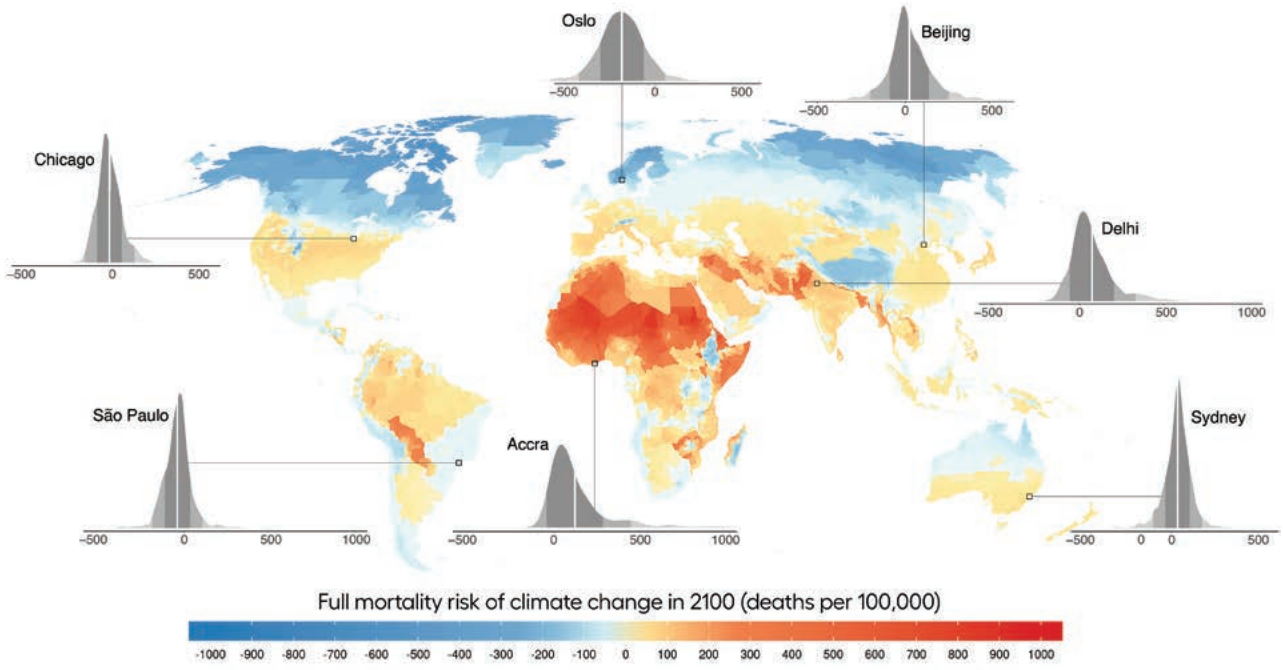
The explosion of empirical findings have raced ahead of our theoretical understanding of how

Figure S5.4.1 In a high greenhouse gas emissions scenario, temperatures are projected to climb to unprecedented levels throughout the developing world by the end of the century



Source: Reproduced from Hsiang and Kopp (2018).

Figure S5.4.2 Average mortality risk due to climate change in 2100, accounting for both the costs and the benefits of adaptation



Note: Density plots for select regions indicate the full probabilistic distribution of estimated impacts across simulations.
Source: Reproduced from Carleton and others (2020).

environmental changes should be integrated into development planning and economic decisionmaking. Achieving the sustainability criterion means that the human influence on these numerous environmental conditions, and their subsequent impact on wellbeing, should be accounted for in major projects. Researchers are now developing the methods necessary to "price" these externalities using the rapidly growing body of empirical findings, so that these impacts can be easily integrated into decisionmaking.[24] This pricing effort allows decisionmakers to explicitly weigh these externalities against the benefits of development projects, provided those benefits are also monetized. These approaches can be further adjusted to account for the unequal costs and benefits of different projects, incorporating equity and justice.[25] Furthermore, as new links are uncovered, our ability to account for the multidimensional impact of environmental changes will strengthen.

The final piece of the puzzle is monitoring how human actions are altering the environment around the world in real time, so that the impacts can be fully accounted for. At present the global community has no system for measuring the comprehensive wealth of countries—that is, tracking changes to environmental assets alongside humanmade assets—so even if we were achieving the sustainability criterion, we would not know. Developing such a system is a major challenge, but it is an essential step towards building global institutions that can account for global environmental changes while balancing the economic interests of current and future generations.

The dual obstacles to assembling such a system are that it must be sensitive and granular enough that small and local environmental changes can be detected but comprehensive enough in both scale and scope that it meaningfully captures the extent of environmental changes that could threaten future human wellbeing. For this task, innovations in machine learning are likely to be a game changer, enabling automated systems to sift through vast quantities of unstructured data to develop structured measurements that are environmentally and economically relevant. For example, applying machine learning to satellite imagery has been fruitful for gathering development-related metrics over large regions,[26] and recent advances suggest that these approaches could be extended to study many environmental and development outcomes simultaneously using current satellite systems.[27]

Just as integrating environmental science with economics revolutionized our understanding of environmental impacts, integrating machine learning will likely revolutionize real-time monitoring of global environmental systems. Together, these elements will empower decisionmakers to integrate the sustainability criterion into their everyday decisionmaking, guiding us towards true sustainable development.

NOTES

1 For example, Costanza and others (1997).
2 Dasgupta 2009; Hartwick 1977; Solow 1986.
3 Graff Zivin and Neidell 2012.
4 Burney and Ramanathan, 2014; Proctor and others 2018.
5 Druckenmiller 2020.
6 Axbard 2016.
7 Blakeslee and others 2020.
8 Heft-Neal and others 2020.
9 Hsiang and others 2011.
10 Maccini and Yang 2009.
11 Hsiang and Jina 2014.
12 Carleton and Hsiang 2016.
13 Schlenker and Lobell 2010.
14 Hsiang and others 2013.
15 Burke and others 2018; Carleton 2017.
16 Carleton and others 2020.,
17 Missirian and Schlenker 2017.
18 Graff Zivin and others 2018.
19 Fishman and others 2019; Park and others 2020.
20 Zhang and others 2018.
21 Burke and others 2015; Hsiang 2010.
22 See Obradovich and others (2018) for an analysis of both extremely hot and cold temperatures
23 See Aufhammer and others (2017) for the case of electricity infrastructure.
24 Bell and others 2020; Carleton and others 2020; Deryugina and Hsiang 2017; Fenichel and Abbott 2014; Hsiang and others 2017; Muller and others 2011.
25 For example, Anthoff and others (2009), Hsiang and others (2017) and Hsiang and others (2019).
26 Blumenstock 2018; Burke and others 2020.
27 Rolf and others 2020.