UN environment programme

Making Peace with Nature

A scientific blueprint to tackle the climate, biodiversity and pollution emergencies

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UN Secretary-General's Foreword

Humanity is waging war on nature. This is senseless and suicidal. The consequences of our recklessness are already apparent in human suffering, towering economic losses and the accelerating erosion of life on Earth.

Ending our war does not mean surrendering hard-won development gains. Nor does it cancel the rightful aspiration of poorer nations and people to enjoy better living standards. On the contrary, making peace with nature, securing its health and building on the critical and undervalued benefits that it provides are key to a prosperous and sustainable future for all.

The urgent need to transform our relationship with nature risks being overlooked amid the huge suffering inflicted by the COVID-19 pandemic. Saving precious lives and livelihoods is our top priority. But by exposing humanity's vulnerability, the pandemic can also help make 2021 a turning point towards a more sustainable and inclusive world.

This report provides the bedrock for hope. By bringing together the latest scientific evidence showing the impacts and threats of the climate emergency, the biodiversity crisis and the pollution that kills millions of people every year, it makes clear that our war on nature has left the planet broken. But it also guides us to a safer place by providing a peace plan and a post-war rebuilding programme. By transforming how we view nature, we can recognize its true value. By reflecting this value in policies, plans and economic systems, we can channel investments into activities that restore nature and are rewarded for it. By recognizing nature as an indispensable ally, we can unleash human ingenuity in the service of sustainability and secure our own health and well-being alongside that of the planet.

Making peace with nature is the defining task of the coming decades. We must seize the opportunity presented by the COVID-19 crisis to accelerate change. This year, several major international conferences, including on climate change, biodiversity and desertification, provide an opportunity to increase ambition and action on recovering better and addressing climate disruption. Our central objective is to build a global coalition for carbon neutrality. If adopted by every country, city, financial institution and company around the world, the drive to reach net-zero emissions by 2050 can still avert the worst impacts of climate change.

Similar urgency and ambition are needed to transform other systems, including how we produce our food and manage our water, land and oceans. Developing countries need more assistance to redress environmental decline. Only then can we get back on track to achieve the Sustainable Development Goals by 2030.

This report shows that we have the ability to transform our impact on the world. A sustainable economy driven by renewable energy and nature-based solutions will create new jobs, cleaner infrastructure and a resilient future. An inclusive world at peace with nature can ensure that people enjoy better health and the full respect of their human rights so they can live with dignity on a healthy planet.

António Guterres
Secretary-General of the United Nations,
February 2021

UNEP Executive Director's Foreword

Before the COVID-19 pandemic, 2020 was emerging as a moment of truth for our commitment to steer Earth and its people toward sustainability. Momentum was building and global meetings were set to discuss bold action on the three interconnected planetary crises facing humanity, namely the climate crisis, the nature crisis and the pollution crisis. These crises, driven by decades of relentless and unsustainable consumption and production, are amplifying deep inequalities and threatening our collective future.

This report makes the strongest scientific case yet for why and how that collective determination must be urgently applied to protecting and restoring our planet. Drawing on a unique and comprehensive synthesis of global environmental assessments, it details the self-defeating and dangerous consequences of our overconsumption of resources and overproduction of waste.

The science is clear that we are putting extreme pressures on the planet. According to the 2020 UNEP Emissions Gap Report, while the pandemic resulted in a temporary decline in greenhouse gas emissions, we are heading for at least a 3°C temperature rise this century. Our colleagues at the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) have sounded the alarm on the rapid decline of nature and what this means for Agenda 2030 and the Sustainable Development Goals (SDG).

Loss of biodiversity and ecosystem integrity, together with climate change and pollution will undermine our efforts on 80 per cent of assessed SDG Targets, making it even more difficult to report progress on poverty reduction, hunger, health, water, cities and climate. We need to look no further than the global pandemic caused by COVID-19, a zoonotic disease, i.e. transmitted from animal to human, to know that the finely-tuned system of the natural world has been disrupted. And finally, the "toxic trail" of economic growth – pollution and waste which results every year in the premature deaths of millions of people across the world.

While the response to the medical emergency of COVID-19 rightly preoccupies government budgets and political action, the response to this pandemic must ultimately accelerate the economic and social transformations needed to address the planetary emergency. As the UN Secretary-General noted in his State of Planet speech, "COVID recovery and our planet's repair must be two sides of the same coin."

The report outlines what the "repair" of our planet entails, the transformative actions that can unleash human ingenuity and cooperation to secure livelihoods and well-being for all. Repair means solutions that recognize how our environmental, social and development challenges are interconnected. Repair means shifting our values and worldviews as well as our financial and economic systems. Repair means taking a whole-of-society approach. And repair means being fair and just.

With science as our guiding light, UNEP's Medium-Term Strategy (2022-2025) seeks to ensure the link between science, policy and decision-making remains stronger than ever, sustained by strong environmental governance and supported by economic policies that can be the foundation of a catalytic response to the challenges of climate change, biodiversity loss and pollution. In doing so, we support member states, working with partners, scientists, civil society and business to tackle the three interconnected crises so that we stabilize climate; live in harmony with nature and secure a pollution free planet.

2021 must be remembered as the year we took it upon ourselves to ensure that the pandemic is remembered not only as a human tragedy, but as the moment when people reconsidered their priorities as individuals and societies and took to heart that safeguarding the health and well-being of current and future generations means safeguarding the health of our planet.

Inger Andersen
Executive Director
United Nations Environment Programme,
February 2021

Preface

This report presents a scientific blueprint for how climate change, biodiversity loss and pollution can be tackled jointly within the framework of the Sustainable Development Goals. The report is a synthesis based on evidence from global environmental assessments. It has been a privilege to oversee the production and peer review of the report by the eminent group of experts and advisors appointed by Inger Andersen, the Executive Director of UNEP, for their leading contributions to and intimate understanding of the interface between science and policy in addressing the environmental challenges of today.

The expert analysis rests on the synthesis of key findings from a range of recent intergovernmental global environmental assessments and assessments prepared under the auspices of Multilateral Environmental Agreements, UN bodies and others (see annex 1). The report makes reference to the assessments, not the original literature referred therein. The presentation of the findings from the assessments is the responsibility of the authors of the current report. In a limited number of cases, additional high-impact peer-reviewed literature and grey literature have been assessed and referenced in order to present a complete and updated picture of the knowledge base.

The results of this synthesis are presented for decision makers in the form of clear, digestible and facts-based key messages and an executive summary substantiated and referenced in the main report. Part I of the report shows how the findings of the assessments are interlinked and add up to an unparalleled planetary emergency. While most of the underlying assessments are relevant for policy formulation, Part II goes a step further in recommending how the accumulated scientific evidence can be turned into concrete and far-reaching actions by a broad range of actors across society in order to transform humankind's relationship with nature.

This report was prepared amid the challenges of the COVID-19 pandemic, which meant that the authors, scientific advisory group and secretariat had to work without ever meeting face to face. All work was carried out through dozens of virtual conference calls.

This synthesis would not have been possible without the work undertaken for the international assessments used as the evidence base in this report and the contribution by experts from these assessments. We also highly appreciate the outstanding contributions by the group of experts who have joined us in authoring this report and the valuable guidance by the members of the scientific advisory group who peer-reviewed the report multiple times. We would particularly like to acknowledge the sustained enthusiasm for this endeavour by authors and advisors given their many other commitments. We are also indebted to the strong support received from the UNEP secretariat, research fellows, designers and the science communications editor, in particular the visionary guidance and inspiration provided by Inger Andersen and the unwavering commitment of the core team of the secretariat.

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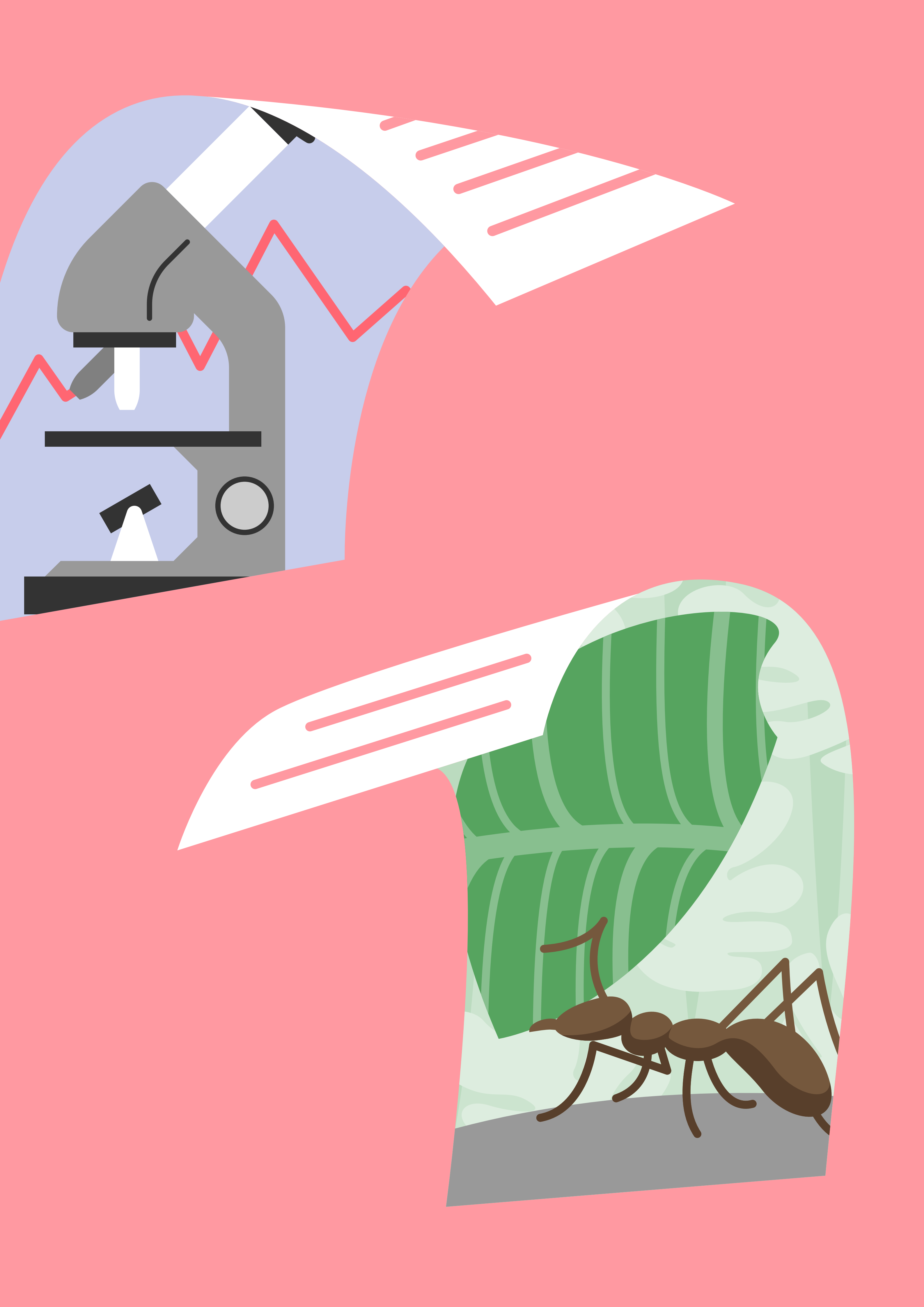
List of Tables, Boxes and Figures



Key Messages

Humanity's environmental challenges have grown in number and severity ever since the Stockholm Conference in 1972 and now represent a planetary emergency. While tackling the emergency is demanding, this report, Making Peace with Nature, lights a path to a sustainable future with new possibilities and opportunities (figure KM.1).

The top five

- Environmental changes are undermining hard-won development gains by causing economic costs and millions of premature deaths annually. They are impeding progress towards ending poverty and hunger, reducing inequalities and promoting sustainable economic growth, work for all and peaceful and inclusive societies.

- The well-being of today's youth and future generations depends on an urgent and clear break with current trends of environmental decline. The coming decade is crucial. Society needs to reduce carbon dioxide emissions by 45 per cent by 2030 compared to 2010 levels and reach net-zero emissions by 2050 to limit warning to 1.5 °C as aspired to in the Paris Agreement, while at the same time conserving and restoring biodiversity and minimizing pollution and waste.

- Earth's environmental emergencies and human well-being need to be addressed together to achieve sustainability. The development of the goals, targets, commitments and mechanisms under the key environmental conventions and their implementation need to be aligned to become more synergistic and effective.

- The economic, financial and productive systems can and should be transformed to lead and power the shift to sustainability. Society needs to include natural capital in decision-making, eliminate environmentally harmful subsidies and invest in the transition to a sustainable future.

- Everyone has a role to play in ensuring that human knowledge, ingenuity, technology and cooperation are redeployed from transforming nature to transforming humankind's relationship with nature. Polycentric governance is key to empowering people to express themselves and act environmentally responsibly without undue difficulty or self-sacrifice.

Transforming nature puts human well-being at risk

The current mode of development degrades the Earth's finite capacity to sustain human well-being

- Human well-being critically depends on the Earth's natural systems. Yet the economic, technological and social advances have also led to a reduction of the Earth's capacity to sustain current and future human well-being. Human prosperity relies on the wise use of the planet's finite space and remaining resources, as well as on the protection and restoration of its life-supporting processes and capacity to absorb waste.

- Over the last 50 years, the global economy has grown nearly fivefold, due largely to a tripling in extraction of natural resources and energy that has fuelled growth in production and consumption. The world population has increased by a factor of two, to 7.8 billion people, and though on average prosperity has also doubled, about 1.3 billion people remain poor and some 700 million are hungry.

- The increasingly unequal and resource-intensive model of development drives environmental decline through climate change, biodiversity loss and other forms of pollution and resource degradation.

- Social, economic and financial systems fail to account for the essential benefits society gets from nature and to provide incentives to manage it wisely and maintain its value. The majority of the essential benefits of nature currently have no financial market value despite being the underpinning of current and future prosperity.

Society is failing to meet most of its commitments to limit environmental damage

- Society is not on course to fulfil the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels and to pursue efforts to further limit the temperature increase to 1.5°C. At the current rate, warming will reach 1.5°C by around 2040 and possibly earlier. Taken together, current national policies to reduce greenhouse gas emissions put the world on a pathway to warming of at least 3°C by 2100. Human-induced current warming of more than 1°C has already led to shifts in climate zones, changes in precipitation patterns, melting of ice sheets and glaciers, accelerating sea level rise and more frequent and more intense extreme events, threatening people and nature.

- None of the agreed global goals for the protection of life on Earth and for halting the degradation of land and oceans have been fully met. Three quarters of the land and two thirds of the oceans are now impacted by humans. One million of the world's estimated 8 million species of plants and animals are threatened with extinction, and many of the ecosystem services essential for human well-being are eroding.

- Society is on course to restore the Earth's protective stratospheric ozone layer. However, there is a lot more to be done to reduce air and water pollution, safely manage chemicals, and reduce and safely manage waste.

The achievement of the Sustainable Development Goals is threatened by an array of escalating and mutually reinforcing environmental risks

- Current and projected changes in climate, biodiversity loss and pollution makes achieving the SDGs even more challenging. For example, even small increases in temperature, along with associated changes such as in weather, precipitation, heavier rainfall events, extreme heat, drought and fire, increase risks to health, food security, water supply and human security, and these risks increase along with warming. In 2018 alone, damages from climate-related natural disasters cost about US$155 billion.

- The burden of environmental decline is felt by everyone, but disproportionally by the poor and vulnerable and looms even larger over today's youth and future generations. Producers and consumers in wealthy countries often export their environmental footprint to poorer countries through trade and the disposal of waste.

- Environmental changes are already undermining hard-won development gains and impeding progress towards ending poverty and hunger, reducing inequalities and promoting sustainable economic growth, work for all and peaceful and inclusive societies. Land degradation, for instance, adversely affects more than 3 billion people.

- Earth's capacity to sustain growing needs for nutritious food, water and sanitation will continue to weaken in the face of ongoing environmental declines, as vulnerable and marginalized people are currently experiencing. For example, food security is threatened by the loss of pollinators and fertile soil. Loss of pollinators, threatens annual global crop output worth between US$235 billion and US$577 billion.

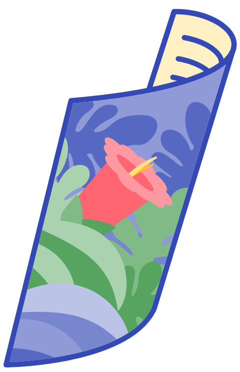
- The deteriorating state of the planet undermines efforts to achieve healthy lives and well-being for all. Around one quarter of the global burden of disease stems from environment-related risks, including those from animal-borne diseases (such as COVID-19), climate change, and exposure to pollution and toxic chemicals. Pollution causes some 9 million premature deaths annually and millions more die every year from other environment-related health risks.

- Environmental risks in cities and urban areas, including those from heatwaves, flash floods, drought, wildfires and pollution, hamper efforts to make human settlements (including informal settlements) inclusive, safe, resilient and sustainable.

There is an urgent need for a clear break with current trends of environmental decline and the coming decade is crucial

- The risks to human well-being and the achievement of the Sustainable Development Goals will continue to escalate unless environmental degradation is halted. Global warming of more than 2°C combined with continued loss of biodiversity and increasing pollution will likely have dire consequences for humanity.

- The costs of inaction on limiting environmental change far outweigh the costs of action. Global aggregate impacts from climate change are estimated to be very high by the end of the century unless cost-effective mitigations strategies are undertaken.



Transforming humankind's relationship with nature is the key to a sustainable future

Human knowledge, ingenuity, technology and cooperation can transform societies and economies and secure a sustainable future

- Decades of incremental efforts have not stemmed the environmental decline resulting from an expansive development model because vested and short-term interests often prevail.

- Only a system-wide transformation will achieve well-being for all within the Earth's capacity to support life, provide resources and absorb waste. This transformation will involve a fundamental change in the technological, economic and social organization of society, including world views, norms, values and governance.

- Major shifts in investment and regulation are key to just and informed transformations that overcome inertia and opposition from vested interests. Regulatory processes should embody transparent decision-making and good governance involving all relevant stakeholders. Opposition to change can be defused by redirecting subsidies toward alternative livelihoods and new business models.

- The COVID-19 crisis provides an impetus to accelerate transformative change. The pandemic and the ensuing economic upheaval have shown the dangers of ecosystem degradation, as well as the need for international cooperation and greater social and economic resilience. The crisis has had major economic costs and is triggering significant investments. Ensuring that these investments support transformative change is key to attaining sustainability.

Earth's environmental emergencies should be addressed together to achieve sustainability

- Given the interconnected nature of climate change, loss of biodiversity, land degradation, and air and water pollution, it is essential that these problems are tackled together. Response options that address multiple issues can mitigate multidimensional vulnerability, minimize trade-offs and maximize synergies.

- Limiting global warming to well below 2°C above pre-industrial levels and pursuing efforts to further limit the temperature increase to 1.5°C requires rapid implementation and a significant strengthening of pledges under the Paris Agreement. Globally, net carbon dioxide emissions need to decline by 45 per cent by 2030 compared with 2010 levels and reach net zero by 2050 to put the world on a pathway to 1.5°C with a probability of about 50 per cent, whereas more ambitious targets would be necessary for higher certainty. A pathway to 2°C would require global emissions to be reduced by 25 per cent by 2030 compared with 2010 levels and reach net zero by around 2070. Both pathways entail rapid transformations in areas including energy systems, land use, agriculture, forest protection, urban development, infrastructure and lifestyles. Mitigating climate change is vital, urgent and cost saving: the lower the degree of warming, the easier and cheaper it will be to adapt.

- The loss of biodiversity can only be halted and reversed by providing space dedicated for nature while also addressing drivers such as changing land and sea use, overexploitation, climate change, pollution and invasive alien species. To prevent extinctions and maintain nature's life-supporting contributions, biodiversity conservation and restoration must be integral to the many uses of terrestrial, freshwater and marine ecosystems, and coupled with an expanded and better-managed global network of interconnected protected areas designed to be resilient to climate change.

- The adverse effects of chemicals and waste on the environment and human health can be substantially reduced by implementing existing international chemicals conventions. Further progress will require strengthening the science-policy interface as the basis for evidence-based policymaking and improved management systems, along with legal and regulatory reform.

The economic and financial systems can and should be transformed to lead and power the shift to sustainability

- Governments should incorporate full natural capital accounting into their decision-making and use policies and regulatory frameworks to provide incentives for businesses to do the same. Yardsticks such as inclusive wealth (the sum of produced, natural, human and social capital) provide a better basis for investment decisions than gross domestic product, as they reflect the capacity of current and future generations to achieve and sustain higher living standards.

- Governments should shift away from environmentally harmful subsidies, invest in low-carbon and nature-friendly solutions and technologies, and systematically internalize environmental and social costs.

- Achieving the Sustainable Development Goals will require massive shifts and increases in public and private financial flows and investment patterns, including in the water, food and energy sectors. Incentives must be shifted so that investments in sustainable development are financially attractive.

- The Global South needs increased access to low-interest finance in order to build its capacity and overhaul accounting systems and policy frameworks in pursuit of the Sustainable Development Goals. The Global North has exacerbated the finance gap by failing to meet its commitments on international environmental and development assistance.

- Shifting taxation from production and labour to resource use and waste promotes a circular economy. Potential inequalities resulting from this shift can be offset through social safety nets.

- Reducing inequalities and the risk of social conflict requires the minimization and reversal of environmental degradation and declines in natural resources. It also requires structural changes to the economy, including steps to promote equity and address individual and community rights to property, resources and education.

The food, water and energy systems can and should be transformed to meet growing human needs in an equitable, resilient and environmentally-friendly manner

- Feeding humanity, ensuring water and energy security, and enhancing the conservation, restoration and sustainable use of nature are complementary and closely interdependent goals. Achieving these goals requires food systems that work with nature, reduce waste, and are adaptive to change and resilient to shocks. Small-scale farmers, especially women farmers, are central to the challenge of food and nutrition security and must be empowered.

- Changes in global patterns of consumption are critical to transforming food, water and energy systems, and to challenging social norms and business practices. Improving access to safe, nutritious and affordable food for all, while reducing food waste and changing dietary choices and consumer behaviour in high-income countries and groups, is central for the achievement of hunger, biodiversity, waste and climate goals.

- Ensuring sustainable food production from the oceans while protecting marine biodiversity requires policy action to apply sustainable harvesting approaches to fisheries management, improve spatial planning and address threats such as climate change, ocean acidification and pollution.

- Sustaining freshwater in the context of climate change, rising demand, and increased pollution involves cross-sectoral and sector-specific interventions at the watershed or river basin scale. This can be achieved by simultaneously increasing water-use efficiency, wisely expanding storage, reducing pollution, improving water quality, minimizing disruption and fostering the restoration of natural habitats and flow regimes.

- Universal access to clean and affordable energy requires a transformation of both the production and use of energy. Increasing the supply of clean energy coupled with innovation and efficiency gains is vital to achieving equitable and sustainable economic growth while limiting global warming. Clean energy will also reduce poverty and indoor and outdoor air pollution and provide critical services such as communications, lighting and water pumping.

Keeping the planet healthy is key to providing health and well-being for all

- Policies, good practices and appropriate technologies to limit climate change, ecosystem degradation and pollution can significantly reduce associated human health risks, including from respiratory diseases, water-borne, vector-borne and animal-borne diseases, malnutrition, extreme weather events and chemical exposure. Technological change and diffusion are important mechanisms to drive transformation.

- A One Health approach integrates action across sectors and disciplines to protect the health of people, animals and the environment. Such an approach is key to minimize future human health risks from climate change, ecosystem degradation and deteriorating food, air and water quality. It is also essential in preventing and limiting the impact of future health emergencies, including pandemic outbreaks of animal-borne diseases such as COVID-19.

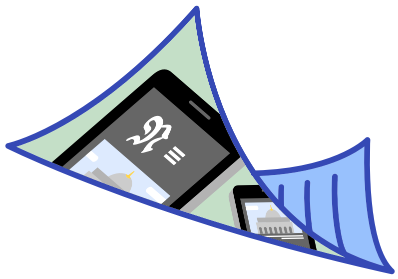
- Cities and other settlements, especially rapidly expanding urban areas and informal settlements, must be made more sustainable. Improvements in urban planning, governance, infrastructure and the use of nature-based solutions can be cost-effective ways to reduce pollution and make settlements more environment friendly and resilient to climate change impacts such as increased urban heat island effects and flooding. Blue and green infrastructure in urban areas have significant benefits for mental health.

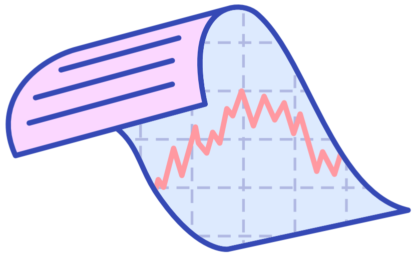
Everyone has a part to play in transforming social and economic systems for a sustainable future

- All actors have individual, complementary and nested roles to play in bringing about cross-sectoral and economy-wide transformative change with immediate and long-term impact. This can be enhanced through capacity-building and education. Governments initiate and lead in intergovernmental cooperation, policies and legislation that transform society and the economy. Such transformations enable the private sector, financial institutions, labour organizations, scientific and educational bodies and media as well as households and civil society groups to initiate and lead transformations in their domains.

- Individuals can facilitate transformation by, for instance, exercising their voting and civic rights, changing their diets and travel habits, avoiding waste of food and resources, and reducing their consumption of water and energy. They can also promote behavioural change by raising awareness in their communities. Human cooperation, innovation and knowledge-sharing will create new social and economic possibilities and opportunities in the transformation to a sustainable future.

Figure KM.1: The well-being of today's youth and future generations depends on an urgent and clear break with the current trends of environmental decline. Human knowledge, ingenuity, technology and cooperation need to be redeployed from transforming nature to transforming humankind's relationship with nature. Time is of the essence. Society needs to reduce carbon dioxide emissions by 45 per cent by 2030 compared to 2010 levels and reach net-zero emissions by 2050 to limit warming to 1.5 °C as aspired to in the Paris Agreement, while at the same time conserving and restoring biodiversity and minimizing pollution and waste.





Executive Summary

Humanity has been grappling with environmental challenges that have grown in number and severity ever since the Stockholm Conference in 1972. The scientific assessments synthesized in this report show that those challenges now represent a planetary emergency. While tackling the emergency is demanding, the report lights a path to a sustainable future marked with new possibilities and opportunities.

I. Transforming nature puts human well-being at risk

Part I of the report addresses how the current expansive mode of development degrades and exceeds the Earth's finite capacity to sustain human well-being. The world is failing to meet most of its commitments to limit environmental damage and this increasingly threatens the achievement of the Sustainable Development Goals (SDGs).

A. The current mode of development degrades the Earth's finite capacity to sustain human well-being

Human well-being is critically dependent on Earth's natural systems. Economic, social and technological advances have come at the expense of the Earth's capacity to sustain current and future human well-being. Human prosperity rests on the wise use of the finite space and resources available to all life on Earth, as well as on the restoration of its life-supporting processes and capacity to absorb human waste. Every person benefits from clean air and water, a protective stratospheric ozone layer, a hospitable climate and the many additional benefits that land and oceans provide, including food, medicines, energy, materials, inspiration and a sense of place. The rich web of life, of which humanity is a part, modulates and maintains Earth's systems in ways critical to people, for example by reducing the severity of natural disasters and by providing soil, pollination and pest control that help people harness the planet's fertility. Over the past 50 years, human societies have dramatically increased the production and extraction of food, energy and materials, resulting in economic, technological and social advances and increased prosperity for many. However, the exploitation of nature has reached unsustainable levels and is undermining the Earth's capacity to sustain human well-being, now and in the future.

Human prosperity is strained by widening inequalities, whereby the burden of environmental decline weighs heaviest on the poor and vulnerable and looms even larger over today's youth and future generations. Across the world, people are living longer, are more educated and have greater opportunities on average than previous generations, but the wealth gap is growing between rich and poor, both among and within countries. Economic growth and poverty reduction occurred across the developing world prior to the COVID-19 pandemic. However, little of the economic progress seen in high- and middle-income countries has benefitted the least developed countries. About 1.3 billion people remain poor, and some 700 million are going hungry, and both numbers are expected to increase significantly because of the economic impact of the pandemic. Environmental decline affects and concerns everyone, rich and poor. However, the burden weighs most heavily on the poor and vulnerable, where women are often overrepresented. Future generations in many localities risk a situation where more people must struggle to make a living from diminished natural resources in a changing environment.

Economic and financial systems fail to account for the essential benefits that humanity gets from nature and to provide incentives to manage nature wisely and maintain its value. Nature provides the foundation for human existence and prosperity. From an economic perspective, nature is a vital capital asset that provides many essential goods and services. Conventional metrics like gross domestic product (GDP) overstate progress because they fail to adequately capture the costs of environmental degradation or reflect declines in natural capital. Conventional economic measures also fail to reflect indicators of health, education and other dimensions of human well-being. Most of the essential benefits of nature currently have no financial or market value despite providing the underpinnings of current and future prosperity. Inclusive wealth, which sums the value of natural, human, manufactured and social capital, is a better measure of sustainable progress. The current practice of excluding the value of nature and the costs of its degradation from economic accounting and market prices, along with the impact of environmentally harmful subsidies such as those for agricultural output and fossil fuel energy, pose an increasing risk to economies and societies. Excluding the value of nature skews investment away from economic solutions that conserve and restore nature, reduce pollution, expand renewable energy and make more sustainable use of resources while also increasing prosperity and well-being.

The resource-intensive and increasingly unequal model of human development indirectly drives global environmental change. Over the last 50 years, the human population has more than doubled, while the extraction of materials and the production of primary energy and food have all more than tripled. The global economy has grown nearly fivefold, and trade has grown tenfold. Resource use is driven by growing supply resulting from innovation and efficiency gains in production of goods and services as well as from marketing, governance and increasing consumer demands from a wealthier and expanding population. People in high-income countries generally consume far more than people in low- and middle-income countries. The world population, the economy and resource use are expected to continue growing, though at a slower rate. By 2050, the global population is projected to have increased from 7.8 billion people today to nearly 9 billion and become wealthier and more urban. The production of energy is projected to increase by about 50 per cent and food by 70 per cent. Projections depend on the implementation of policies in areas ranging from reproductive health and tenure rights to the economy.

Increases in resource use and waste generation drive global environmental change in ways that transcend borders and continents. To satisfy growing demands, humans use an ever-increasing fraction of the Earth's land, freshwater and oceans for the production and extraction of food, fibre, energy and minerals as well as for industrial facilities, infrastructure and settlements. In doing so, society also releases greenhouse gases and pollutants, including nutrients and toxic chemicals as well as household, industrial and human waste. Humans modify life and move organisms around the world in pursuit of increased production or through accidental introductions. These practices also narrow down the range of genetic material in domesticated species. Many of the impacts of human activities are felt over large distances, such as through transboundary pollution or when wealthy countries export their environmental footprint by meeting their demands through trade.

B. Society is failing to meet most of its commitments to limit environmental damage

The Earth's climate is changing and its web of life is unravelling as land and oceans degrade and chemicals and waste accumulate beyond agreed limits. The international community has set targets, informed by science, in multilateral agreements for protecting natural assets and limiting harmful environmental change. Despite some progress, efforts to date have failed to meet any of the agreed targets.

The world is not on course to fulfil the Paris Agreement to limit global warming to well below 2°C above pre-industrial levels, let alone meet the 1.5°C aspiration. The Earth's mean near-surface temperature has already risen by more than 1°C compared to the period from 1850 to 1900. At the current rate, warming will reach 1.5°C by around 2040 and possibly earlier. Taken together, current national policies to reduce greenhouse gas emissions put the world on a pathway to warming of at least 3°C by 2100, though this may change as countries update their pledges.[1] Current warming, which is greater over land than over the ocean and is highest in the polar regions, has already led to melting of ice sheets and glaciers, accelerating increases in sea level, more frequent and more intense extreme events, changes in precipitation patterns, as well as shifts in climate zones, including expansion of arid zones and contraction of polar zones. Emissions of heat-trapping greenhouse gases are still increasing, with current atmospheric concentrations much higher than at any time in the past 800,000 years. The accumulation of heat in the oceans will persist for centuries and affect many future generations. About two thirds of the warming caused by anthropogenic greenhouse gases is due to carbon dioxide, mostly originating from the use of fossil fuels and some industrial processes. About one quarter of the warming results from activities related to the land – agriculture, pastoralism, forestry and especially changing natural land covers to human-dominated ones. Natural sinks today are only able to absorb around half of anthropogenic carbon dioxide emissions, split between terrestrial ecosystems and the ocean. The increased uptake of carbon dioxide by the oceans is causing harmful ocean acidification. To fulfil the Paris Agreement to limit warming to well below 2°C or meet the agreement's aspiration of restricting the increase to 1.5°C, net global emissions from human activities need to reach zero or even

1 At the Climate Ambition Summit on 12 December 2020, 45 countries pledged significant emissions reductions by 2030, and 24 countries committed to reach net-zero by the middle of the century.

become negative by the middle of the century. While meeting the Paris Agreement is technically feasible, political commitment to do so is currently lacking.

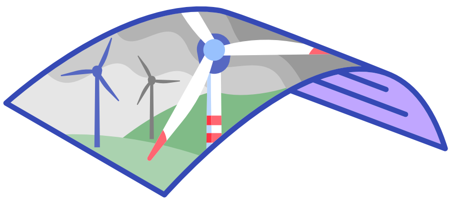
None of the global goals for the protection of life on Earth have been fully met, including those in the strategic plan for biodiversity 2011–2020 and its Aichi biodiversity targets. At the global level, only six of the 20 Aichi targets have been partially achieved, including increases in the proportion of land and oceans designated as protected areas and improved international financial flows to developing countries. Little or no progress has been made on others, such as eliminating harmful subsidies. Species are currently going extinct tens to hundreds of times faster than the natural background rate. One million of the world's estimated 8 million species of plants and animals are threatened with extinction. The population sizes of wild vertebrates have dropped by an average of 68 per cent in the last 50 years, and the abundance of many wild insect species has fallen by more than half. The number of local varieties of domesticated plants and animal breeds and their wild relatives has been reduced sharply. For example, over 9 per cent of animal breeds have become extinct and at least another 17 per cent are threatened with extinction. Ecosystems are degrading at an unprecedented rate, driven by land-use change, exploitation, climate change, pollution and invasive alien species. Climate change exacerbates other threats to biodiversity, and many plant and animal species have already experienced changes in their range, abundance and seasonal activity. Degradation of ecosystems is impacting their functions and harming their ability to support human well-being. Loss of biodiversity is anticipated to accelerate in coming decades, unless actions to halt and reverse human transformation and degradation of ecosystems and to limit climate change are urgently implemented.

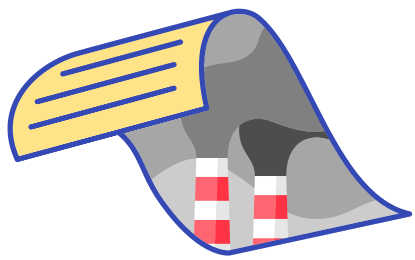
Society is not on course to achieve land degradation neutrality, where degradation is minimized and offset by restoration. Land degradation objectives are embedded in the SDGs and land degradation neutrality is a focus of the UN Convention to Combat Desertification (UNCCD). International targets on aspects such as combatting desertification, soil degradation, or wetland loss as well as national targets on preventing or reversing land degradation have not been sufficient to achieve land degradation neutrality. Natural ecosystems have been transformed by humans at an accelerating rate since the middle of the twentieth century. Only a quarter of the original habitat on ice-free land is still functioning in a nearly natural way. Much of this habitat is located in dry, cold, or mountainous areas with low human population densities and also includes the protected areas that currently cover 15 per cent of the total land area. A quarter of land has been radically transformed to cropland, plantations and other human uses. Half of the land area functions in an increasingly human-dominated and semi-natural way. It includes the rangelands grazed by livestock, the semi-natural forests harvested for wood and the freshwater systems altered by water use. The world's forests constitute nearly a third of the land area, and about 10 per cent of their area has been lost through conversions to other land uses since 1990, though the deforestation rate is decreasing. Of the combined area of semi-natural and highly transformed landscapes, around one sixth is degraded to the degree that ecological capacities to support human well-being are reduced. Of particular concern is degradation where ecological processes have been impaired to the point that the ecosystem is no longer able to recover. Wetlands are the most transformed and degraded ecosystem type. Only 15 per cent of wetlands remain. Land degradation and transformation contributed around a quarter of greenhouse gas emissions in the decade 2010–2019. Over half of these emissions derive from land transformation (particularly deforestation) and most of the remainder from the loss of soil carbon in cultivated land. Notwithstanding the agreed goal of halting land degradation, all development scenarios explored in the relevant assessments project that land degradation will continue to increase in the twenty-first century. The fraction of remaining near-natural land is projected to be only 10 per cent by mid-century, while degraded land will reach over 20 per cent.

Many of the targets for conservation, restoration and sustainable use of oceans, coasts and marine resources will likely not be fully met as marine and coastal ecosystems are declining. Targets for oceans and coasts have been agreed as part of the SDGs. Detrimental human activities including overfishing, coastal and offshore infrastructure and shipping, climate change, ocean acidification and waste and nutrient runoff combine to affect two thirds of ocean area. One third of wild marine fish stocks were overharvested in 2015, a portion that has increased from 10 per cent in 1974. Sixty per cent of stocks are fished at maximum sustainable yield and only 7 per cent are underexploited. Fertilizers entering coastal ecosystems have produced more than 400 "dead zones" totalling more than 245,000 km^2 – an area bigger than the United Kingdom or Ecuador. Marine plastics pollution has increased tenfold since 1980, constituting 60–80 per cent of marine debris, and is found in all oceans at all depths and concentrates in the ocean currents. Marine plastic litter causes ecological impacts including entanglement and ingestion and can act as a vector for invasive species and other pollutants. The risk of irreversible loss of marine and coastal ecosystems including seagrass meadows and kelp forests increases with global warming. Warming of 2°C is projected to result in a decrease in the biomass of marine animal communities and their productivity. Coral reefs are particularly vulnerable to climate change and are projected to decline to 10–30 per cent of their former cover at 1.5°C of warming and to less than 1 per cent at 2°C of warming, compromising food provision, tourism and coastal protection. Depending on the amount of sea level rise, 20–90 per cent of current coastal wetlands may be lost by the end of the century. Climate change is increasing the chances of the Arctic Ocean being ice-free in summer, further disrupting ocean circulation and Arctic ecosystems.

The world is on course to restore Earth's protective stratospheric ozone layer, but there is much more to be done to reduce air and water pollution and to safely manage chemicals and waste. Large quantities of hazardous chemicals and pollutants continue to leak or be dumped into the environment. Up to 400 million tons of heavy metals, solvents, toxic sludge and other industrial wastes enter the world's waters annually. The global chemical industry's production capacity almost doubled between 2000 and 2017. Chemicals of particular concern include those that are carcinogens, mutagens, bioaccumulative and toxic, as well as those with endocrine-disrupting or neurodevelopmental effects. The synergies between multilateral agreements related to chemicals and waste have been instrumental in addressing the life cycle of chemicals, but many developing countries still lack the capacity to manage chemicals safely. In recent decades, outdoor air pollution – for example, sulphur dioxide and particulate matter in the troposphere (i.e. lower atmosphere) – has improved in high-income countries but continues to worsen in most low-income countries. Urban areas typically have high levels of pollution. Of 45 megacities with measurements, only four satisfied World Health Organization (WHO) guidelines for air quality. Currently, more than 90 per cent of the world's population lives in places breaching WHO guidelines for particulate matter. The stratospheric ozone layer that protects life from ultraviolet radiation has started to recover and should return to its pre-1980 levels by mid-century as long as countries continue to eliminate the production and consumption of ozone-depleting chemicals as agreed under the Montreal Protocol. Some of these gases are also potent greenhouse gases. The success in phasing out these gases demonstrates the role that multilateral treaties can play in achieving joint action based on the scientific findings in international assessments.

Climate change, loss of biodiversity, land degradation, and accumulating chemicals and waste reinforce each other and are caused by the same indirect drivers. Environmental changes are projected to increase and accelerate in the coming decades due to further expansion in human activities and time lags in the Earth's systems. Climate change drives changes in wildfires and water stress and combines with biodiversity loss to degrade land and enhance drought in some regions. Globally, risks from dryland water scarcity and wildfire damage are projected to be high with global warming of 1.5°C, and very high for warming of 3°C. The combination of climate, land-use and land-cover changes has over the last few decades already resulted in more frequent and intense dust storms in many dryland areas. Climate change and land degradation combine to drive loss of biodiversity and increase extinction risks. Geographic range losses of over 50 per cent are expected for between a quarter and a half of terrestrial species at 3°C warming. Climate change, land degradation and pollution of land, water and oceans can degrade ecosystems in ways which exacerbate air and water pollution, reduce water availability and diminish nature's uptake of carbon dioxide, which in turn can further increase climate change. Efforts to reduce carbon dioxide emissions from the use of fossil fuels also reduces local air pollution (as fossil fuels are also responsible for a very large share of pollutant emissions). Efforts to reduce local air pollution, such as from black carbon (soot), and ground-level ozone and its precursors, can also contribute to mitigating climate change.





C. An array of escalating and mutually reinforcing environmental risks threatens human well-being and the achievement of the Sustainable Development Goals

Current and projected future environmental degradation will seriously undermine society's chances of achieving the Sustainable Development Goals (figure ES.1). Recent data and projected trends show that society prior to the COVID-19 pandemic was reducing hunger, increasing access to safe drinking water and adequate sanitation and increasing access to clean modern energy services, but not enough to meet the targets in the 2030 Agenda for Sustainable Development. Current and projected changes in climate, biodiversity loss and pollution make achieving the SDGs even more challenging. For example, even small increases in temperature, along with associated changes such as in weather, precipitation, heavier rainfall events, extreme heat, drought and fire, increase risks to health, food security, water supply and human security, and these risks increase along with warming. Combined environmental changes increase the risks of crossing thresholds beyond which ecological and climatic shifts accelerate and become very hard to reverse. Socioeconomic development patterns strongly determine the vulnerability and exposure of people, and thus related impacts, as well as the groups in society that would bear the brunt of these impacts. The COVID-19 pandemic has disrupted already uneven progress towards achieving many of the SDGs and caused the first increase in global poverty in decades by pushing an estimated 70 million more people into extreme poverty in 2020.

Damaging and long-lasting environmental change impedes progress towards ending poverty, reducing inequalities and promoting sustainable economic growth, decent work for all and peaceful and inclusive societies. Progress towards ending poverty in all its forms (SDG 1) is countered by the impacts of climate change, which are expected to exacerbate poverty in most developing countries and, in combination with increasing inequalities, create new pockets of poverty everywhere. Worldwide, 3.2 billion people (around 40 per cent of global population) are adversely affected by land degradation, and the number is growing. Environmental change impedes the achievement of gender equality (SDG 5) especially in rural, agricultural and resource-based economies and livelihood systems, where women's adaptive capacities are hampered by poorer access than men to financial resources, land, education, health and other basic rights. Inequalities in environmental opportunities and burdens along ethnicity, gender, race and income levels hamper efforts to reduce inequalities within and among countries (SDG 10). Countries with high average temperatures, low levels of development and high dependence on climate-sensitive sectors such as agriculture, are expected to bear the largest burdens of climate change. Efforts to promote sustained, inclusive and sustainable economic growth and decent work for all (SDG 8) are hampered by loss of natural capital and climate change. In 2018 alone, damages from climate-related natural disasters cost about US$155 billion. Poorer workers in industry, agriculture or the informal sector are more likely than higher-wage workers to be employed in dangerous, unregulated settings with high exposures to heat stress and hazardous chemicals. Environmental change also hampers the promotion of peaceful and inclusive societies (SDG 16). Climate change can amplify migration, environmental degradation and intensify competition for natural resources, which in turn can spark conflicts, including between actors with power asymmetries where indigenous peoples or local communities are often vulnerable. Since the mid-twentieth century, at least 40 per cent of all intrastate conflicts have been linked to the exploitation of natural resources. More than 2,500 conflicts over such resources are currently occurring across the planet, and at least 1,000 environmental activists and journalists were killed between 2002 and 2013.

Earth's capacity to meet growing human needs for nutritious food, water and sanitation for all will weaken in the face of continued environmental decline. Environmental degradation makes ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture (SDG 2) more demanding. Agricultural yields are projected to be negatively impacted by climate change due to warming, changing precipitation patterns, greater frequency of extreme events such as heatwaves, heavy precipitation in several regions, and droughts in some regions, and changes in the incidence of pests and diseases. While sustainability choices influence food security at the local scale, climate change risks to food security could become very high at 2°C, whilst 4°C of warming is considered catastrophic. Air pollution such as ground-level ozone also negatively impacts agricultural yields and will be impacted by climate change. Species and genetic diversity in agriculture, which are critical to resilient food systems, is lower than ever. Future agricultural expansion is projected to take place on more marginal lands with lower yields. Biodiversity loss poses risks to food production. The loss of animal pollinators, critical to more than 75 per cent of food crops, including many fruit and vegetables and cash crops such as coffee, cocoa and almonds, threatens annual global crop output worth between US$235 billion and US$577 billion. Soil erosion from agricultural fields is estimated to be 10 to more than 100 times higher than the soil formation rate, affecting agricultural yields through reduced water-holding capacity and loss of nutrients. An estimated 176 gigatonnes of soil organic carbon has been lost historically, mostly from land-use change, and another 27 gigatonnes is projected to be lost between 2010 and 2050. Wild fish catch, which has already declined due to overfishing, is under additional threat due to changing climatic conditions, ocean acidification and pollution. Efforts to ensure the availability and sustainable management of water and sanitation for all (SDG 6) are also impeded by environmental change. Climate change will exacerbate water stress risks, especially in areas of decreased precipitation and where groundwater is already being depleted, affecting both agriculture and more than 2 billion people who already experience water stress. Water pollution has continued to worsen over the last two decades, increasing the threats to freshwater ecosystems and human health.

The deteriorating health of the planet undermines efforts to secure healthy lives and well-being for all (SDG 3). Pollution is estimated to cause some 9 million premature deaths annually and millions more die every year from other environment related health risks. Around one quarter of the global burden of disease stems from environment-related risks, including climate change, air and water pollution, and exposure to toxic chemicals. Climate-related health risks, which become greater with rising temperatures, include undernutrition, vector-borne diseases (including dengue, chikungunya, yellow fever and zika virus), animal-borne (zoonotic) diseases (see box below), heat-related morbidity and mortality, and food- and water-borne diseases. Indoor air pollution from cooking with biomass on traditional stoves, and outdoor air pollution, much from the combustion of fossil fuels, currently cause around 6.5 million premature deaths per year related to respiratory diseases and are projected to continue to represent a serious human health risk. Other major environmental health risks include lack of access to clean drinking water and sanitation services, causing 1.7 million deaths per year from diarrheal diseases, many of which are deaths of children under the age of five. Pollution-related health risks also stem from exposure to heavy metals and chemicals. The stratospheric ozone layer – which is slowly recovering – reduces the risk of excessive solar ultraviolet radiation exposure that leads to skin cancer, cataracts and other health problems in humans. As a result of the loss of biodiversity and ecosystem services, nature's ability to support human health through regulation of air and water quality is in decline in many places, as well as its ability to provide opportunities for recreation and relaxation, which support physical and mental health and well-being. Biodiversity loss is also negatively affecting nature's ability to supply medicines. An estimated 4 billion people – more than half the global population – rely primarily on natural medicines for their health care, and some 70 per cent of drugs used for treating cancer are natural or are synthetic products inspired by nature. Antimicrobial resistance, industrial chemicals, multi-exposures and newly emerging diseases are increasingly threatening human health and well-being.

Box ES.1 COVID-19 and One Health

Diseases that originate in wild and domestic animals (zoonotic diseases) pose threats to human health and the economy, as the COVID-19 pandemic demonstrates. Addressing the pandemic has upended people's lives, brought sectors such as travel and tourism to a standstill, and caused major health, economic and social impacts around the world. The crisis, which was still unfolding as this report was completed, shows that modern society is susceptible to the risks that zoonotic diseases have presented throughout human history.
It has been estimated that, of the 1.6 million potential viruses in mammals and birds, 700,000 could pose a future risk to human health. Risks depend partly on how human interaction with nature is managed. Ecological degradation increases the risk of zoonotic diseases through increased human contact with pathogens and changes in pathogen ecology. Human impacts that may increase the risk include climate change, land-use change and fragmentation, agricultural intensification, deforestation, and the legal and illegal wildlife trade. The creation of new habitat edges provides more opportunities for spillover events from wildlife hosts into humans and livestock. A One Health approach recognizing how human health is interconnected with the health of animals, plants and the shared environment and applied at all levels of decision-making – from the global to the local – can reduce the risk of zoonotic pandemics and epidemics into the future.

Environmental degradation hampers efforts to make cities and human settlements inclusive, safe, resilient and sustainable (SDG 11). Climate change and loss of biodiversity and ecosystem services can negatively impact the provision of basic services and accentuate natural disasters, while air pollution and waste management remain challenging in many cities. Coastal communities are exposed to multiple climate-related hazards, including tropical cyclones, sea level rise and flooding, marine heatwaves, sea-ice loss and permafrost thaw. Global warming exacerbates the urban heat island effect in cities and their surroundings, especially during heatwaves, increasing people's exposure to heat stress. At 1.5°C of warming, twice as many megacities than at present are likely to become heat-stressed, possibly exposing more than

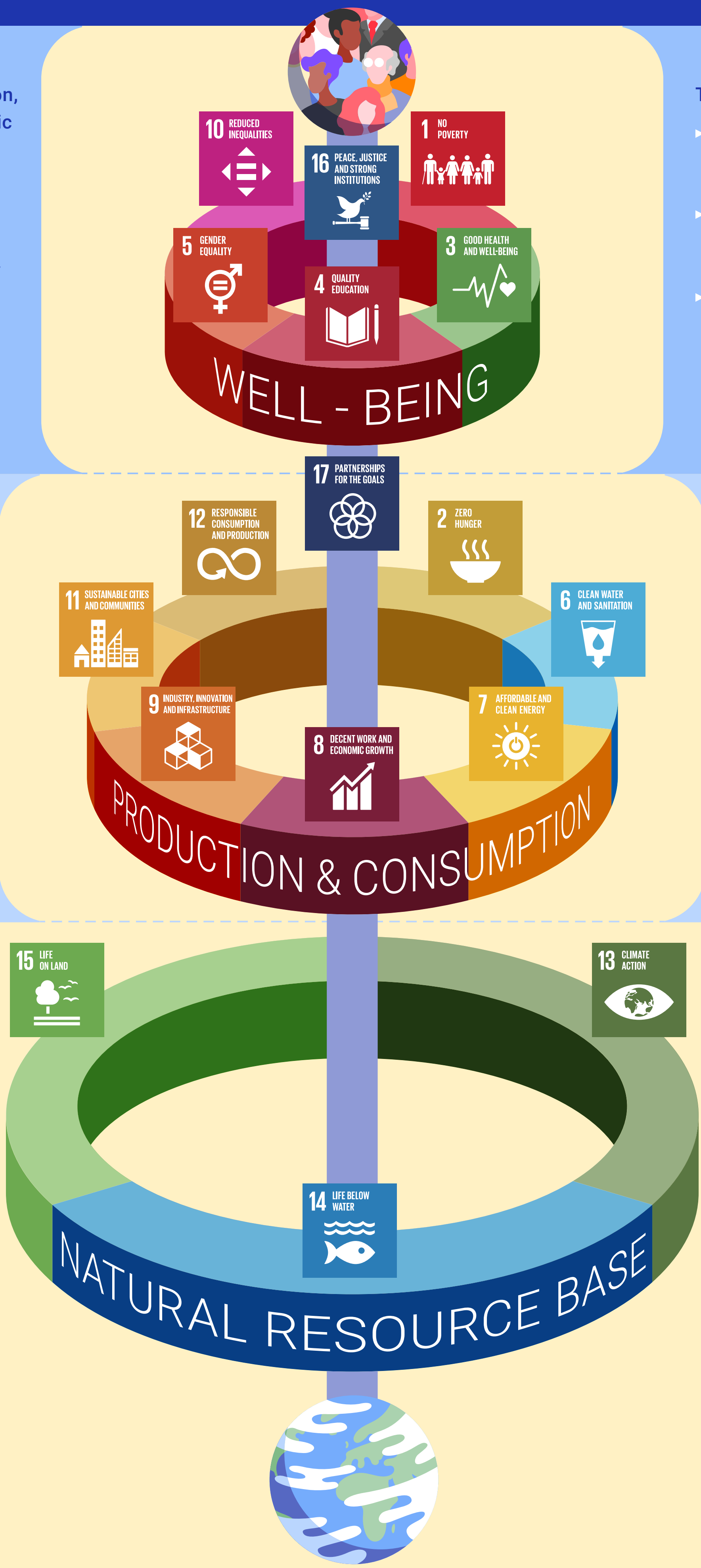
Environmental degradation threatens the achievement of the SDGs

Impeding poverty elimination, inequity reduction, economic development and peace

- Exacerbated multi-dimensional poverty
- Accentuated inequality, including gender inequality
- Lost income opportunities
- Increased risk of conflict over resources
- Increased risk of displacement and outmigration

Threatening human health

- Increased undernutrition, heat stress and air pollution-related diseases
- Exacerbated food- and water-borne infections and zoonotic diseases
- Reduced ability of nature to provide medicines and support physical and mental well-being



Hampering efforts to make cities and communities sustainable

- Increased vulnerability to natural disasters
- Stresses on urban infrastructure
- Rising air and water pollution
- Rising waste disposal problems

Weakening food and water security

- Increased food-system vulnerability
- Reduced agricultural productivity
- Reduced nutritional value of crops
- Lower catch in fisheries
- Increased water scarcity

Changing climate

- Higher temperatures
- More extreme weather events, e.g. flooding, droughts, storm surges and heatwaves
- Rising sea level
- Changing precipitation patterns
- Ocean acidification

Biodiversity loss and ecosystem degradation

- Loss of species richness and accelerated species extinction
- Loss of genetic resources in domestic and wild species
- Loss of ecosystem functions, such as pollination, seed dispersal, soil formation and biological productivity

Figure ES.1: Selected environmental changes and related impacts on the SDGs. The clustering of SDGs provides an integrated perspective with the environment as the foundation for the economy, human development and, ultimately, human well-being. Human-induced environmental degradation adversely impacts human well-being.

350 million more people to potentially deadly heat stress by 2050. Urbanization can amplify the effects of extreme rainfall and wind. Large-scale urbanization is also impacting on biodiversity hotspots and agricultural land, which in turn will have consequences for human settlements in terms of declining ecosystem services and food security. Urban populations are particularly exposed to air pollution. Solid waste per capita has doubled in the last decade to 1.3 billion tons a year, most of which is generated and disposed of in cities. At least 2 billion people lack access to collection services for solid waste and 3 billion people lack access to adequate waste disposal facilities. Many low-income cities still have waste collection coverage in the range of 30–60 per cent.

The risks to human well-being and to the achievement of the Sustainable Development Goals will continue to escalate unless current rates of environmental degradation are halted. Global warming of more than 2°C combined with continued loss of biodiversity and increasing pollution will likely have dire consequences for humanity. If warming exceeds 2°C, both marine and terrestrial animals and plants are projected to decline, including the decline of warm-water coral reefs by 99 per cent, the decline of Arctic summer sea ice, large declines in marine fishery catches and the placing of 20–30 per cent of terrestrial species at increased risk of extinction. Substantial increases in heatwaves, heavy precipitation in several regions and drought in some regions are associated with global warming, and in turn increase risks to food security. Crop yields are already declining in some regions due to global warming. The fraction of remaining near-natural land is projected to be only 10 per cent by mid-century, while degraded land will reach over 20 per cent.

The costs of inaction on limiting environmental changes far outweighs the costs of action. By 2100, negative impacts from climate change exceeding 2.5°C of warming are likely to be substantial, far in excess of impacts with limiting warming to 1.5°C or well below 2°C. Furthermore, limiting greenhouse gas emissions would also generate considerable benefits, including for human health. Cost estimates for reducing emissions, though substantial, are far less than the avoided economic damage. There is an urgent need for a clear break with current trends of environmental decline, and the coming decade is crucial.

II. Transforming humankind's relationship with nature is the key to a sustainable future

Part II of the report addresses the transformational changes required to achieve a sustainable world. It also assesses the roles and responsibilities of different actors and presents options for action in the interconnected sectors of environment, economics, finance, energy, food, water, health and cities.

D. Human knowledge, ingenuity, technology and cooperation can transform societies and economies and secure a sustainable future

Decades of growing efforts have not stemmed the environmental decline resulting from the current development model because vested and short-term interests often prevail. While progress has been made in addressing climate change, biodiversity loss, land degradation, and air and water pollution, the types of transformational change needed have often been thwarted by vested interests that benefit from preserving the status quo.

Only system-wide transformation will enable humanity to achieve well-being for all within the Earth's finite capacity to provide resources and absorb human waste. Society continues to exceed and degrade the Earth's capacities despite clear evidence of the risk that this development path poses to humanity and growing efforts to reduce its environmental impacts. Continuing along this path constitutes an ongoing and increasing risk to current and future prosperity and well-being. Human skills need to be redeployed from transforming nature to transforming the social and economic fabric of society. This effort needs to put human well-being centre stage, and speed progress towards achieving the opportunities set out in the indivisible and interdependent SDGs, whose target date is fast approaching. Transformation involves a fundamental, system-wide shift in world views and values and in the technological, economic and social organization of society. Transformations requires, amongst other things, innovation, learning, collaboration, multilateralism and adaptation of governance structures, policies, business models, technologies, education and knowledge systems. In particular, cross-sectoral planning and integrated policy mixes are essential to find synergies, address trade-offs, and manage the interactions between areas including water, food, energy, climate change and human health. Beyond policy, initiatives from actors in society that challenge current social norms or the status quo can spark organizational and societal deliberation, which may substantially speed up transformations.

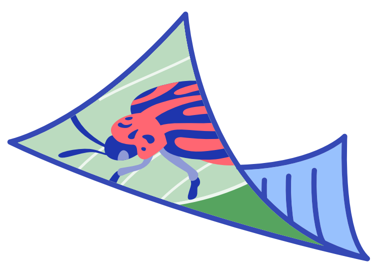
Transformation towards sustainability involves significant and mutually reinforcing changes in behaviour, culture, material flows and systems of management and knowledge transmission. With successful transformative change, the consumption of resources would decrease in wealthy contexts and increase sustainably elsewhere. People would be empowered to express and act in accordance with values of environmental responsibility without undue difficulty or self-sacrifice. Human opportunities and outcomes would be more equitable across dimensions of social difference including gender, ethnicity, race and region. Trade and other economic activities including resource extraction and production of goods and services would yield net-positive effects, resulting in a substantial reduction in negative consequences. Systems of innovation and investment would yield technologies that enable net-positive environmental effects. Education and knowledge transmission would enable everyone to participate in well-functioning societies and new practices of stewardship and sustainability. Human ambitions for a good life would no longer be centred around high levels of material consumption, but around rich relationships involving people and nature, in keeping with diverse traditions throughout the world. Behaviour change can be achieved by enabling the strong underlying values of responsibility that are already present via subtle or structural changes in institutions and infrastructure, but paradigms, goals and values would further change as systems and human action transform. The above components of transformative change have been called the "leverage points" to reflect the potentially synergistic nature of change.

Achieving sustainability will entail interventions across scales and sectors and changes to incentive structures, management systems, decision-making processes, rules and regulations. Transformed incentive structures would encourage conservation and discourage actions that result in environmental degradation. Systems for policymaking, planning and managing natural resources and the use of lands and waters would be coordinated across sectors and jurisdictions; pre-emptive in addressing emerging threats via effective environmental monitoring and evaluation; include meaningful participation, especially of stakeholders and rightsholders such as indigenous peoples and local communities; and be designed for resilience and adapted to uncertainties. Strong environmental laws would protect ecosystems and the human enjoyment of a healthy environment, bolstered by consistent enforcement of laws and independent judiciaries. These three sets of governance interventions have been called the "levers" of transformation to reflect their power to effect change at the specified leverage points and also more broadly.

Opposition from vested interests to transformations aiming to secure a sustainable and prosperous future is to be expected but can be addressed. Existing infrastructure and built capital provide system inertia that can make change difficult and incurs short-term costs, especially if change involves the premature retirement of capital stock. Also, individuals and organizations have habits, procedures and ways of doing business that can yield a reluctance and resistance to change. Individuals and organizations can also oppose change that disrupts their livelihoods, market share and revenues, or that otherwise appear unfair. Transparent regulatory action and consistent enforcement, coupled with political leadership, media vigilance and civil society engagement, can shift the status quo and help level the playing field so that firms cannot gain competitive advantages by externalizing costs that are then borne by society. Some opposition can be addressed proactively by redirecting subsidies to steer workers and firms toward opportunities associated with transformative change. Programmes fostering a just transition can include, for instance, retraining workers from unsustainable industries and helping them relocate in order to take up new jobs.

Box ES.2 Recovering from the COVID-19 pandemic

The COVID-19 crisis provides the impetus to rethink how society can accelerate the transformation to a sustainable future. Governments and other actors are rolling out significant policy measures and investments to help societies and economies recover from the COVID-19 crisis. These initiatives are an opportunity to move away from unsustainable practices and accelerate transformation towards implementation of the SDGs. Economic support can be channelled into, for example, sustainable infrastructure and programmes that reduce the risks and impacts of future pandemics. A post-COVID world needs to address the issues of habitat destruction, wildlife trade and other human-nature interactions that increase exposure to zoonotic diseases. It also needs stronger international governance structures that can help take coordinated actions quickly and transparently.



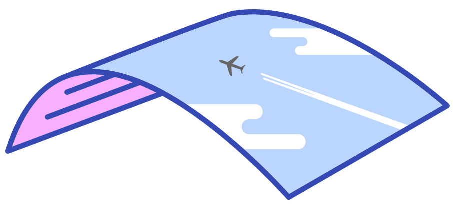
E. Earth's environmental emergencies must be addressed together to achieve sustainability

Given the interconnected nature of climate change, loss of biodiversity, land degradation, and air and water pollution, it is essential that these problems are tackled together now. Immediate action is required to mitigate climate change, conserve and restore biodiversity, improve air and water quality, make more efficient use of resources and reduce the adverse effects of chemicals. Actions also need to be taken now even where the benefits may not be realized for years due to the long-lasting nature of environmental effects or to inertia in the socio-economic system. Essential actions with delayed effects include reforestation and restoration of degraded lands. Response options that can address multiple environmental issues, mitigate multidimensional vulnerability and help minimize trade-offs and maximize synergies, need to be implemented. Numerous response options that can preserve and restore the environment and contribute to achieving some of the other SDGs have already been identified. For example, large-scale reforestation with native vegetation can simultaneously help address climate change, biodiversity loss, land degradation and water security. A key challenge is to avoid unintended consequences. For instance, large scale afforestation schemes and replacing native vegetation with monoculture crops to supply bioenergy can be detrimental to biodiversity and water resources.

The further development and implementation of the goals, targets, commitments, and mechanisms under the key multilateral agreements on climate change, biodiversity, land-degradation, oceans and pollution need to be aligned and become more synergistic and mutually supportive. There needs to be enhanced harmonization in the implementation, monitoring and financing of the multilateral agreements. Sustainable policies, technologies and management practices need to be implemented within the interconnected agriculture-fisheries-forestry-water-energy systems given their impact on climate, biodiversity and land degradation.

Governments must scale up and accelerate action to meet the Paris Agreement goals and limit dangerous climate change. Evidence shows that the risks associated with climate change, including the risks of extreme weather events, impacts on unique and threatened systems, and large-scale discontinuities such as the disintegration of the Greenland and Antarctic ice sheets (Figure 1.1), are generally higher than previously understood. Limiting the global mean temperature increase to well below 2°C and pursuing efforts to hold it to 1.5°C, in line with the Paris Agreement, require immediate significant strengthening and rapid implementation of existing national pledges to reduce greenhouse gas emissions. To limit global warming to 1.5°C, with a probability of about 50 per cent, net emissions of carbon dioxide will need to be reduced by 45 per cent by 2030 compared to 2010 levels and reach zero by 2050. To limit global warming to 2°C, emissions need to decline by about 25 per cent by 2030 compared to 2010 levels and reach net zero by around 2070. The emissions of other greenhouse gases must also be reduced. More ambitious reductions would be necessary for higher certainty in limiting dangerous climate change. The emission gaps presented in figure ES.2 show pathways with about 66 per cent chance of limiting global warming to 1.5°C and 2°C. Delaying action exacerbates difficulties and incurs greater costs. Scenarios in which warming temporarily exceeds the Paris Agreement around mid-century before falling rapidly depend heavily on the development of carbon dioxide removal technologies, whose ability to capture and store carbon dioxide at scale is so far unproven and could lead to unintended negative impacts on biodiversity and food production.

Emissions reductions entail rapid and far-reaching transformations in the energy, land, industrial production, urban and infrastructure sectors. Such transformations are unprecedented in scale, implying deep emissions reductions in all sectors and in all countries, as well as new lifestyles, norms and values. Developing countries will need financial and technical assistance. Nature-based solutions, such as reforestation with native trees, restoration of degraded lands, improved soil management and agroforestry can contribute significantly to reducing the atmospheric abundance of carbon dioxide. Such solutions have been



ES . 2 The Emissions Gap

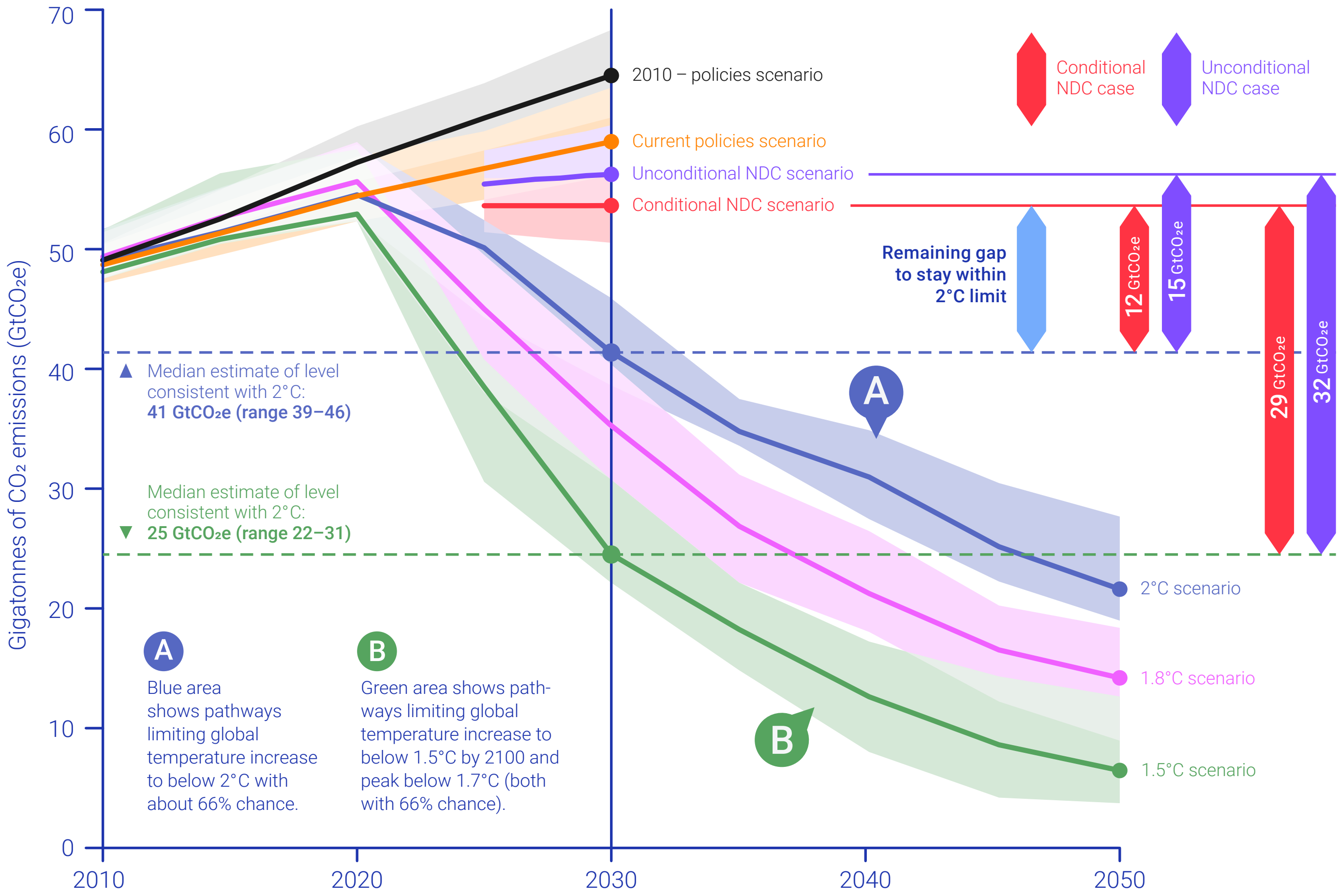


Figure ES.2: Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 for unconditional and conditional nationally determined contributions (NDCs) scenarios (median and 10th to 90th percentile range; based on the pre-COVID-19 current policies scenario).

Source: Figure adapted from UNEP 2020a, EGR, ES, Figure ES.5

estimated to be able to provide between 35 and 40 per cent of the mitigation effort needed until 2030 to limit warming to 2°C. Bioenergy (often in combination with carbon capture and storage) and afforestation can contribute to mitigation but must be designed to avoid or minimize adverse effects on biodiversity, food and water security, and air quality.

Reducing short-lived climate forcers is a key part of the global climate response and must be pursued with high priority. Reducing short-lived climate forcers such as black carbon, ground-level ozone and methane is one of the most effective options for slowing the rate of global warming in the near term. It also delivers ancillary benefits by improving public health from lowering air pollution, improving food security from increasing crop yields, and reducing poverty and inequality.

Adaptation to the impacts of climate change is critical and involves both preparations for and responses to the impacts, with nature-based solutions playing a vital role. Mitigating climate change is vital, urgent and cost saving: the lower the degree of warming the easier and cheaper it will be to adapt. Societies, economies and ecosystems must adapt to changing temperature and precipitation patterns, including more heatwaves, heavy precipitation in several regions, droughts in some regions and higher sea levels. There has been significant progress in planning for climate change preparedness over the last two decades. Adaptation options, if well designed and managed in a participatory manner, can reduce the vulnerability of human and natural systems, and have many synergies with most of the SDGs, such as food and water security, though potential trade-offs must be recognized. Adaptation is place- and context-specific and can be enhanced through complementary actions across all levels from individuals to governments. Increasing investment in social and physical infrastructure is vital to enhance the resilience and adaptive capacity of societies. Specific interventions can include climate-resilient agriculture, nature-based solutions such as conserving and restoring ecosystems, land-use planning, coastal defence systems and social safety nets. Nature-based solutions have gained prominence, given the prominence, given the many interlinkages between climate change and biodiversity loss, and the potential to deliver co-benefits for livelihoods and human well-being. Adaptation actions include restoration or protection of coral reefs, seagrass meadows, coastal wetlands, mangroves, and beaches to reduce coastal flooding and erosion; green and blue spaces to reduce urban flooding and heat-related risks; protecting and restoring floodplains, peatlands and riparian vegetation to reduce river flooding.

The unravelling of the web of life on Earth can only be halted and ultimately reversed by addressing the indirect and direct human drivers of its decline. The causes of biodiversity decline are many and deeply embedded in society, so the future of life on land, in freshwater and in the oceans fundamentally depends on society embracing transformative pathways. Halting and reversing biodiversity loss means addressing the direct drivers such as land and sea use, overexploitation, climate change, air and water pollution and invasive species. That in turn is contingent on incentive structures, improved management systems and the rule of law that promotes conservation, restoration and sustainable use of biodiversity. Such efforts need to be embedded in system-wide reforms addressing poverty, sustainable livelihoods, food, energy and resource-use systems. They also need to encompass combatting the illegal wildlife trade and avoiding human development in biodiversity hotspots. Systemic shifts will mean changing lifestyles and economic systems, including measures of progress. Alleviating these existing and growing pressures will permit populations of many wild organisms to remain viable as they shift their ranges under the influence of climate change. Measures to protect biodiversity from the impacts of trade and corporate supply chains are important to slow and reverse biodiversity loss. This includes the removal of implicit or explicit harmful subsidies for farming, fishing, mining and industries that export commodities. Production standards, moratorium agreements, consumer pressure and education, product traceability to source and certification are all important complementary interventions. Well-designed, legitimate offsets could facilitate market transformation.

Biodiversity conservation and restoration must be integral to the many uses of terrestrial, freshwater and marine ecosystems. Reduction of pressure on biodiversity and ecosystem services in populated, productive and human-transformed landscapes and freshwater systems is a key conservation strategy, especially in large-scale intense and highly transformed agricultural lands. The use of transparent participatory approaches to landscape planning and resource management is key to success. Recognition of the custodial traditions and knowledge of indigenous peoples and local communities is also important. Pastoral, cropping and forestry practices can sustain biodiversity while supporting local livelihoods, avoiding land degradation and embracing restoration of degraded lands. Community gardens and parks can be designed and implemented to enhance biodiversity in cities. Equally, there need to be reduced pressures on coastal ecosystems and the open ocean.

A more extensive, better managed and more representative global network of interconnected terrestrial, freshwater and marine protected areas, designed to adapt to climate change, can contribute to the conservation of biodiversity. A more extensive network of protected areas is needed in order to include key biodiversity currently not protected. Many protected areas are currently too small or isolated to be effective in the long term, given that climate change is shifting the geographic ranges of animal and plant species. Increasing connectivity between protected areas makes them more resilient to climate change and more able to sustain viable populations of threatened species. Some ostensibly protected areas have weak management and governance and need increased investment for surveillance, law enforcement and restoration. A number of governments and NGOs are committing to or promoting the protection of 30 per cent of the land and oceans by 2030.

Fisheries reform, integrated spatial planning, conservation, climate mitigation and reduced pollution are all key to restoring marine life. Sustainable fish quotas are essential to reform fisheries, end overfishing and restore marine biodiversity. Trade negotiations are ongoing to craft new rules on the elimination of harmful fisheries subsidies. Expanded protected areas in both territorial waters and the open ocean can conserve and rebuild stocks of commercial and non-commercial species. Achieving the Paris Agreement aspiration of holding global warming to 1.5°C would limit harmful ocean acidification. Protecting marine life also means countering ocean contamination from chemicals, plastics, sewage and excess sediment resulting from land degradation. Integrated spatial planning covering multiple uses of marine resources can help advance sustainable development in oceans and coastal areas.

The impact of chemicals and waste on human health and the environment can be substantially reduced by implementing existing international chemicals conventions, strengthening the science-policy interface, and further legal and regulatory reform. A strengthened scientific assessment process is needed to provide a stronger basis for evidence-based policymaking aimed at improving the management of chemicals and waste and minimizing their adverse impacts. Successful implementation of the 2030 Agenda for Sustainable Development can accelerate progress in achieving sound whole cycle management and minimizing adverse impacts. This will require more ambitious, urgent and worldwide collaborative action by all stakeholders in all countries. Policies and procedures need to be enacted to reduce the pollution loads of these chemicals and human exposure by reducing their release to the air, water and soils. A well-defined set of indicators for chemicals management needs to be developed for global and national accounting.

F. Economic and financial systems can and must be transformed to lead and power the shift toward sustainability

Economic and financial systems need to be significantly transformed to attain a vibrant and sustainable world. These systems need to help align production, consumption, infrastructure and human settlement with the SDGs. Governments should incorporate full natural capital accounting into their decision-making and use policies and regulatory frameworks to provide incentives for businesses to do the same. Incentives can favour sustainability and penalize environmental degradation, for instance by taxing unsustainable resource use and pollution rather than production and labour, measures that also promote a circular economy. Governments phasing out harmful subsidies can redirect that support to low-carbon and nature-friendly solutions and technologies. Governments and businesses need to systematically internalize environmental costs and benefits throughout their management systems and supply chains. Using full natural capital accounting and providing economic incentives will also shift finance away from investing in environmentally harmful activities and towards sustainable investments. Some nations may need development assistance to help finance shifts towards a more sustainable economy. Transforming the nexus of energy, human settlements, agriculture, forestry and water systems is among the highest priorities.

Measures of economic performance must include the value of nature's contributions to human well-being. Conventional measures of economic activity such as GDP are commonly used as indicators of national prosperity and to guide economic planning. But GDP fails to properly account for gains or losses in the natural capital that underpin many vital economic activities or for environmental quality and other non-monetary factors that contribute to human well-being. More inclusive economic yardsticks such as changes in inclusive wealth – the sum of produced, human, social and natural capital – provide a better measure of the capacity of current and future generations to achieve and sustain higher living standards and quality of life without eroding natural capital and causing environmental harm, as well as a better basis for investment decisions. Some natural capital cannot be fully substituted by other forms of capital and may require special protection. Another approach is to use a Genuine Progress Indicator to correct GDP for social and environmental factors such as inequality, costs of underemployment and costs of pollution. Quality-added GDP is a further alternative to conventional GDP.

Progress towards achieving the Sustainable Development Goals requires increased financing and massive shifts in public and private financial flows and investment patterns. To meet the SDGs, large increases and shifts in investments will be needed in the water, food, energy and other sectors. The investments required exceed the capacity of public financing, therefore substantial private sector financing is essential. Socially and environmentally oriented investment funds that provide low-cost financing to sustainable initiatives can partly close the gap but achieving large-scale financial flows will require shifting incentives such that only investments in sustainable development are financially attractive. New tools and approaches that can leverage and incentivize private sector funding include the use of capital markets to unlock private sector investment in sustainable infrastructure. The Global South needs increased access to low-interest finance in order to achieve the

SDGs. The Global North has exacerbated the shortfall by failing to meet its commitments under environmental conventions and on international development assistance.

Reducing inequalities and the risk of social conflict requires the minimization and reversal of environmental degradation and declines in natural resources, as well as structural changes to the economy. Removing inequality requires steps to address individual and community property rights, persistent poverty, hunger, education, equity and inclusion in resource management. Actions include reforming trade agreements, eliminating perverse subsidies and taxes that promote wasteful and harmful use of natural resources, and investing in urban areas, public services, education and health care facilities. Investments should be targeted at indigenous peoples and local communities, as well as underrepresented and marginalized social groups.

G. Food, water and energy systems can and must be transformed to meet growing human needs in an equitable, resilient and environmentally friendly manner

Feeding humanity, ensuring water security, and enhancing the conservation, restoration and sustainable use of nature are complementary and closely interdependent goals. Irrigated agriculture is the largest human use of water, currently accounting for about 70 per cent of freshwater withdrawals worldwide and projected to increase. The impacts of land and water use on nature, and therefore on long-term food and water security, must be addressed together. Practices and policies that affect the demand for food, as well as its production, will have strong feedbacks on water and nature. Sustainable solutions will be context-specific. Reducing food and water waste is critical, requiring changes in areas ranging from production and extraction systems to storage and distribution infrastructure to individual consumption patterns.

Agricultural systems that work with nature, are adaptive to change, resilient to shocks and minimize environmental impacts, are critical to eliminate hunger and malnutrition and contribute to human health. Sustainable agricultural systems and practices include integrated pest and nutrient management, organic agriculture, agroecological practices, soil and water conservation, conservation aquaculture and livestock systems, agroforestry, silvopastoralism, integrated farming systems, improved water management and practices to improve animal welfare. Sustainable agriculture conserves and restores soils and ecosystems, rather than degrading them. Sustainable agricultural systems must be resilient to climate change, addressing issues of temperature, drought, pests and salinity through the development of new traits, and the conservation of genetic and species diversity will help facilitate this. Multifunctional landscapes and waterscapes can be the basis for a shift towards ecological intensification or biodiversity-based agriculture, which aims to enhance ecosystem services generated by agro-diversity, some of which boost production.

Changes in patterns of consumption are critical to transforming food, water and energy systems and can be achieved through altered norms in business and cultural practices. Strategic use of economic instruments, new forms of polycentric governance involving all key stakeholders, and changes in purchasing patterns will all be necessary to transform food, water and energy systems. Sustainable agricultural practices are often disincentivized by current systems of industrial-scale agricultural production, inappropriate subsidies, crop insurance and capital investments. Changing the dietary habits of consumers, particularly in developed countries, where consumption of energy- and water-intensive meat and dairy products is high, would reduce pressure on biodiversity and the climate system. These habits are a function of individual choices but are also influenced by advertising, food and agricultural subsidies and excess availability of cheap food that provides poor nutrition.

Small-scale farmers, particularly women farmers, are central to the challenge of achieving sustainable food security and need to be empowered. Women farmers need access to education and training, information and technology, gender-sensitive extension services, financial and legal services, markets, crop insurance and social safety nets. They also need access to and control over land and production inputs such as high-yielding, water efficient, and pest-and disease-resistant crops, fertilizers and other inputs, as well as groundwater and irrigation services.

Maintaining aquatic food production requires sustainable fisheries management, the implementation and expansion of marine protected areas, including no-take zones, and action on climate change and pollution. Pathways to sustainable fisheries entail conserving, restoring and sustainably using marine and freshwater ecosystems, rebuilding overfished stocks (including through targeted limits on catches or moratoria), reducing pollution from chemicals and plastics, managing destructive extractive activities, eliminating harmful subsidies and illegal, unreported and unregulated fishing, adapting fisheries management to climate change impacts and reducing the environmental impact of aquaculture. Marine protected areas, including no-take zones and locally managed marine areas, have demonstrated success in biodiversity conservation and rebuilding fish stocks when managed effectively; they can be further expanded through larger or more interconnected protected areas or new protected areas in currently underrepresented regions and key biodiversity areas.

Sustaining adequate and high-quality freshwater in the context of climate change, rising demand and increased pollution requires improving efficiency, wisely increasing storage and fostering the restoration of natural habitats and flow regimes. Cross-sectoral and sector-specific interventions may require actions to reduce pollution, improve water quality, sustainably manage groundwater extraction and minimize disruption. Achieving sustainability will require increased water use productivity in agriculture, improved management of urban water and other water users, redirected investments in water distribution infrastructure and in wastewater treatments that recover resources, and climate- and biodiversity-sensitive increases in water storage. Policy instruments include water reallocation at the basin scale, shifting incentives to increase water-use efficiency, drought resilience and appropriate pricing. Transboundary agreements and regional frameworks provide a strong foundation for regional coordination and cooperation for the equitable sharing of water.

Universal access to clean energy requires a rapid transition to low-carbon systems in both the production and use of energy. Improving access to affordable and modern energy (SDG 7) coupled with innovation and efficiency gains are vital to achieving equitable and sustainable economic growth while limiting global warming. Clean energy will also reduce poverty and indoor and outdoor air pollution and provide critical services such as communications, lighting and water pumping. Achieving this goal while combating climate change involves a rapid transition to low-carbon energy systems encompassing both production and consumption. Investments in the energy transition need to grow five- or sixfold between now and 2050 to achieve the Paris Agreement aspiration of limiting warming to 1.5°C. Renewable energy technologies such as wind and solar, along with improved energy efficiency in buildings and elsewhere, will be key. Governments must develop laws and policies that enable greater public and private investments in generation and distribution, while also encouraging more responsible energy consumption. Government policy and incentives can speed the phase-out of fossil fuels in power generation and transportation, including by supporting the development of renewable energy storage and electric vehicles. Large-scale renewable energy installations on land, watercourses and in the ocean require careful planning to avoid or minimize adverse effects on nature and on food and water security.

H. Keeping the planet healthy is key to providing health and well-being for all

Reversing environmental decline reduces threats to human health and well-being. Human health and the health of the planet are closely interlinked, underlining how policies aimed at protecting human and planetary health should also be integrated. For example, mitigating greenhouse gas emissions will limit the health risks and impacts from climate change. These include vector- and water-borne diseases such as malaria and cholera, heat stress, extreme weather events, loss of nutrients in foods, air pollution leading to cardiovascular and respiratory diseases. Halting and reversing ecosystem degradation will help safeguard food and water security, secure medicinal plants and genetic resources valuable to medical research and reduce the risk of zoonotic disease pandemics. The reduction of air and water pollution and safe management of chemicals are key to safeguarding human health.

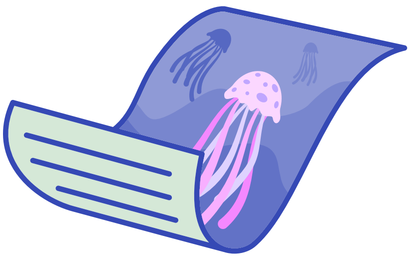
Future human health risks from environmental decline can be minimized with a One Health approach. One Health is an approach that seeks to simultaneously secure optimal outcomes for human health, animal health and the health of the environment. A healthy society relies on a multifactorial foundation of physical, mental and social well-being, which can only be maintained and fostered if cross-sectoral and interdisciplinary approaches are pursued. Collaborative efforts under a One Health approach can prevent human health disasters such as zoonotic pandemics. The need for such an approach is widely recognized as a critical component in creating a healthier world. The COVID-19 pandemic has underlined the need for bold and creative actions and agendas that facilitate cooperation across institutional, geographical, and socioeconomic boundaries and help remove current constraints. Health is increasingly influenced by geopolitical developments that are affected by environmental factors, such as climate change-induced mass migration. It is key to target the social determinants of the many aspects of human health.

Cities and communities, including informal settlements, can and must be made much more sustainable, including with nature-based solutions. Urban populations face immense risks from environmental degradation, including extreme heat and flooding, air and water pollution, infectious diseases and growing inequality. The opportunities for promoting sustainability are also huge, including the transition to a low-carbon economy, reduced pollution and energy demand, sustainable consumption and production, and the restoration of biodiversity. Improved urban planning and nature-based solutions offer cost-effective ways to address the SDGs in cities and make urban areas more resilient to climate change. Options include protecting or expanding green spaces that can reduce the heat island effect and absorb rainwater, retrofitting infrastructure, and promoting urban and peri-urban agriculture. Cities are expected to expand significantly in the next two decades, making the application of sustainable urban planning and development to existing and new residential and commercial areas extremely urgent. Cities must also address the issue of informal settlements, which contribute to environmental degradation and bear the brunt of its consequences. City planners must deliver or facilitate high-density, mixed-use and resource-efficient settlements, connected by multimodal and low-carbon transport and other infrastructural systems, with access to safe and abundant green space. Coastal cities need to be designed or retrofitted to face the threat of flooding due to sea level rise and salt water intrusion into freshwater systems, including, in some cases, planned retreat.

I. All actors have a part to play in transforming social and economic systems for a sustainable future

Transformations can be just, informed and effective if the full range of actors in the public, private and civil society sectors collaborate. At the heart of the various transformational changes needed for a sustainable future are informed, fair and participatory governance systems, where all relevant stakeholders have a voice. Polycentric systems of governance allow for improved information flow as well as collaborative planning, participation and coordination. Because governance systems are not merely the product of governments but rather of all societal actors, realizing governance systems suited for sustainability will require coordination amongst many different actors, including those who may not cooperate at present. This will mean transcending formal boundaries between individuals, and between and within organizations, agencies, and sectors to achieve vibrant, sustainable futures.

All actors have individual, complementary and nested roles to play in bringing about cross-sectoral and economy-wide transformative change with immediate and long-term impact (Table ES.1). Governments initiate and lead in intergovernmental cooperation, policies and legislation that transform society and the economy. Such transformations enable the private sector, financial institutions, non-governmental organizations, scientific and educational institutions and media, as well as households and civil society groups, to initiate and lead transformations in their domains. Multiple actors will need to cooperate within each transformation, for example in developing frameworks to use inclusive wealth in decision-making, or policies and strategies to integrate biodiversity conservation and restoration into the many uses of terrestrial, freshwater and marine ecosystems. Human innovation and knowledge-sharing will create new social and economic possibilities and opportunities in the transformation to a sustainable future.



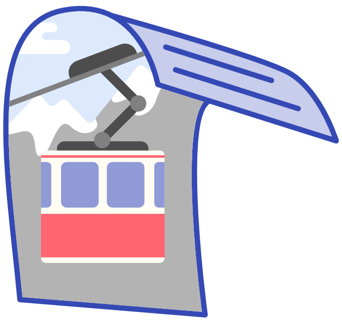
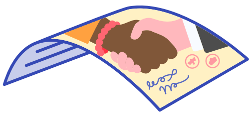
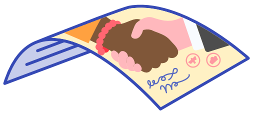


Table ES.1 Actors and actions to transform humankind's relationship with nature

Actors	Examples of key actions to be taken
Governments – legislature, judicial and executive branches at national, subnational and local level 	**1. Address Earth's environmental emergencies and human well-being together** a) **Synergies** Establish mechanisms and approaches for cross-sectoral coordination of assessments, policies, legislation, enforcement and financing, including through integrated approaches such as a One Health policy for human and animal health and the environment. b) **Climate change** Adopt plans and goals consistent with the Paris Agreement for transitioning to net-zero carbon dioxide emissions by 2050, cutting emissions by 45 per cent by 2030 compared with 2010. Put a price on carbon, phase out fossil fuel finance and end fossil fuel subsidies, stop building new coal power plants and advance adaptation and resilience to climate change. c) **Biodiversity loss and ecosystem degradation** Develop policies and strategies to integrate biodiversity conservation and restoration into the many uses of terrestrial, freshwater and marine ecosystems, as well as expanding and improving protected areas. Drastically reduce deforestation and systematically restore forests and other ecosystems as the single largest nature-based opportunity for climate mitigation. d) **Health and well-being** Recognize a healthy environment as a basic human right and provide health and well-being for all. Comply with obligations under the chemicals conventions. Implement and enforce chemicals and waste policies, adopt reuse and recycling standards and develop strategies to meet WHO guidelines for air pollutants. Invest in community-based family planning and assist women to access financing and education. e) **Cities and settlements** Design and develop socially and environmentally sustainable cities and settlements by embracing nature-based solutions, promoting enhanced access to services such as clean water and energy and public transport, and making infrastructure and buildings sustainable. **2. Transform economic and financial systems so they lead and power the shift toward sustainability** a) **Accounting for nature** Reform national economic, financial, planning and tax systems to include natural capital (using inclusive wealth as a measure of sustainable economic performance) and environmental costs (by internalizing externalities) in decision-making. Integrate the goals of carbon neutrality, land degradation neutrality and conservation of biodiversity into all economic and fiscal policies and decisions. b) **Subsidies and markets** Reform subsidies to eliminate harmful environmental and social effects including by ending fossil fuel subsidies. Establish carbon taxes, carbon pricing, markets for carbon trading, and schemes for offsetting of nature and payments for ecosystem services. Regulate to establish a level playing field in national and international markets. c) **Investments** Invest in economic activities, research and development – nationally and through international development assistance and transfer of technology – that enhance the stock of natural assets and advance the shift towards sustainability and a low-carbon economy. Provide funding for developing countries to meet their obligations under the multilateral environmental agreements and SDGs.

Governments – legislature, judicial and executive branches at national, subnational and local level
(continued)



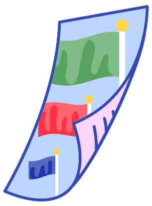
3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Develop and implement policies to provide sustainable access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Integrate sustainable production and management of food and water within terrestrial, freshwater and marine ecosystems. Make agriculture, forestry, fisheries, aquaculture and resource extraction biodiversity-positive. Promote sustainable agricultural intensification, agroecological practices and conservation of genetic resources. Stop overfishing. Promote healthy diets and reductions in food and water waste. Restrict groundwater extraction and advance appropriate water pricing and the use of agricultural, forestry and fisheries certification standards.

c) **Energy** Develop energy efficiency regulations, renewable energy targets, sustainable bioenergy strategies and infrastructure for electric vehicles.

Intergovernmental organizations



1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Facilitate international cooperation in science-policy interfaces and advance UN system-wide efforts including by promoting synergies among scientific assessments and multilateral environmental agreements through norms, implementation, financing, capacity-building and technological cooperation.

b) **Climate change** Build a global coalition for carbon neutrality consistent with the Paris Agreement for transitioning to net-zero carbon dioxide emissions by 2050 and cutting emissions by 45 per cent by 2030 compared with 2010. Advance adaptation, especially in least developed countries.

c) **Biodiversity loss and ecosystem degradation** Advance international cooperation on addressing the biodiversity emergency, including through relevant multilateral environmental agreements. Promote ambitious post-2020 targets and actions for biodiversity and land neutrality. Support the UN Decade on Ecosystem Restoration focused on preventing, halting and reversing the degradation of forests, land and other ecosystems worldwide. Make own international activities and operations sustainable.

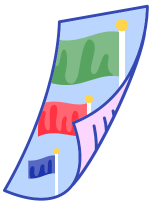
d) **Health and well-being** Facilitate international cooperation on protecting the health of the planet in order to provide health and well-being for all. Advance a One Health approach and strategies to meet WHO guidelines for air pollutants. Continue to promote the coordination and implementation of existing chemicals conventions and strengthen the science-policy interface for chemicals and waste. Implement monitoring and surveillance and early warning systems.

e) **Cities and settlements** Promote sustainable urban planning, nature-based solutions for climate and biodiversity in urban areas, retrofitting of blue and green infrastructure, and access to urban services including clean energy and water.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Facilitate international cooperation on frameworks for natural capital accounting, reform of measures and models of economic growth including through the use of natural capital and inclusive wealth in decision-making, and reform of trade systems to make them more fair and environmentally sustainable.

Intergovernmental organizations (continued)



b) **Subsidies and markets** Promote a circular economy, elimination of environmentally damaging fossil fuel and agricultural subsidies, harmonization of environmental taxes such as carbon taxes, cooperation on carbon trading, schemes for offsetting nature and payments for ecosystem services. Support private sector initiatives to create sustainable global supply chains.

c) **Investments** Facilitate cooperation on international development assistance, capacity-building and transfer of technology that help enhance the stock of natural assets in recipient countries and advance their shift towards sustainability and a low-carbon economy.

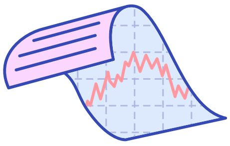
3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Facilitate international research and cooperation on improving access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Promote and facilitate sustainable policies, technologies and management within agriculture-fisheries-forestry-water-energy systems, including through sustainable fisheries, agricultural intensification, agroecological practices and multifunctional landscapes. Advance the use of agricultural, forestry, aquaculture and fisheries certification standards and labelling. Encourage healthy diets, and reductions in food and water waste. Support cooperation on water management including through freshwater treaties and assist the development of agreements for the protection of genetic resources for agriculture and the fair and equitable sharing of benefits arising from their use.

c) **Energy** Support the transition to a low-carbon economy, both in the production and use of energy.

Financial organizations



1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Finance international and cross-sectoral cooperation, capacity-building and technological cooperation that address environmental challenges and human well-being. Disclose climate-related financial risk, and the use of natural resources and the impact of these activities on the environment. Align operations with the net-zero carbon emissions objective and sustainability principles.

b) **Climate change** Multilateral, regional and national development institutions as well as private banks should commit to align their lending to the global net-zero carbon emissions objective. Asset owners and managers should decarbonize their portfolios and join initiatives including the Global Investors for Sustainable Development Alliance and the Net-Zero Asset Owners Alliance. Multilateral and national development banks should commit to increase the share of adaptation and resilience finance to at least 50 per cent of their climate finance to support activities such as early warning systems, and climate-resilient infrastructure and agriculture.

c) **Biodiversity loss and ecosystem degradation** Develop and promote innovative financing mechanisms for the conservation and restoration of biodiversity, including through payments for ecosystem services. Support the expansion and better management of protected areas and other effective area-based conservation measures and activities aligned with the UN Decade on Ecosystem Restoration.

d) **Health and well-being** Support One Health and disease prevention initiatives and strategies to meet WHO guidelines for air pollutants. Support health research, especially in developing countries. Provide financing for improved waste management.

e) **Cities and settlements** Develop and promote innovative financing for sustainable infrastructure. Support sustainable urban planning and investments in low-carbon infrastructure, including mass transportation, congestion charges, nature-based solutions and green and blue spaces.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Promote and use natural capital accounting and inclusive wealth in decision-making, including lending and grant-making policies. Promote the internalization of externalities in prices and a circular economy.

b) **Subsidies and markets** Promote the elimination of environmentally harmful subsidies. Facilitate carbon trading, schemes for offsetting nature and payments for ecosystem services. Develop environmental and social risk registers for all financial transactions.

c) **Investments** Facilitate a major shift away from investments in environmentally unsustainable activities and toward economic activities that enhance the stock of natural assets. Fund the transition to a circular, green and low-carbon economy. Funding should flow to resilience, adaptation and just transition programmes. Fund research and development nationally and through international development assistance.

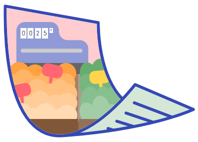
3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Fund programmes that improve access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Finance sustainable intensification and ecological intensification of agriculture, and sustainable fisheries, and stop supporting unsustainable activities such as deforestation. Advance the use of agricultural, forestry, aquaculture and fisheries certification standards and labelling and encourage healthy diets, and reductions in food, water and energy waste. Support the development and use of certification standards for agriculture, fishing, aquaculture, forestry and water use.

c) **Energy** Finance low-carbon energy production and use, and stop supporting unsustainable activities, such as fossil fuel energy.

Private sector



1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Help develop and comply with strong environmental legislation that levels the playing field so that firms cannot gain competitive advantage by externalizing costs that are then borne by society. Implement certified and traceable sustainable practices along the complete supply chain. Disclose climate-related financial risk, use of natural resources and the impact of activities on the environment. Practise corporate social responsibility.

b) **Climate change** Adjust business models and align them with the global net-zero carbon emissions objective and sustainability practices in all sectors, including in shipping and aviation. Investors should demand information from companies on the resilience of those models.

c) **Biodiversity loss and ecosystem degradation** Develop and promote innovative public-private partnerships for financing and engaging in the conservation and restoration of biodiversity, including through the use of payments for ecosystem services. Implement sustainable land management practices for agriculture and forestry. Engage in transformative landscape governance networks. Develop sustainable global supply chains for deforestation-free agricultural commodities.

d) **Health and well-being** Comply with environmental standards to protect human health. Move industries to a sustainable and circular business model by reducing waste and resource use and encouraging sharing, reuse and recycling. Promote and support plastic free/environmentally friendly packaging. Conduct transparent risk assessments of the impact of chemicals on the environment and human health. Increase the use of green chemistry, invest in waste recycling and set high standards for waste disposal.

e) **Cities and settlements** Engage with and support government in sustainable urban planning, public transport, energy-efficient buildings and partnerships to enhance access to urban services.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Use natural capital in decision-making and develop environmental and social risk registers for all projects and investments.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting nature, and payments for ecosystem services. Promote behaviour change in customers. Further develop and implement social and environmental standards for corporate operations.

c) **Investments** Shift investments and operations away from unsustainable industries, such as fossil fuels. Invest in innovation, environmentally sound technologies and move towards a circular economy.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Develop and invest in systems to produce, store and distribute affordable and clean power and water and healthy food to all.

b) **Food and water** Provide modern food storage and distribution services that minimize waste. Promote the development and use of food certification standards and product labelling. Invest in sustainable intensification in agriculture, fisheries and aquaculture. Develop climate-resilient crops and livestock breeds as well as alternatives to harmful agricultural inputs, including to fertilizers and pesticides.

c) **Energy** Develop, invest in and use low-carbon energy technologies and distribution networks.

Non-governmental organizations

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Support education, promote youth movements and engage communities in citizen science. Participate in community-led initiatives to promote sustainable consumption and production. Help hold societal actors accountable for their environmental promises, commitments and responsibilities. Support the training of the next generation of leaders.

b) **Climate change** Promote and align activities and operations with the net-zero carbon emissions objective. Implement mitigation, adaptation and resilience programmes and projects, including through nature-based solutions.

c) **Biodiversity loss and ecosystem degradation** Support and implement efforts for the conservation, restoration and sustainable use of biodiversity. Develop local-regional-national conservation programmes. Participate in community-led initiatives to conserve nature. Engage in transformative landscape governance networks. Support the development and management of protected areas and other effective area-based conservation measures.

d) **Health and well-being** Raise awareness on chemical safety and take a greater role in the SAICM chemicals management processes. Work with communities and local municipalities for the safe disposal of waste.

e) **Cities and settlements** Campaign for and support sustainable urban planning and improved access to urban services and community initiatives, especially for the urban poor.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Promote the use of natural capital accounting, and initiatives for the transformation to a sustainable and circular economy.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting of nature and payment for ecosystem services Promote behavioural change in consumption and production, including among their own members and wider society.

c) **Investments** Advocate for policies and regulations that promote investment in sustainable development.

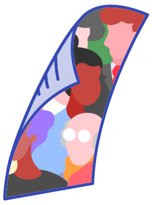
3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Advocate for and implement programmes and projects for improved access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Develop and implement initiatives for the ecological intensification and sustainable use of multifunctional landscapes. Promote dietary transitions and reductions in food, water and energy waste. Assist in improving certification standards.

c) **Energy** Participate in community-led initiatives to shift toward cleaner fuels, increase energy-efficiency, conserve energy and develop sustainable bioenergy strategies.

Individuals, households, civil society and youth groups, and indigenous peoples and local communities



1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Foster social norms and behaviours that embody sustainability principles by exercising voting and civic rights and holding governments and the private sector accountable for their actions. Review and comment on local and national policies. Engage in initiatives that promote sustainable consumption. Engage in education and citizen-science initiatives.

b) **Climate change** Make climate-friendly everyday choices on travel and consumption that contribute to the net-zero carbon emissions objective. Engage in local adaptation and resilience initiatives, including through nature-based solutions.

c) **Biodiversity loss and ecosystem degradation** Engage in local and national conservation and restoration efforts, transformative landscape governance networks and awareness campaigns to influence consumer behaviour.

d) **Health and well-being** Understand and promote the links between environment and human health. Participate in community-led clean-ups of waste in public spaces. Ensure materials are recycled and waste is properly disposed of.

e) **Cities and settlements** Engage in participatory processes to advance sustainable urban planning and initiatives to increase access to urban services, and promote nature-based solutions and green and blue infrastructure.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Foster economic and financial transformations by supporting initiatives to include environmental costs in the prices of goods and services.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting nature, and payments for ecosystem services. Support fair trade and companies with sustainable production models that provide services and products that foster societal well-being.

c) **Investments** Support shifts in investment towards those needed to achieve the SDGs, and away from unsustainable industries, such as fossil fuels.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Support and engage in local production and distribution systems for healthy food, safe water and clean energy.

b) **Food and water** Consider what constitutes a healthy diet and also reduces environmental damage. Adopt sustainable practices in community-based and small-scale food production. Purchase sustainably produced food and reduce waste. Reduce wasting water, and collect rainwater and use grey water.

c) **Energy** Support community-based energy production. Reduce energy consumption and chose clean energy when possible.

Scientific and educational organizations

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Develop analytical tools, including plausible futures models, using exploratory, target-seeking and policy-screening scenarios that account for the complex interlinkages between environment and development. Further develop observational programs. Engage in national and international scientific assessments. Develop environmental education programs for all age groups. Raise public awareness through public engagements, editorials, social media.

b) **Climate change** Assess the impact of climate change on socio-economic sectors, nature and human health at all scales. Assess the efficacy and cost-effectiveness of different mitigation and adaptation policies and technologies.

c) **Biodiversity loss and ecosystem degradation** Assess the impact of multiple drivers on biodiversity and ecosystem degradation, and the efficacy and cost-effectiveness of conservation and restoration activities, including nature-based solutions.

d) **Health and well-being** Promote education, information and awareness of One Health approaches. Assess interactions among environmental issues and their impacts on socio-economic sectors and human health. Assess the implications of chemicals for human health and the environment, and develop health surveillance and monitoring systems, and approaches to prevent disease outbreaks, including pandemics. Assess the mental health implications of green and blue infrastructure in urban environments.

e) **Cities and settlements** Support sustainable urban planning and development, including the use of nature-based solutions. Promote education, information and awareness on sustainable cities and settlements and their importance for human health.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Further develop the framework for natural capital accounting and the relevant databases. Assess the costs and benefits of mitigating and adapting to climate change, loss of biodiversity and ecosystem degradation, land degradation, and air and water pollution at a range of spatial scales. Assess the implications of reforming measures and models of economic growth. Promote education, information and awareness on sustainable economic and financial systems.

b) **Subsidies and markets** Assess the environmental and distributional social impacts of reductions in harmful subsidies, and the reallocation of these resources to support sustainable consumption and production.

c) **Investments** Assess the environmental and social impacts of switching investments from unsustainable activities such as fossil fuels to sustainable activities.

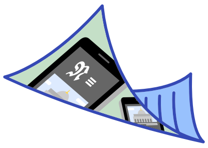
3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Help develop and monitor systems and networks to produce and distribute clean water and energy and nutritional food. Support the development of certification processes.

b) **Food and water** Promote education, information and awareness on sustainability within agriculture-fisheries-forestry-water-energy systems. Assess the implications of environmental degradation on agriculture and water resources. Develop temperature, drought, pest and salinity resistant crops. Assess how to reduce the environmental footprint of agriculture. Facilitate the conservation and sustainable use of genetic resources. Develop water purification and desalination technologies.

c) **Energy** Develop low-carbon production and use technologies, and assess how to overcome the barriers to market penetration of these technologies.

Media and social networks



1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Inform all actors about the relationships between environment and development issues. Help hold societal actors accountable for their environmental promises, commitments and responsibilities. Support campaigns for meaningful actions to address environmental degradation. Counter disinformation and promote environmentally responsible social norms.

b) **Climate change** Highlight the implications of climate change for people and nature, and the opportunities for adaptation and mitigation.

c) **Biodiversity loss and ecosystem degradation** Highlight the importance of biodiversity for human prosperity and well-being and the options for its conservation and restoration.

d) **Health and well-being** Spread understanding and awareness of One Health approaches. Support campaigns for meaningful transformations in the health sector.

e) **Cities and settlements** Document the impact on people and nature of unsustainable systems in urban areas and support campaigns for transformations in how cities and settlements are planned and designed, including the supply of essential services.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Raise awareness of how current economic models and performance measures as well as the price of some goods and services fail to fully account for natural capital and environmental costs, and how this skews investment toward unsustainable activities. Support campaigns for meaningful transformations in economic and financial systems.

b) **Subsidies and markets** Inform the public and other actors of the adverse consequences of fossil fuel and agricultural subsidies that lead to environmental damage, and explore the impact of redirecting the financing of subsidies to sustainable activities.

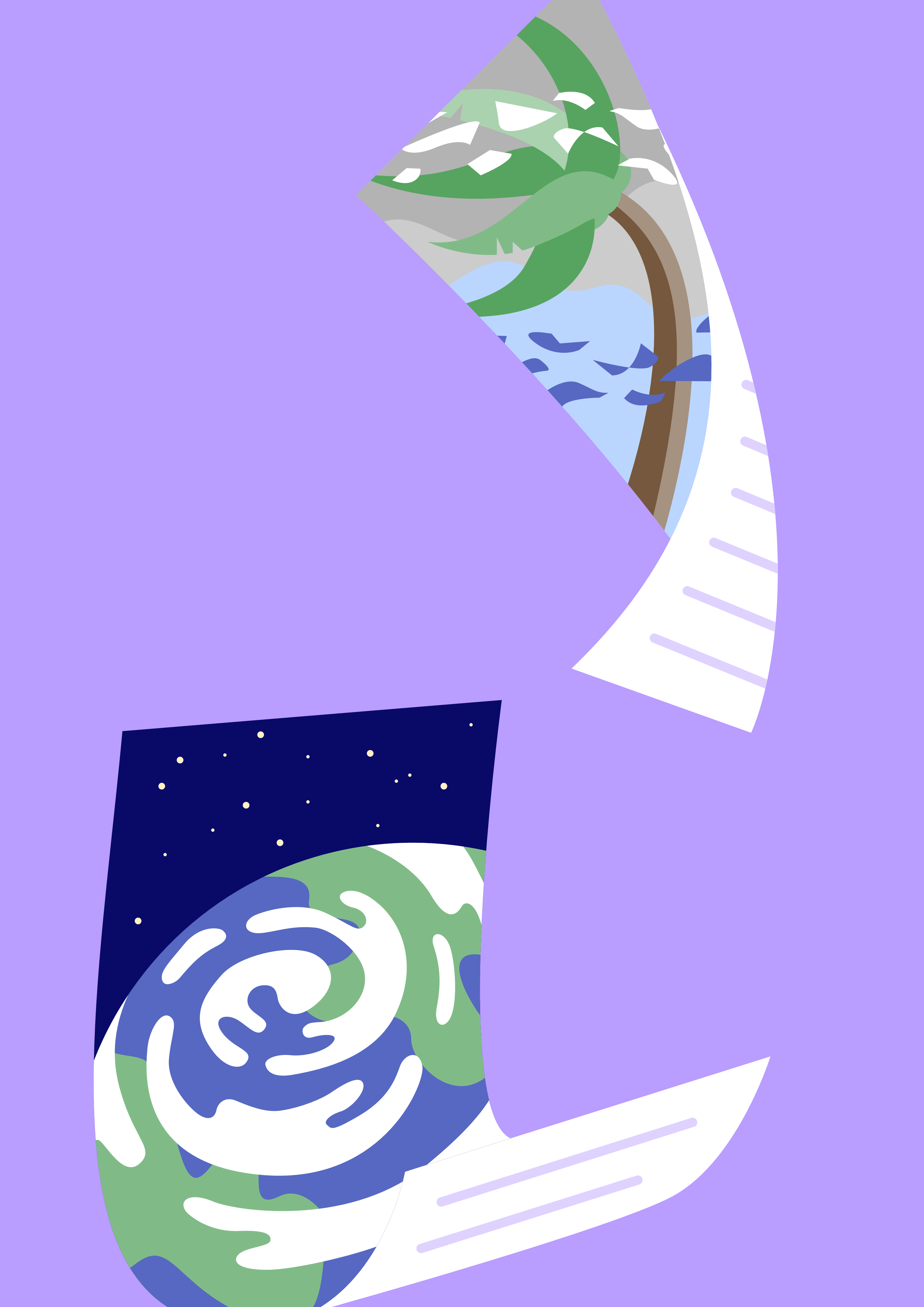
c) **Investments** Highlight government spending and private sector investments that are unsustainable and those which are sustainable.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Highlight the inequitable access to safe and affordable food, clean water and clean energy, and ways to improve access.

b) **Food and water** Provide information and raise awareness of the need for more sustainable practices in the agriculture-fisheries-forestry-water-energy systems. Support campaigns for meaningful transformations in the agricultural, water and energy sectors. Provide information on the health and environmental effects of different diets.

c) **Energy** Raise awareness of the benefits from and pathways for meaningful transformations in the energy sector.



1

Tackling the planetary emergency and lighting a path to a sustainable future with new opportunities

Humanity has been grappling with a growing number of environmental challenges of increasing severity ever since the Stockholm Conference in 1972. The decision to hold what became the first in a series of decadal conferences on sustainable development was taken by the General Assembly of the United Nations (UN) in 1969.[1] The Stockholm Conference identified the environment as a challenge needing a UN system-wide response and resulted in the establishment of the UN Environment Programme (UNEP) to help spearhead and coordinate the effort.[2] Governments have since put in place a number of specific multilateral environmental agreements and instruments, some of which address issues largely unknown in 1972, such as the depletion of the ozone layer and climate change.[3] Environmental challenges such as climate change, biodiversity loss and pollution have become increasingly severe. For example, the Intergovernmental Panel on Climate Change (IPCC) has compared key impacts and risks of global warming across sectors and regions to people, economies and ecosystems for selected natural, managed and human systems through a sequence of science-based assessments (figure 1.1). The more recent assessments find that the risks kick in at lower temperature increases than the earlier ones did, and that the reasons for concern about climate change have increased over time.

Science in interaction with policy has played a key role in identifying emerging environmental issues and providing the evidence base needed to address them. International environmental cooperation has developed an elaborate science-policy interface, including intergovernmental assessments co-designed and co-produced by independent experts interacting with government representatives and stakeholders. International assessments have established a foundation of shared knowledge that has often gone hand in hand with the development of international actions to curb environmental decline. A prominent example is the international effort to restore the life-protecting ozone layer in the upper atmosphere. Stratospheric ozone depletion was first hypothesized in 1974 and prompted a series of discoveries showing that human-produced substances were to blame (figure 1.2). An elaborate interplay between science and policy resulted in the Montreal Protocol, which initiated the phasing out of ozone-depleting substances so that the ozone layer could start to recover, as detected in 2014. How science and policy interacted on this issue is detailed in Section 3. Advanced science-policy processes are key to generating actions needed to address more complex problems such as climate change and biodiversity loss.

Current environmental challenges together represent a planetary emergency that demands transformative change to secure a sustainable future. Humanity can make peace with nature and tackle the combined environmental crisis by redeploying human skills from transforming nature to transforming the social and economic fabric of society. Such an effort needs to put human well-being centre stage and speed up progress towards the Sustainable Development Goals (SDGs). The 17 indivisible SDGs frame the transformations required as part of the 2030 Agenda for Sustainable Development adopted by the UN General Assembly in 2015. The Agenda sets out a partnership for people, planet, prosperity and peace under what the General Assembly refers to as "a supremely ambitious transformational vision."[4] The Agenda and its integrated and indivisible goals link to a number of other instruments, including multilateral environmental agreements and the Sendai Framework for Disaster Risk Reduction 2015–2030.[5] Transformations require amongst other things innovation, learning, solidarity and adaptation. As well as costs and disruption, transformations promise to open up many new social and economic possibilities and opportunities.

This report presents a flexible scientific blueprint for how the climate change, biodiversity and pollution emergencies can be tackled jointly within the framework of the SDGs. The first of its kind, this report gathers expertise from across recent global assessments to gauge Earth's environmental decline and suggest how society at large can best respond. The expert analysis synthesizes key findings from

1.1. Comparison of risk thresholds across Intergovernmental Panel on Climate Change (IPCC) Assessments

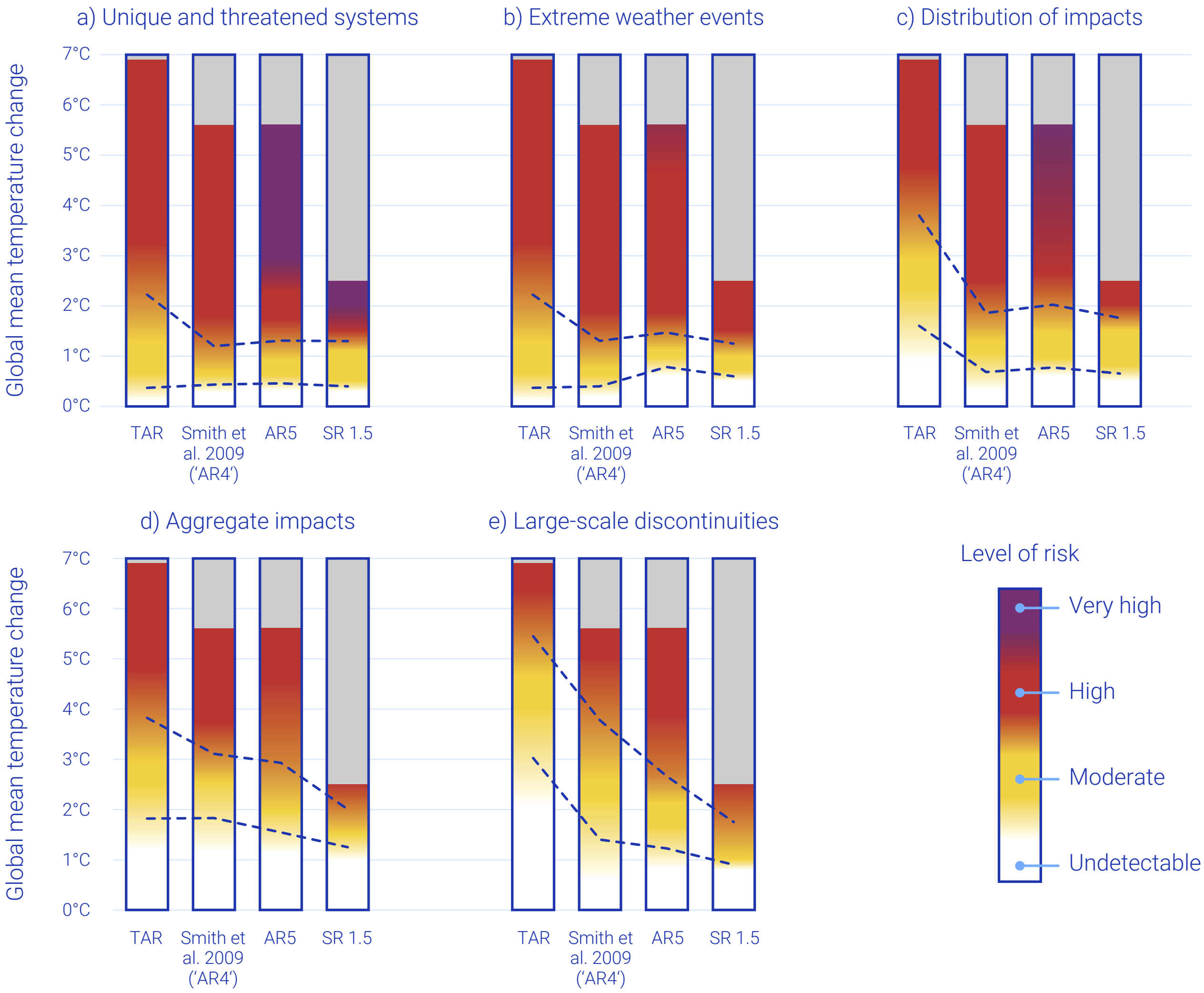


Figure 1.1: The "burning embers" diagrams in the IPCC assessments link global warming to estimates of impacts and risks for people, economies and ecosystems across sectors and regions for selected natural, managed and human systems. The systems include (a) unique and threatened systems (such as tropical glaciers, coral reefs and indigenous communities), (b) extreme weather events (including floods, droughts and tropical storms; term used in the Special Report on Global Warming of 1.5 Degrees (SR 1.5) but called extreme climate events in Zommers *et al.* 2020), (c) distribution of impacts (including the heightened vulnerability of developing countries), (d) aggregate impacts (such as global monetary damage, global-scale degradation and loss of ecosystems and biodiversity) and (e) large-scale discontinuities (such as the shutdown of the North Atlantic thermohaline circulation or the collapse of the West Antarctic Ice Sheet; called large-scale singular events in the IPCC Fifth Assessment Report (AR5) and the Special Report on Global Warming of 1.5 Degrees (SR 1.5)). All burning embers are presented with the same colour and temperature scale, removing technical details that varied between the original publications. Grey areas at the top of each column correspond to temperatures above the assessed range in the corresponding report. Dashed lines connect the midpoints between undetectable and moderate risk, and moderate and high risk. Risks transitions have generally shifted towards lower temperatures with updated scientific understanding. TAR is the IPCC Third Assessment Report and AR4 is the IPCC Fourth Assessment Report. Smith *et al.* (2009) updated the TAR diagram incorporating AR4 findings. Figure produced using the Ember Factory online application.[6]

Source: Figure adapted from Zommers *et al.* 2020, Figure 3.

the assessments with those from additional high-impact peer-reviewed literature and grey literature. Part I of this report shows how the findings of the assessments are interlinked and add up to an unparalleled planetary emergency. It presents a diagnosis of how the human transformation of Earth's natural systems puts the collective human future at risk. Within Part I, Section 2 examines how human survival and well-being remain critically dependent on the natural world, how the economy fails to reflect this relationship and how the environment is increasingly shaped by human

1.2. Milestones in the History of Stratospheric Ozone Depletion

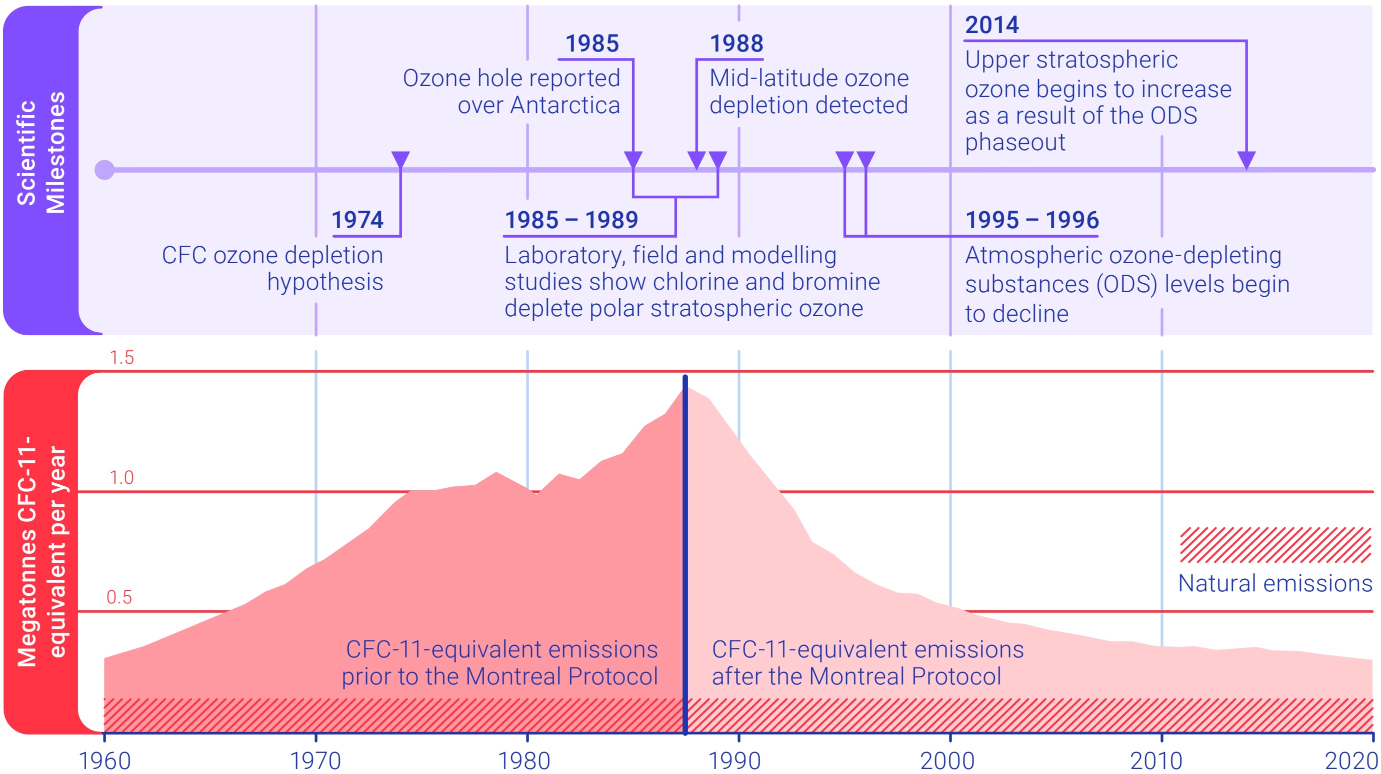
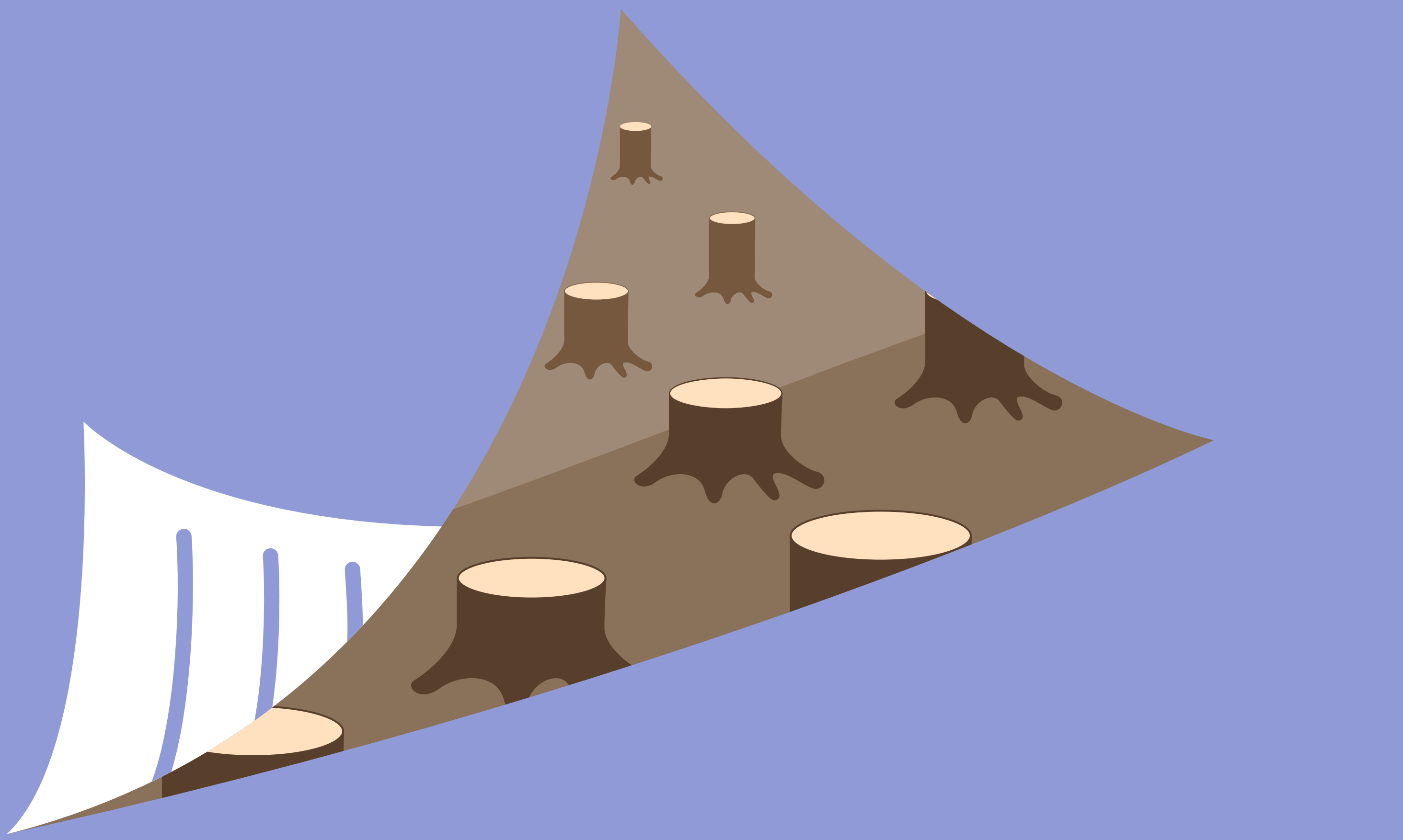


Figure 1.2: The key role of science in identifying the depletion of the life-protecting stratospheric ozone layer and the generation of knowledge needed to curb emissions of ozone-depleting substances. Emissions are presented in CFC-11 (trichlorofluoromethane) equivalents. For a graphic representation of the interaction between science and policy that yielded this result, see figure 3.6.

Source: figure adapted from Salawitch *et al.* (2019)

activities. Section 3 explores how the world is currently failing to meet almost all of its targets on limiting environmental decline. Section 4 analyses how an array of deepening and mutually reinforcing environmental risks now threatens human well-being and the achievement of the SDGs. In Part II, the report urges the world to respond to the planetary emergency by transforming people's relationship with nature and with each other. Section 5 analyses how this daunting goal of a fundamental, system-wide change in the technological, economic and social organization of society can be achieved. Section 6 then assesses how the Earth's environmental emergencies should be addressed together to achieve sustainability. Section 7 moves on to examine how the economic and financial systems can be transformed to lead and power the shift to a sustainable future, and then explores how food, water and energy systems can be transformed to meet growing human needs in an equitable, resilient and environmentally friendly manner. Actions to reverse environmental decline in order to reduce the threats it poses to human health and well-being are addressed in Section 8. It also examines the environmental dimensions of promoting peaceful societies before addressing how cities and communities could become more sustainable. Finally, Section 9 sets out the roles and responsibilities that actors in the public and private sphere should assume if transformation is to succeed. It makes clear that humanity needs to take ingenuity and cooperation to a whole new level in order to achieve the sustainable development that will safeguard people and the planet in both the immediate and distant future.

1 United Nations General Assembly Resolution 2581 (XXIV) of 15 December 1969
2 United Nations General Assembly Resolution 2997 (XXVII) of 15 December 1972.
3 UNEP/GC.26/INF/23, Environment in the United Nations System, Note by the Executive Director.
4 United Nations General Assembly Resolution 70/1 of 21 October 2015
5 UN 2015, Transforming our world: the 2030 Agenda for Sustainable Development.
6 Smith *et al.* 2009




I. Transforming nature puts human well-being at risk

2

The current mode of development degrades the Earth‘s finite capacity to sustain human well-being

People rely on nature for livelihoods, prosperity, health and well-being. This section lays out the many ways in which people depend on nature, including through the provision of resources, the cycling of materials and the regulation of environmental conditions, and the many non-material contributions that nature makes to a good quality of life. It assesses how current economic and financial systems fail to account for society's dependence on the environment. The section then explores the underlying social and economic dynamics driving the human activities that directly degrade the environment through appropriation of space, modification of life, production, extraction, consumption, pollution and waste disposal.

2.1 Human well-being is critically dependent on the Earth's natural systems

Human survival and well-being rests on the Earth and its ecosystems, and though the benefits of nature are received by all, the burden of environmental decline is unjustly distributed. Humans depend on the Earth's finite space and resources as well as its capacity to regenerate renewable resources, absorb waste and sustain life. The Earth provides humanity with clean water and air,[1] a protective stratospheric ozone layer,[2] a stable global climate and many other critical benefits. Human dependence on Earth and its ecosystems is often exposed when human systems degrade or surpass the planet's capacity to sustain prosperity. The growing use of land, freshwaters, coasts, oceans and natural resources such as fossil fuels, food crops, timber and aquatic foods have fuelled economic, technological and social advances (see figure 2.2).[3] However, human use of space and resources leaves less room for other living beings, and disposal of waste surpasses the Earth's absorptive capacity (see Section 3). The consequences, as this report shows, are devastating for human well-being and unjust (see Section 4). The benefits of nature have accrued unequally, and the burden of environmental decline is often disproportionately borne by poor and vulnerable communities.[4,5]

Nature provides both material and non-material benefits crucial to human well-being and regulates Earth system functions that secure liveable conditions and protect people from harm. Many benefits derived from nature flow from interactions between people and the environment. Nature provides food, medicines, fibre, materials and energy and, with the aid of human inputs the production of many of these goods has increased over the past 50 years.[6] Nature also provides inspiration and learning, physical and psychological experiences, a sense of place and supports human identities.[7] The diversity of nature maintains humanity's ability to choose alternatives in the face of an uncertain future; for example, wild species might be domesticated as new crops.[8] In addition, natural processes modulate and maintain Earth systems, thereby providing a stable climate, mitigating natural hazards such as floods and fires, maintaining air and water quality, and supporting biological productivity.[9] Food production, for example, depends not only on food plants themselves but on many contributions from nature, including animal pollination, maintenance of soil fertility and water holding capacity and genetic diversity to withstand environmental changes such as increased temperatures or pests and disease (see Section 4).[10]

Human well-being, now and in the future, depends on a healthy planet, achieved by avoiding climate change, pollution of air and water, degradation of land, water and oceans, and erosion of life on Earth. A changing climate, a degraded ozone layer, pollution and the degradation of ecosystems threaten human health, infrastructure and the many benefits that nature provides to people.[11] Nature itself is critical in mitigating these impacts, though in doing so its integrity is threatened. For example, oceans and land ecosystems have absorbed roughly 50 per cent of total human carbon dioxide emissions, but in so doing the oceans have acidified, negatively affecting ocean ecosystems that many people depend on,[12] and the persistence of natural carbon sinks are themselves uncertain due to climate change[13,14] and other drivers (see Section 2.3).[15] Sustaining the flow of benefits from nature increasingly depends on avoiding further loss of biodiversity.[16] For example, biodiversity in agricultural systems, including species and genetic variability, reduces vulnerability to stresses and shocks, in part by increasing the choices available to producers.[17] Avoiding land degradation will benefit billions of people by maintaining crop yields and other benefits of nature.[18] A healthy planet is a prerequisite and foundation for long-term prosperity, human health and well-being and for the achievement of the 2030 Agenda.

The aggregate value of nature is often difficult to quantify because people value nature and its contributions to quality of life and cultural integrity in many different ways.[19] Groups with different culture, history, experience, education, income or other factors may use and value nature quite differently.[20] People experience the value of nature through their physical and mental health and as social, cultural and holistic well-being.[21] Multiple dimensions of value integrate cultural uniqueness; community reliance on nature that links to livelihoods, incomes, and level of importance for well-being; cultural traditions, including connectedness to place, rituals, and width of interest across the community; and dramatic cultural change.[22]

2.2 Economic and financial systems fail to account for nature

Natural capital, as an asset that contributes to human well-being, is an important component of human wealth. Natural capital refers to the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.[23] Inclusive wealth accounting measures the value of all forms of capital assets. It includes natural capital, human capital (skills, knowledge and experience), manufactured capital (building, infrastructure and machinery) and social capital (institutions and relationships among people). A partial accounting puts the value of natural capital at 20 per cent of planetary wealth.[24] This estimate excludes the many values of nature that are not sold as goods in market economies and hence have no conventionally measured economic value. However, since natural capital provides the life support system for humanity, all wealth is ultimately dependent on preserving natural capital.[25]

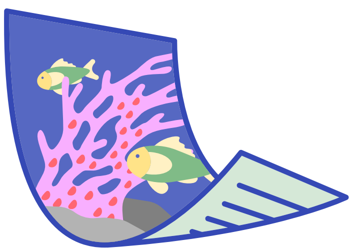
Gross Domestic Product fails to fully account for the benefits people get from nature and the costs of its degradation. The standard measure of economic performance, gross domestic product (GDP), only measures the value of market transactions and therefore excludes much of the value of nature's contribution to human well-being. GDP excludes the value of ecosystem functions that regulate environmental conditions and the value of non-material benefits related to spiritual or cultural values. It also excludes measures of negative externalities associated with the depletion and destruction of nature. GDP measures current income but does not show whether that income is sustainable. Supporting current income through depletion of natural capital is not sustainable.

Inclusive wealth is a better measure of sustainable prosperity. Rising GDP overstates human progress because it does not account for declines in natural capital. Maintaining or enhancing inclusive wealth (also known as weak sustainability) gives future generations the possibility to be at least as well off as the current generation.[26] Between 1990 and 2014, the annual growth rate in GDP for a set of 135 countries was almost double the increase in inclusive wealth (3.4 per cent versus 1.8 per cent).[27] Yet even this comparison only partially reflects the loss of nature's contributions over this period.

Natural capital provides contributions to human well-being for which there may not be substitutes. Maintaining stocks of critical natural capital for which there are no substitutes is necessary for sustainability (also known as strong sustainability).[28] For example, the natural processes integral to growing food cannot be replaced. Even where substitutes for natural capital exist, they may be limited and costly. For example, biodiversity often reduces the need for food and agricultural producers to rely on costly or environmentally harmful external inputs. Similarly, high-quality drinking water can be provided through ecosystems that filter pollutants, through human-engineered water treatment facilities, or through hybrid solutions such as constructed wetlands and greywater treatment. Coastal flooding from storm surges can be reduced by coastal mangroves or by dikes and sea walls. Where limited or no substitutes for natural capital are available, policymakers can set science-based standards for environmental sustainability and adopt measures to ensure that these standards are met. This approach has been adopted for climate change, biodiversity loss and protection of the stratospheric ozone layer.

Markets do not provide sufficient reward for businesses to invest in conserving or restoring natural capital. Businesses often find it unprofitable to invest in natural capital because they bear the costs but are not able to capture fully the benefits of conserving or restoring natural capital that accrue to wider society. The lack of investment results in natural capital's continued decline.

Market prices fail to internalize environmental costs, magnifying environmental harm. Business and consumers often fail to pay the full costs of producing and consuming goods and services. For example, production and use of fossil fuels causes climate change, air pollution, destruction of habitat, ocean acidification and other environmental costs that are borne by society as a whole. Failure to pay for external costs encourages overproduction and overconsumption of environmentally harmful goods and services and discourages shifts towards more environmentally friendly substitutes such as renewable energy.



Subsidies to environmentally destructive industries increase environmental degradation and its costs to people. Subsidies to fossil fuels, non-sustainable agriculture and fishing, non-renewable energy, mining and transportation exceed US$5 trillion annually. Globally, fossil fuel subsidies alone have been estimated at US$4.7 trillion (6.3 per cent of global GDP) in 2015 and are projected at US$5.2 trillion (6.5 per cent of GDP) in 2017.[29] In 2017–2019, the net transfers to the agricultural sector in 54 countries was more than US$600 billion per year.[30] These subsidies distort market outcomes and result in greater environmental degradation. Removing harmful subsidies would improve both economic and environmental outcomes.

The failure to recognize the true costs of resource use or the value of waste reduction impedes movement towards a sustainable and circular economy. Failure to include the full costs of environmentally harmful activities skews investment away from sustainable solutions that involve the restoration of nature, development of renewable energy, more efficient use of resources, the reuse of materials and other characteristics of a circular economy. In a circular economy, the by-products of production or consumption becomes the raw material for other products.[31] A circular economy eases the pressure on natural resources and reduces waste and the costs of disposal. The current economic system does not provide effective incentives to reduce resource use, reuse materials or reduce waste, thereby slowing progress towards a circular economy.

2.3 Rapidly expanding human activities are driving environmental change

Human activities are changing the Earth's ecosystems and climate and leaving a geological signature so significant that the current geological epoch may be named the Anthropocene.[I,32] These changes in the Earth system are driven by an array of underlying causes anchored in socioeconomic dynamics, the indirect drivers of environmental change, which

I See Working Group on the Anthropocene of the Subcommission on Quaternary Stratigraphy of the International Commission on Stratigraphy http://quaternary.stratigraphy.org/working-groups/anthropocene/;

are addressed in Section 2.3.1. Indirect drivers determine the way societies produce and extract resources use space, and rid themselves of waste matter. The direct drivers of environmental change are discussed in Section 2.3.2.

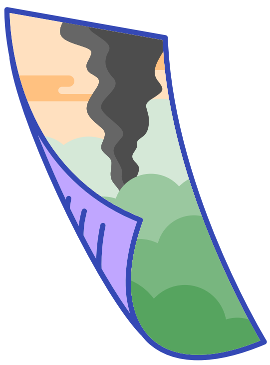
2.3.1 Resource-intensive and increasingly unequal human development indirectly drives global environmental change in ways that transcend borders and continents

Environmental change is driven by accelerating human activities that result from an array of underlying causes anchored in societal values, behaviour and governance. Indirect drivers of environmental change reflect socioeconomic dynamics, including developments in population, economy, consumption, production, equity, technology, human health, culture, conflicts, governance and behaviour. Indirect drivers interact. For example, human consumption and production patterns are perhaps the major determinants of environmental impact, and they are a function of both population and per capita income. Per capita consumption is highest in high-income segments of the world population. However, as both population and per capita consumption increase, emerging economies are increasing their consumption. As with all indirect drivers, understanding the interaction between population and per-capita consumption is key to explaining past and future consumption patterns. Indirect drivers evolve with social and economic development paths, and scenario analysis can improve the understanding of future pathways (see box 2.1). Transformation to a sustainable future rests on collectively committing to a pathway that addresses the drivers of environmental change, keeping in mind that they are subject to time lags, non-linearities and thresholds in the socioeconomic systems.

Box 2.1: The role of scenario analysis and the shared socioeconomic pathways (SSPs)

Scenario analysis can guide society's response to environmental challenges. Human-environment interactions affect human well-being, and society can deduce how environmental change is likely to increase due to time lags and the projected growth in human activities. However, future developments in environmental change and related trends in human well-being have substantial uncertainties, linked to population dynamics, economic growth and income distributions, behavioural change and technological progress. To address uncertainties and to account for the complex interrelations among their sources, the assessments explore plausible futures based on, among other methods, scenario analysis. Scenarios are plausible descriptions of how future developments might evolve, based on a coherent and internally consistent set of assumptions about the key relationships and driving forces. They can be model-based quantifications or narrative storylines and often include both. A storyline is quantified using computer models. While scenarios are not forecasts, they can inform decision makers on potential and alternative future developments on specific environmental issues or likely progress towards globally agreed environmental goals.

A widely used set of scenarios are the shared socioeconomic pathways (SSPs). The SSPs describe five alternative trajectories of future socioeconomic development with a focus on challenges to climate change mitigation and adaptation (figure 2.1). For example, SSP1 represents a sustainable and cooperative society with a low-carbon economy and high capacity to adapt to climate change, while SSP3 is characterized by social inequality that entrenches reliance on fossil fuels and limits adaptive capacity. Although developed principally to support climate research, the SSPs are also used extensively for other fields of environmental research (e.g. land, biodiversity, resource use) and in many recent assessments. It should be noted that not all environmental issues discussed in this synthesis report are addressed equally in the scenario literature and thereby the assessments. For instance, there are many scenarios published on climate change, land-use change and air pollution, while only a few scenario studies focus on land degradation and chemicals.



2.1. Shared socio economic pathways (SSPs)

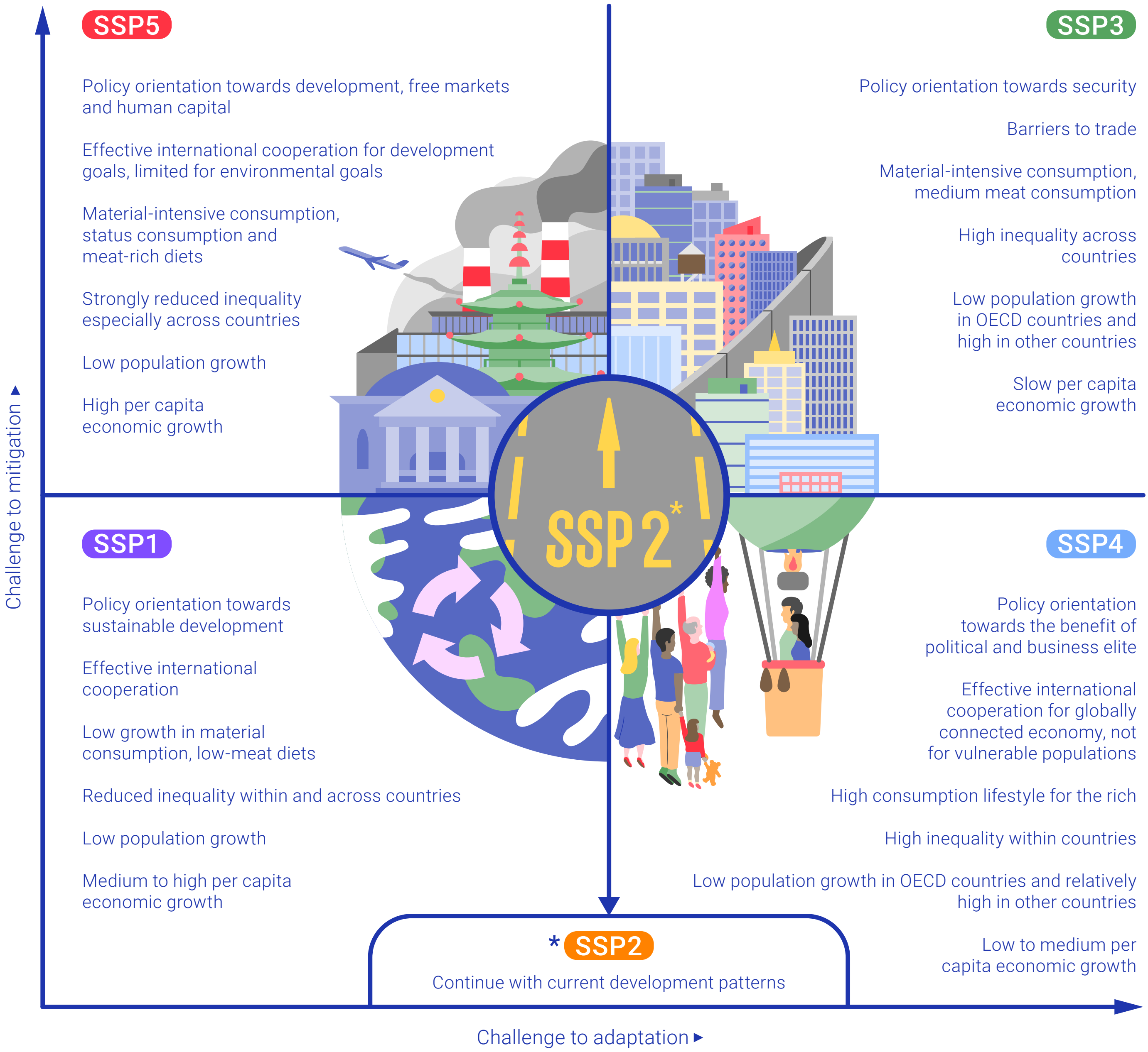


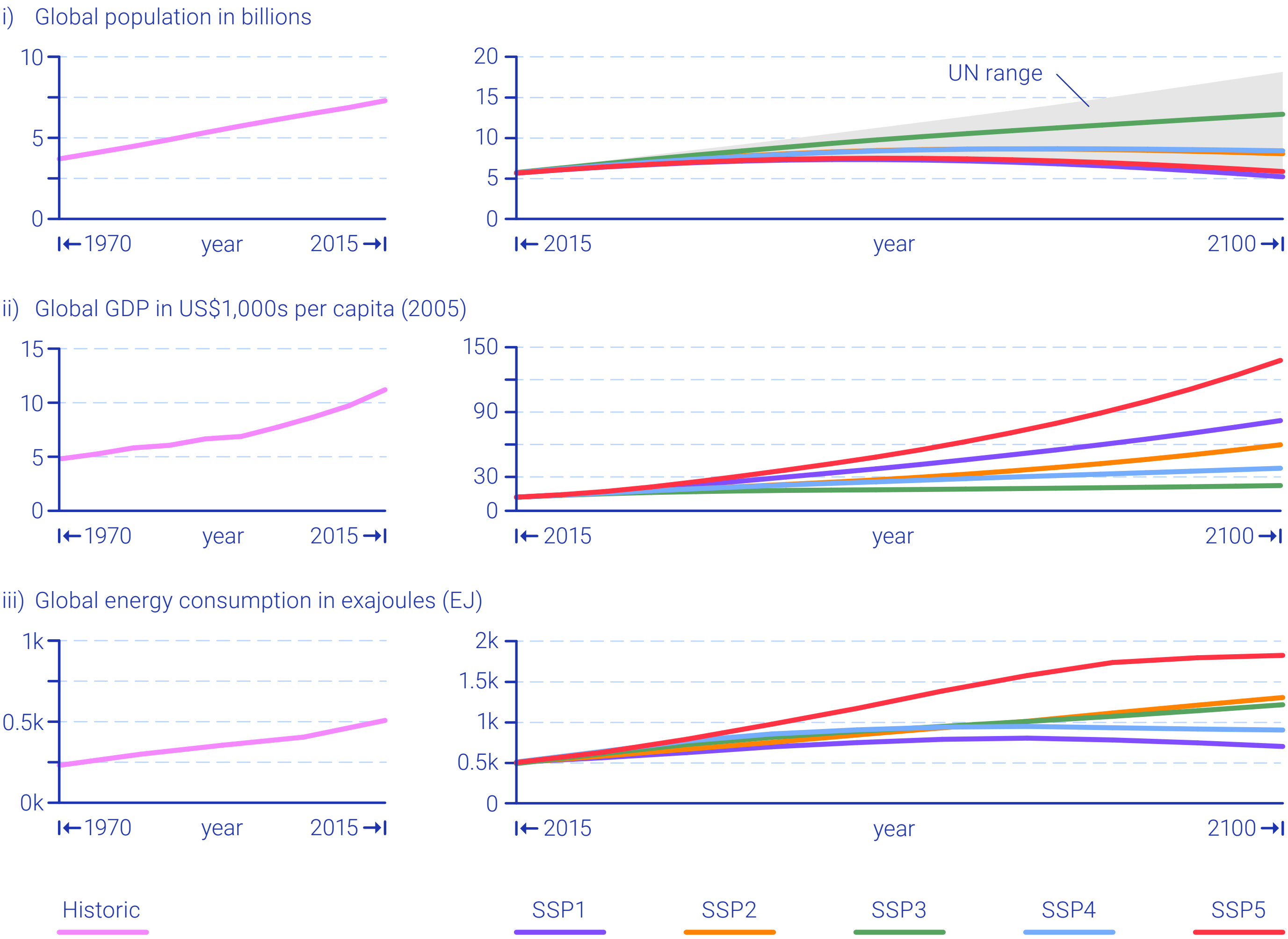
Figure 2.1: Shared socioeconomic pathways (in the figure, OECD stands for Organisation for Economic Co-operation and Development)

Source: figure adapted from O'Neill *et al.* 2017

The number of people on Earth has more than doubled over the last 50 years but the growth rate is projected to slow. The world population has grown from 3.7 billion people in 1970 to an estimated 7.8 billion in 2020 (see figure 2.2 panel a.i).[33] Although the population growth rate is projected to slow, the total population is expected to continue expanding in most regions. Based on a range of future fertility, mortality, migration and education assumptions, population projections used in existing assessments vary between 8.5 billion and 10.0 billion people by 2050 and between 6.9 billion and 12.6 billion people by 2100 (figure 2.2 panel a.i).[34,35,36,37,38,39] The largest uncertainty is the speed of the fertility transition, with low population projections resulting from a relatively rapid drop in fertility rates, though drops in fertility rates have a lag time

2.2. Development pathways in human relationship with nature

a) Past developments and future projections for different shared socio economic pathways (SSPs)



b) Declines in the Living Planet Indices

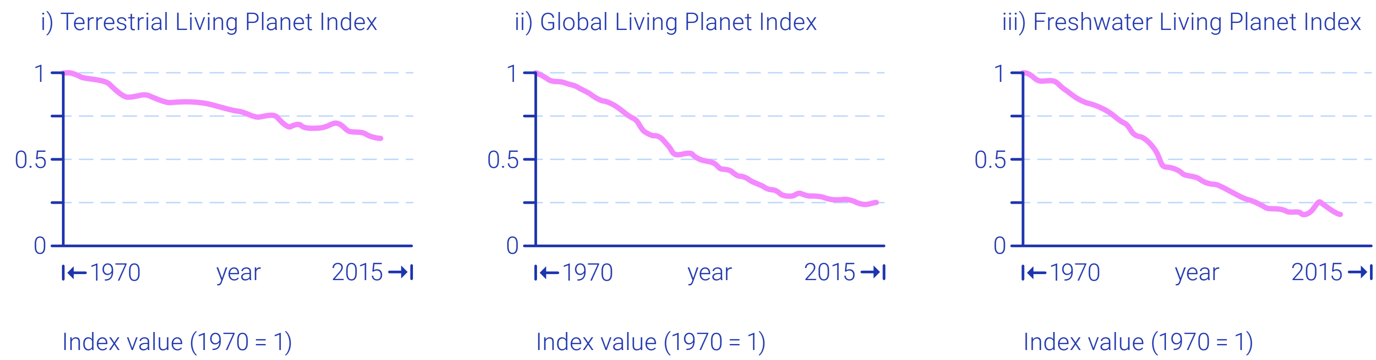


Figure 2.2 a) Past developments and future projections under different SSPs for global population, per capita GDP and energy consumption. b) Past declines in the Living Planet Index.

Data sources: a) IIASA 2018, SSPs Database, b) WWF 2020, Living Planet Report, 1

2.3. Development pathways by country income

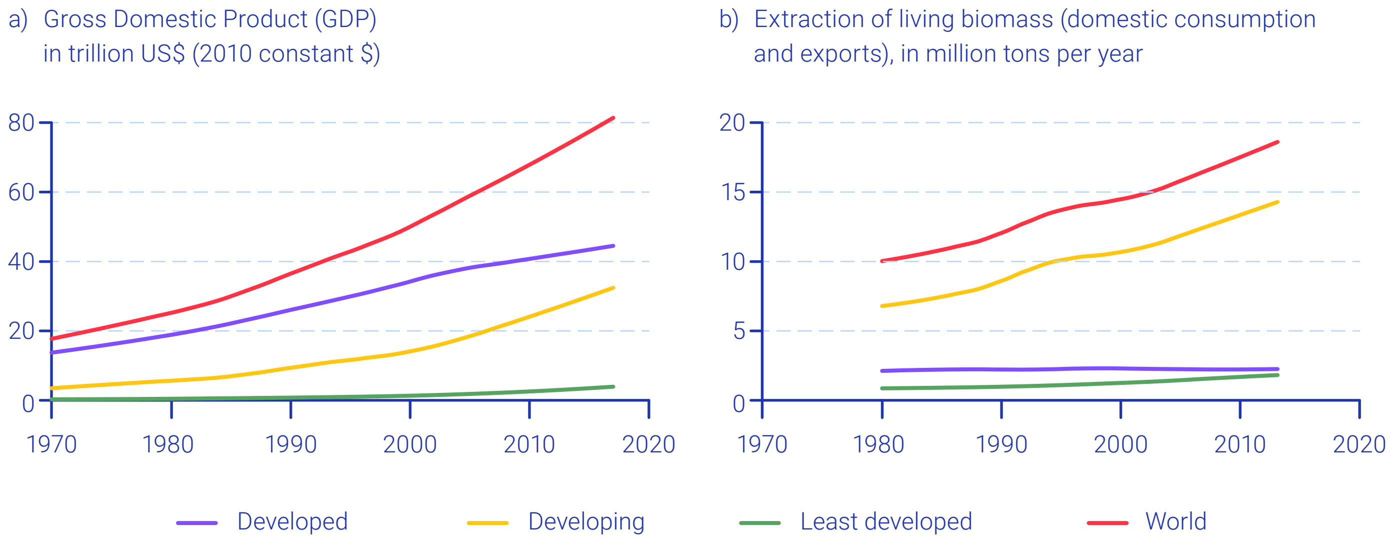


Figure 2.3: Development pathways since 1970 across developed, developing and least developed countries. The vast majority of growth in gross domestic product (GDP) have occurred in developed and developing countries (panel a) while extraction of living biomass (e.g. crops and fish) to meet the demand for domestic consumption and for export is highest in developing countries and rising rapidly (panel b). Countries are classified according to the United Nations World Economic Situation and Prospects.

Source: Figure adapted from IPBES 2019a, GA SPM, Figure SPM.4

on population growth. Towards 2050, the largest growth is projected in developing countries with low per capita carbon footprints and high gender inequity in access to education, work, and sexual and reproductive rights, for instance in Sub-Saharan Africa and South Asia. A recently published scenario study suggests that meeting the SDGs of universal secondary education and universal contraception coverage by 2030 could result in a significant slow down in population growth, resulting in a global population of between 4.8 billion and 8.7 billion people in 2100.[40] A decline in total world population in the latter half of 2100 is potentially good news for the global environment, although climate change and loss of biodiversity will still be a major challenge. Population decline and shifts in age structures also have other profound and potential negative social, economic and geopolitical consequences.[41]

Urbanization is increasing and is associated with rising energy consumption, greenhouse gas emissions, air and water pollution and generation of waste such as plastic. Since 1975, the total area of urban settlements has grown by approximately 2.5 times, accounting for 7.6 per cent of the global land area and housing 3.5 billion people in 2015. Most future population growth is projected to take place in cities. The share of people living in urban areas is projected to increase from 54 per cent in 2015 to 78 per cent in 2050. Around 90 per cent of population growth in cities is projected to take place in low-income countries, mainly in small and medium-sized cities in Sub-Saharan Africa and South Asia. Rural-urban migration is the critical factor for future urbanization trends, more important than urban fertility rates. Trends in urbanization are critical to environmental change. While more than 50 per cent of the global population live in cities, cities are responsible for around 75 per cent of all carbon dioxide emissions from energy use.[42] Climate change is expected to increase urban energy demand.[43] Unplanned urban expansion has been observed worldwide, mostly on fertile and productive lands.[44] Urban areas have generally smaller land use-related biodiversity impacts due to their limited extent compared to agriculture and forestry, but urbanization may alter consumption patterns and hence indirectly lead to additional impacts on land and biodiversity.[45] On the other hand, urbanization and infrastructure development can generate positive economic effects and even environmental gains based on efficiency, innovation and migration, depending on where and how investment is implemented and governed.

The global economy has grown nearly fivefold over the last 50 years[46] and growth is projected to continue while inequalities deepen (figure 2.3 panel a and figure 2.2 panel a.ii). Across the world, on average, people live longer, are more educated and have greater opportunities. The global Human Development Index value grew nearly 22 per cent from 1990 to 2017.[47] Still, little of the economic growth seen in developed and developing countries has benefitted least developed countries (figure 2.3 panel a). Around 1.3 billion people are still poor according to the 2020 update of the Multidimensional Poverty Index, which captures deprivations in education, health and nutrition, access to services, and security, in addition to income poverty,[48] and in 2017 nearly 700 million people still lived in extreme income poverty (on less than US$1.90 a day) (see Section 4.1).[49] In addition, these measures often mask asymmetries within households where women are often more exposed to deprivations than men.[50] The COVID-19 pandemic is projected to push more than 70 million additional people into extreme poverty, and hundreds of millions more into unemployment and poverty.[51,52,53] Furthermore, in 2019 nearly 700 million people were estimated to be undernourished, up by nearly 60 million in five years. The COVID-19 pandemic may add more than 80 million people to the total number of undernourished in the world in 2020 (see Section 4.2).[54] Resources and opportunities are far from equally distributed within the most developed countries as well as among countries.[55] Inequalities start at birth and accumulate through life in all countries. For example, a person born in a country with very high human development[56] has a 50 per cent chance of attending higher education and only a 1 per cent chance of dying before the age of 20. In contrast, someone born in a country with low human development[57] has a 17 per cent chance of dying before the age of 20 and a 1 per cent chance of attending higher education. In the five SSP scenarios, global average per capita income is projected to increase by 60 per cent to 275 per cent between 2015 and 2050, ranging between US$20,000 and more than US$50,000 per capita in 2050 (in purchasing power parity values) (see figure 2.2 panel a.ii).[58] The wide range of these projections is largely driven by alternative assumptions on human development, technological progress and development convergence between and within regions.

Consumption has tripled over the last 50 years and is projected to grow further, with developed countries having the largest environmental footprint. The quantity of materials consumed per capita when all resources mobilized globally to the final consumer is taken into account (material footprint of consumption) is highest in high-income countries. The material footprint of consumption was, in 2017, 60 per cent higher in high-income countries than in upper-middle income countries, and thirteen times the level in low-income ones (figure 2.4).[59] Extraction of living biomass (e.g. crops and fish) to meet the demand for domestic consumption and for export is highest in developing countries and rising rapidly (figure 2.3 panel b). Global demand is projected to increase faster than population growth due to a shift to more resource-intensive lifestyles fuelled by increasing per capita incomes. Between 2015 and 2050, consumption of materials (including biomass, fossil fuels, metal ores and non-metallic materials) is projected to increase by 110 per cent.[61]

2.4. Domestic material consumption and footprint by country income, 2017

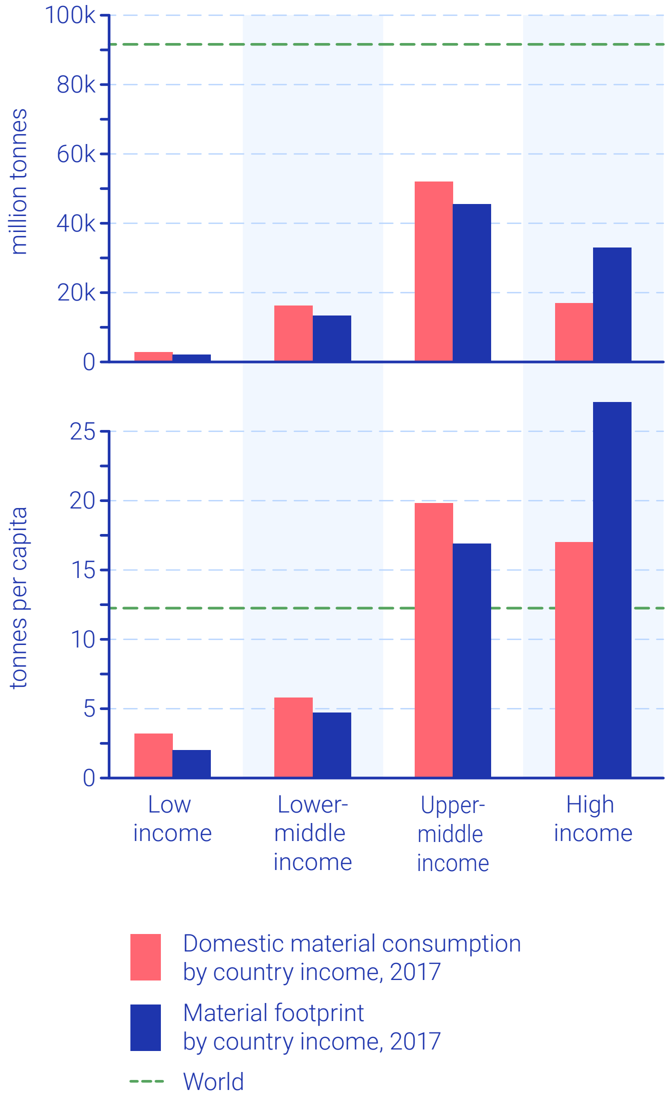


Figure 2.4: Domestic material consumption and footprint by country income (2017). Domestic material consumption measures the physical quantity of materials extracted from or imported into a nation's territory. This consumption is compared with the material footprint, which attributes all resources mobilized globally to the final consumer, according to country income. These metrics are used to monitor progress towards SDG Target 12.2, which calls for the sustainable management of natural resources, and SDG Target 8.4 concerning resource efficiency. [60]

Source: Figure adapted from IRP 2019a, GRO SPM, Figure IV

2.5. Global Primary Energy Consumption by source

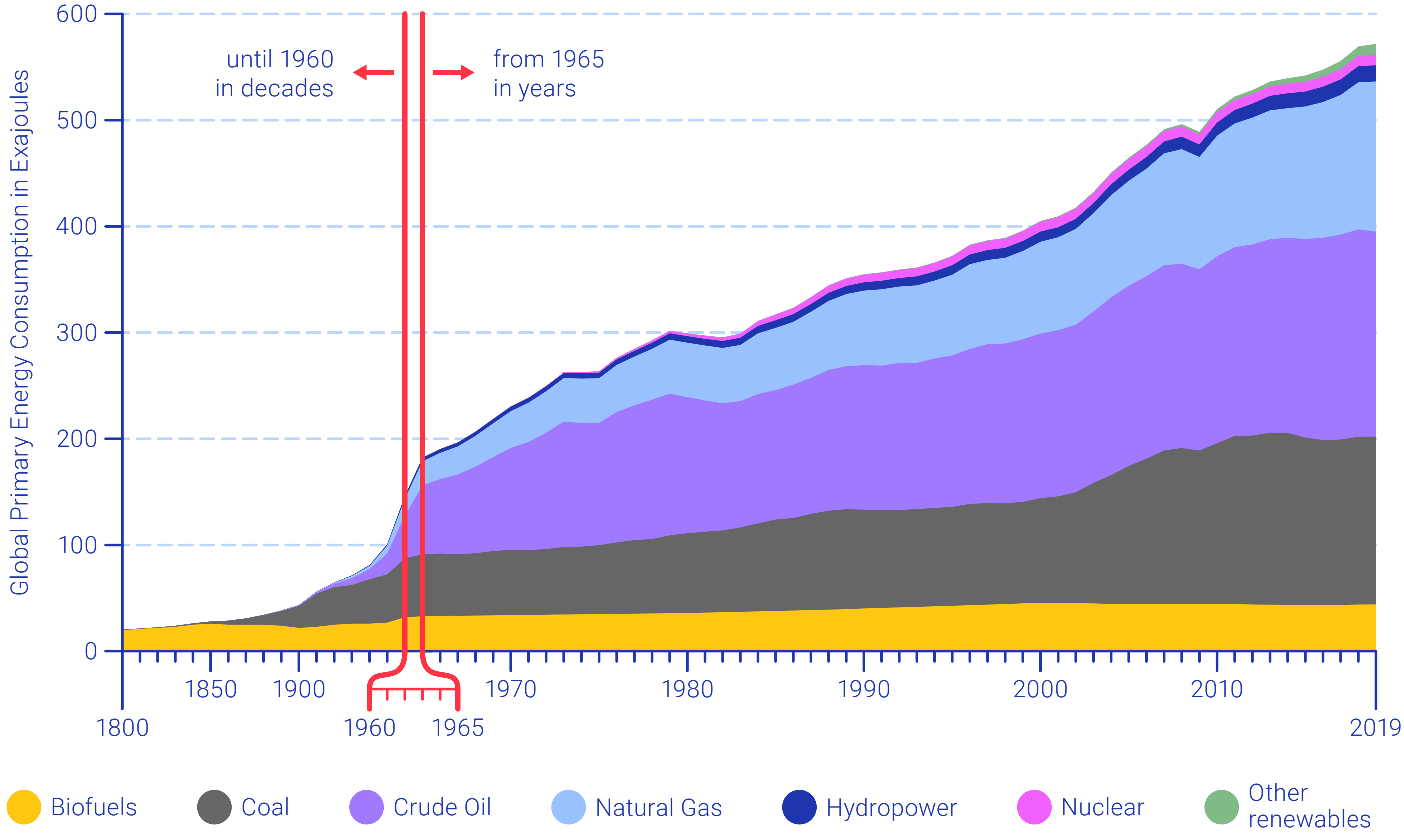


Figure 2.5: Development in global primary energy consumption by source since 1800 for biofuels (traditional and modern), coal, crude oil, natural gas, hydropower, nuclear and other renewables (wind, solar and other renewables).

Data source: Our World in Data converted from TWh to EJ

The fastest growth is projected for non-metallic materials, reflecting additional needs for buildings and infrastructure.[62] Increased material consumption is putting further pressure on an already stressed environment, as the decreases in the Living Planet Indexes indicates (see figure 2.2 panel b).

Production, marketing and consumer choices have driven changes in energy and agriculture systems involving a significant and ongoing rise in the use of natural resources. Economic growth has been fuelled by an increase in global primary energy production of more than 270 per cent over the last 50 years. While the share of renewable energy is increasing, fossil fuels are still the source of more than 80 per cent of primary energy and continue to drive climate change (figure 2.5).[63] Innovations, marketing and changes in consumer preferences shape production systems, including that for food. There has been a shift towards more meat-intensive diets and increases in material consumption among those in society who can afford it. The extent to which diets shift is a key variable in how much food is required by 2050. Between 2015 and 2050, demand for agricultural products (including wood, grass and fodder, food, feed and energy crops) is projected to increase by 30–80 per cent (SSP1-3), while primary energy demand is expected to rise by 80–130 per cent (SSP1-5) (figure 2.2 panel a.iii).[64] Future developments in demand for energy and materials are also sensitive to economic growth and structure, while agricultural demand is more directly affected by population growth.[65]

Technology can yield important efficiency gains but is not a panacea for unsustainable resource use. Technological innovation and efficiency gains can reduce the environmental footprint of human activities. For example, energy

2.6. Ratio of biomass of mammals

Figure 2.6: Estimates of the biomass of mammals on Earth, split between humans, domesticated mammals and wild mammals (the area of the circles indicates the relative biomass of each group measured in gigatons of carbon.)

Source: Bar-On *et al.* 2018

efficiency increased by an estimated 12 per cent between 2000 and 2018.[66] However, growth in consumption due to reduced cost to consumers, sometimes called the rebound effect may offset efficiency gains.[67] Structural shifts may also offset efficiency gains. Material productivity has not improved globally since the year 2000 due to structural shifts in production towards economies with low material productivity.[68] Although the assessed SSPs show some decoupling of resource use from economic output (for example, in improved energy, water and nutrient-use efficiency and increasing agricultural yields) they fall short of offsetting rising demand driven by increases in population and per capita income.[69]

Massively expanded global trade is exporting environmental footprints and distancing consumers from their impacts on the climate and biodiversity. Global trade has grown by nearly ten times in the last 50 years.[70] Ever-more distant consumers are shifting the environmental burden of consumption and production across regions.[71] Assessment of the "upstream resource requirements" of trade (that is, the additional resources used in the country of origin for producing traded goods but left behind as wastes and emissions) reveals that resource-intensive processes have shifted from high-income importing countries to low-income exporting countries, with a corresponding shift in associated environmental burdens.[72]

2.3.2 Increases in resource use and waste generation drive global environmental change

Human-caused direct drivers of environmental change are now a dominant force shaping the Earth. To satisfy growing demands, people use an ever-increasing fraction of the Earth's land, freshwater and oceans for the production and extraction of food, fibre, energy and minerals as well as for industrial facilities, infrastructure and settlements. Humans and farm animals have become the dominant species among all mammals on Earth. One estimate of the combined biomass[II] of mammals on Earth shows that the human population constitutes about a third and livestock nearly two thirds, while wild mammals, from whales to mice, amount to

II Biomass measured in gigatons of carbon

2.7. Global use of ice-free land around year 2015

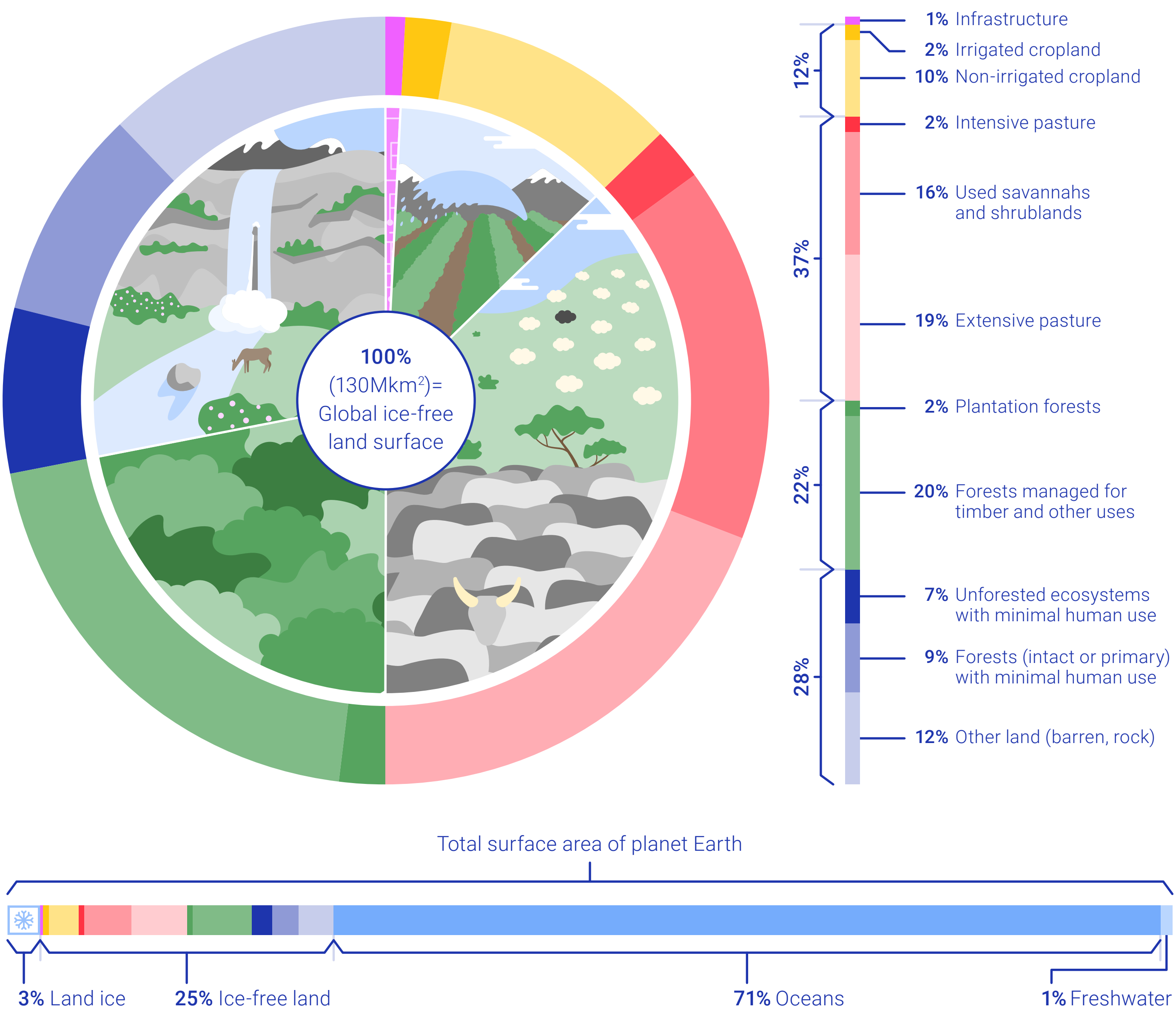


Figure 2.7: Global use of ice-free land around year 2015 for different categories of use ordered by decreasing land-use intensity clockwise from the top.
Source: Figure adapted from IPCC 2019b, SRCCL SPM, Figure SPM.1

less than 5 per cent (figure 2.6).[73] Society's use of resources results in the release of greenhouse gases and pollutants, including nutrients and chemicals as well as household, industrial and human waste. In addition, people modify life and move organisms, both intentionally, to achieve benefits such as increased food production, and unintentionally.

Human transformation of landscapes and seascapes drives biodiversity loss, climate change and degradation of land, freshwater and oceans. Close to three quarters of ice-free land and two thirds of the oceans are significantly impacted by people.[74] Food production occupies half of the habitable land on Earth[75] (figure 2.7). Increasing agricultural extent

2.8. Global greenhouse gas emissions from all sources

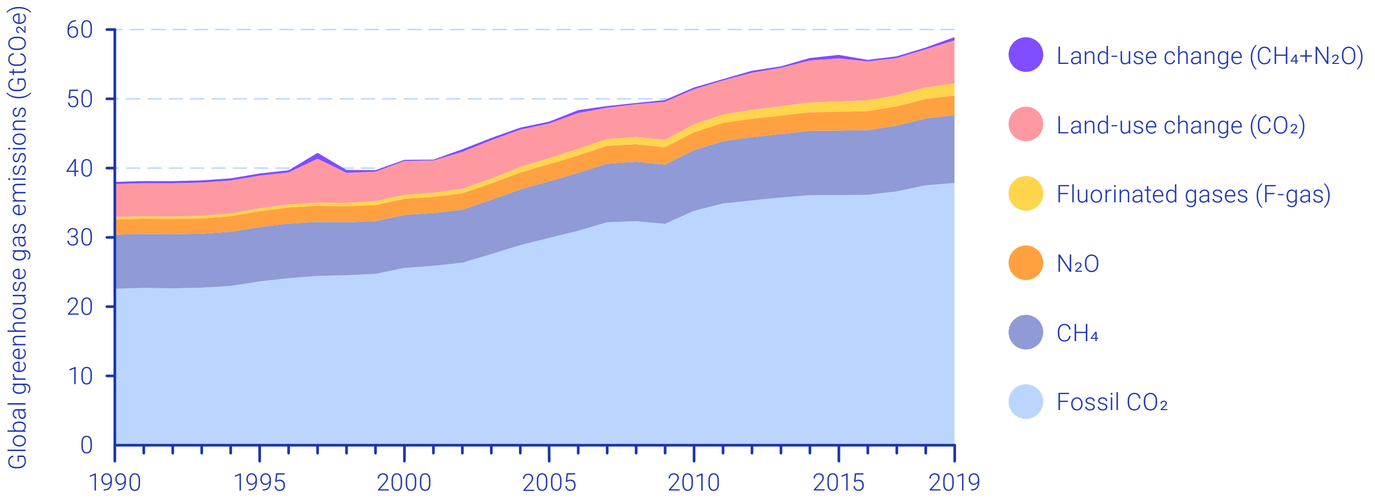


Figure 2.8: Global greenhouse gas emissions from all sources from 1990 to 2019. (CH_4 Methane, CO_2 Carbon Dioxide, N_2O Nitrous Oxide)
Source: UNEP 2020a, EGR, Figure ES.1

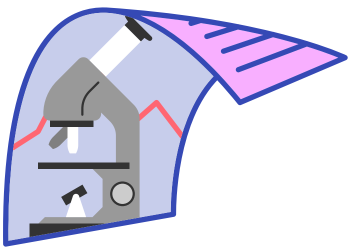
converts natural habitats, resulting in a loss of biodiversity and carbon sinks, while agricultural intensification typically uses more inputs, often with adverse impacts on soil and water quality and on biodiversity. Half of all agricultural expansion from 1980 to 2000 occurred at the expense of forests, primarily in the tropics, partly to accommodate cattle ranching and palm oil production.[76] The world's forests constitute nearly a third of Earth's land area, and about 10 per cent of forest area has been lost through conversions to other land uses since 1990, though the deforestation rate is decreasing.[77] Satellite imaging shows that human pressures reduced intact forest landscapes by 7 per cent globally from 2000 to 2013.[78] More than two thirds of the remaining forests are either managed or plantation. Land is also converted for infrastructure and mining. Urban areas have more than doubled since 1992.[79] Land use change is ranked the most important direct driver of land degradation and loss of biodiversity on land,[80] as well as the most important driver impacting freshwaters (see figure 3.1). An estimated 23 per cent of total anthropogenic greenhouse gas emissions (2007–2016) stem from agriculture, forestry and other forms of land use, including carbon dioxide emissions from deforestation, methane emissions from ruminants and rice cultivation, and nitrous oxide emissions from fertilizer use.[81] In the oceans, which covers 70 per cent of the planet, human use of seascapes is ranked the second most important driver of biodiversity loss (see figure 3.1).[82] Indigenous peoples' land, which is less impacted than other lands, includes approximately 35 per cent of all remaining terrestrial areas with very low human intervention.[83]

Extraction of natural resources has more than tripled and extraction of living biomass has doubled over the last 40 years (figure 2.3 panel b). One third of fish stocks globally were overharvested in 2015, up from 10 per cent of stocks in 1974. Another 60 per cent are fished at the limit of sustainability. Just 7 per cent are harvested at levels below the maximum sustainable yield.[84,85] Agricultural crop production has increased by about 300 per cent since 1970. However, 25–30 per cent of total food produced is currently lost or wasted.[86] Agriculture accounts for nearly three quarters of all freshwater use,[87] and water withdrawals, predominantly for irrigated agriculture, grew by nearly 65 per cent from 1970 to 2010.[88] Resource extraction is ranked the second most important driver of biodiversity loss in freshwater (see figure 3.1).[89] Between 1970 and 2017, mining of metal ores increased by three and a half times and mining for sand, gravel and clay increased by nearly five times. Raw timber production has risen by 45 per cent. Approximately 60 billion tons of renewable and non-renewable resources are now extracted globally every year, having nearly doubled since 1980.[90] Resource extraction often happens in combination with use of land and seascapes, and related emissions and waste can drive climate change and pollution.

Human emissions of heat-trapping greenhouse gases drive climate change. Emissions of greenhouse gases, in particular, carbon dioxide, methane and nitrous oxide, as a result of human activities have continuously increased since the industrial revolution. Greenhouse gas emissions grew 1.5 per cent per year in the last decade (2009 to 2018), excluding emissions resulting from land-use change, and 1.3 per cent per year including land use-related emissions (figure 2.8). Atmospheric concentrations of greenhouse gases have reached levels much higher than at any time in the last 800,000 years. Emissions of carbon dioxide from fossil fuels and industrial processes accounted for nearly 80 per cent of the total anthropogenic increase in emissions in carbon dioxide equivalents from 1970 to 2010. Carbon dioxide from these sources contributes two thirds of the warming caused by anthropogenic greenhouse gas emissions.[91] About one quarter of the warming stems from greenhouse gas emissions from agriculture, forestry and other forms of land use. Land use (mostly agriculture) and land-use change is associated with 13 per cent of carbon dioxide emissions, 44 per cent of methane emissions and 82 per cent of nitrous oxide emissions.[92] Natural sinks today are only able to absorb around half of all carbon dioxide emissions, more or less equally split between terrestrial ecosystems and the ocean. Increased uptake of carbon dioxide is causing harmful ocean acidification.[93,94] In order to limit warming to well below 2°C, net global emissions from human activities need to reach zero or even become negative by the middle of the century.[95]

Disposal, release and leaks of chemicals, nutrients and waste are driving environmental declines, especially in aquatic ecosystems. Pollution is regarded as the third most important driver of biodiversity loss in freshwater and the fourth in terrestrial and marine systems (see figure 3.1). Up to 400 million tons of heavy metals, solvents, toxic sludge and other industrial wastes are dumped annually into the world's waters, and fertilizers entering coastal ecosystems have produced dead zones.[96] Marine plastic pollution has increased tenfold since 1980, constituting 60 to 80 per cent of marine debris, and is found in all oceans at all depths and concentrates in the ocean currents. Marine plastics cause ecological impacts from entanglement and ingestion and can also act as a vector for invasive species and pollutants.[97,98,99] There has been a near-doubling of the global chemical industry's production capacity between 2000 and 2017. Air pollution (indoor and ambient), pathogen-polluted drinking water and inadequate sanitation currently causes millions of premature deaths per year, as discussed in Section 4.[100] Pollutants like black carbon (soot) also act as short-lived forcers to climate change,[101] while some halogenated gases both deplete the stratospheric ozone layer and act as greenhouse gases (see Section 3.7).

Animal and plant domestication, gene technology and the spread of invasive alien species alters biodiversity. Domestication and human selection, sometimes over centuries or millennia, have created a large variety of plants and animals used by humans that are highly adapted to local conditions. The number of local varieties and breeds of domesticated plants and animals and their wild relatives has, however, been reduced sharply as a result of land use change, selective breeding for increased productivity, knowledge loss, market dynamics and large-scale trade.[102,103] Gene technology has opened up new ways of altering the traits of microorganisms, plants and animals to boost production or improve tolerance of pests, heat and drought, but its application could potentially have negative effects on human health, food production and the environment unless managed carefully.[104] The spread of invasive species is the fifth most important direct driver of biodiversity loss (figure 3.1). Cumulative records of alien species have increased by 40 per cent since 1980 and are associated with increased trade. Nearly one fifth of Earth's surface is at risk of plant and animal invasions.[105] More rapid spread of infectious diseases, partially caused by the expanding range of vectors such as mosquitos, or the transmission of zoonotic diseases such as COVID-19, is a threat to human health (see box 4.4).



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9 IPBES 2019b, GA, 2
10 IPBES 2019b, GA, 2
11 IPBES 2019a, GA SPM, A1
12 IPCC 2019a, SROCC SPM, A5, A6
13 IPCC 2019a, SROCC SPM, A2.5
14 IPCC 2019b, SRCCL SPM, Figure 1
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24 UNEP 2018, IWR, Figure 1.8a, ES Box 1
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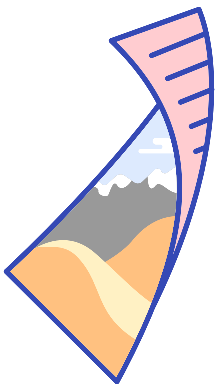
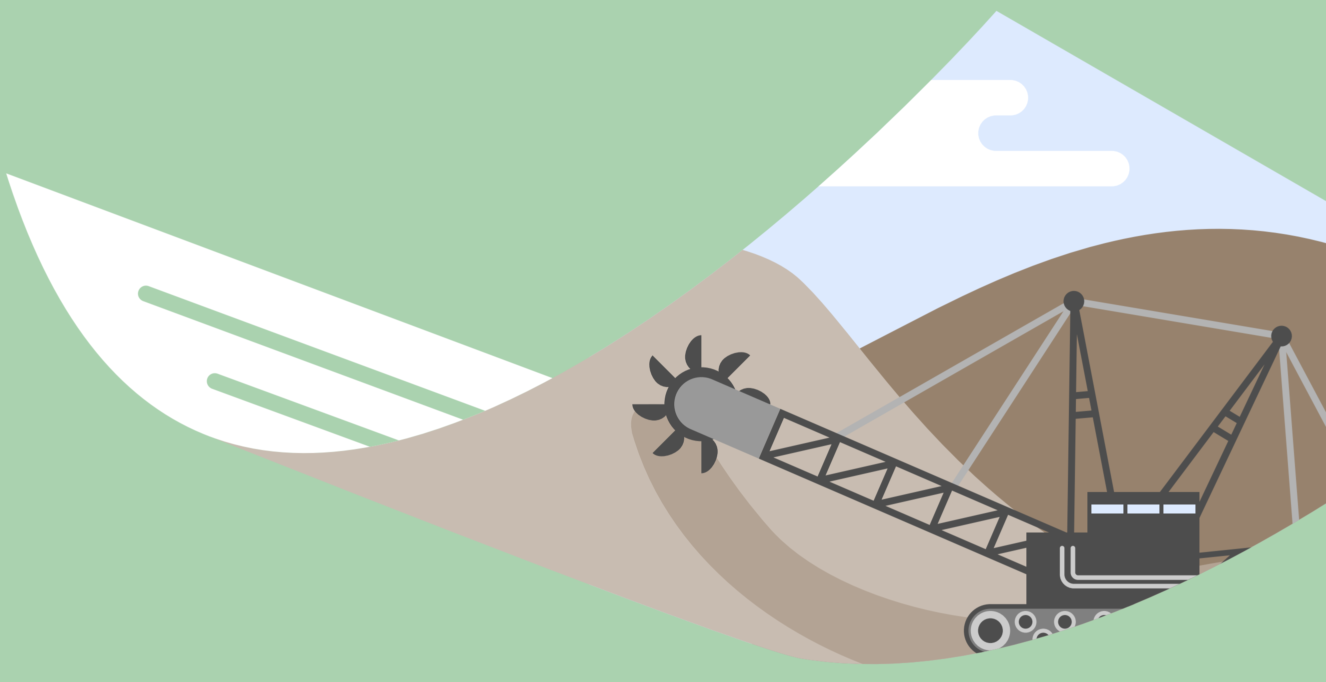




3

Society is failing to meet most of its commitments to limit environmental damage

This section examines the state of the Earth from six perspectives, each relating to a cluster of international agreements: climate change; biodiversity loss; land degradation; air pollution; chemicals in the biosphere; and the depletion of stratospheric ozone. It demonstrates how society is failing to meet most of the internationally agreed environmental and sustainable development goals and targets relating to these topics. It concludes with a subsection showing how these major environmental challenges are linked to one another, and therefore why their collective solution requires a coordinated approach.

The future is not entirely bleak. Multilateral cooperation and actions by individual nations, industries and households have yielded positive results, albeit insufficient to date. In general, these successes are not keeping pace with the growing negative ecological consequences of expanding human activities. If humanity continues on this path, the environment will keep changing for the worse, and this decline will contribute to conflicts, a reduction in the quality of human life and deteriorating prospects for most other lifeforms on the planet.

Almost all of the Earth system and human system processes involved in the dramatic changes observed over the past century contain time lags of years to centuries. This imparts an inertia to the changes observed and reinforces the urgency with which people must act. There is a high risk that systems will cross thresholds beyond which change accelerates and becomes effectively impossible to reverse.

3.1 Society is not on course to fulfil the Paris Agreement to limit global warming

Human activities have already caused the Earth's surface to warm by more than 1°C since the industrial period of 1850–1900.[1,2] Warming substantially greater than the global average is being experienced in most land regions: up to twice as large for hot extremes in mid-latitudes and more than three times larger in the cold season in the Arctic.[3] The increased atmospheric warming has led to more frequent and intense heavy precipitation events at global scale, but also to an increase in the frequency and intensity of droughts in some regions.[4,5] The additional warming has also led to Arctic sea ice retreat, permafrost thaw, and to melting of glaciers and ice sheets, which together with the thermal expansion of the oceans, have resulted in accelerating sea level rise.[6] Non-climatic drivers such as land subsidence, partly human-caused, have also played an important role in increasing vulnerability to sea level rise. Human-induced climate change has led to increases in the intensity and frequency of many extreme events, in particular hot extremes in all land regions, heavy precipitation in several regions and droughts in some regions.[7,8] In many regions, changing patterns of precipitation and the melting of snow and ice are altering the volume and seasonal timing of water flows in rivers, affecting both the quantity and quality of water resources, and the potential occurrence of peak flow events. Climate zones are shifting, including expansion of arid zones and contraction of polar zones.[9]

The heat-trapping effect of atmospheric greenhouse gases will persist for centuries to millennia,[10] **and the resultant continued increase in global temperature will have large adverse consequences.** There is inertia in the climate system. While some changes in the natural system, such as ocean acidification, can be detected almost immediately and can be clearly attributed to anthropogenic influence, other effects, such as sea level rise, will gradually but inexorably reveal themselves over the next several centuries. They are equally attributable to climate change, but the connection is less obvious to non-scientific observers because of the delay. Ice loss from the Greenland and Antarctic ice sheets is already contributing to sea level rise.[11] The unstable retreat of some Antarctic and Greenland glaciers may further accelerate sea level rise,[12] possibly abruptly. Mass loss from the Greenland Ice Sheet could be irreversible in the foreseeable future.[13] Risks of biodiversity loss and extinction increase greatly both for terrestrial and marine species as warming increases, with large increases for warming levels between 1.5 and 2°C (see Section 3.2) and further increases in risk beyond 2°C warming. Ocean warming, acidification and deoxygenation, permafrost degradation, and the extinction of species are phenomena that are highly relevant to human societies and ecosystem integrity but are effectively irreversible on century time scales.[14,15] Other effects, such as marine heatwaves and the retreat of Arctic sea ice, may be reversible over a period of decades to centuries (table 6.1) if the drivers of warming are reversed. Widespread disappearance of Arctic near-surface permafrost is projected to occur this century, 2–66 per cent of the area is at risk under low emission scenarios, and 30–99 per cent under high emission scenarios, releasing as much as 240 gigatonnes of carbon to the atmosphere, further accelerating climate change. Permafrost melting dries out the soil in some places, results in flooding in other places, and causes damage to infrastructure.[16]

Rising concern about the climate has led to the Paris Agreement and other international accords to curb greenhouse gas emissions. The United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992,[17] led to the Kyoto Protocol in 1997,[18] the first coordinated attempt to limit greenhouse gas emissions. The subsequent Paris Agreement of 2015 was the result of several years of intensive international efforts to reach an agreement between all countries on limiting climate change. It includes the aim of "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels." In the light of different national circumstances, the Paris Agreement calls for "rapid reductions" of emissions to be achieved "on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."[19] The connections between eradicating poverty and reducing inequality and addressing climate change are embedded in the sustainable development goals (SDGs, see Section 4).

Despite growing awareness and alarm about climate change, greenhouse gas emissions have continued to rise. Emissions of greenhouse gases increased from the equivalent of around 30 gigatonnes of carbon dioxide ($GtCO_2e$) in 1970 to around 55 $GtCO_2e$ in 2019.[20] In the absence of vigorous mitigation measures and policies, most projections show further increases in greenhouse gas emissions in the future, driven by increasing fossil fuel use, land-use changes and other human activities.

If society continues on its current emissions pathway, it will miss the target of keeping warming to well below 2°C, let alone that of stabilizing global warming at 1.5°C, and be on course for warming of more than 3°C. Taken together, the national climate mitigation pledges (known as Nationally Determined Contributions) made to date fall far short of the reductions needed to achieve the goals set under the Paris Agreement. Current pledges are more consistent with scenarios that lead to a warming well in excess of 3°C by the latter part of the century.[21] Many countries are failing to achieve even the modest emissions reductions goals they set for themselves.[22] Unless major emissions reductions are achieved by 2030, any chance of stabilizing global warming at 1.5°C will be lost.[23] Typical scenarios aimed at holding warming well below 2°C or even to 1.5°C typically show a 25–50 per cent reduction compared to 2010 (see also Section 6.1).[24] Scenarios in which warming temporarily exceeds the Paris Agreement goals around mid-century before falling rapidly depend heavily on the development of carbon dioxide removal technologies, whose ability to capture and store carbon dioxide at scale is as yet unproven and could lead to unintended negative impacts on biodiversity and food production.[25,26]

In 2020, greenhouse gas emissions have shown a temporary drop as a result of the COVID-19 crisis. Carbon dioxide emissions could decrease by about 7 per cent in 2020 (range 2–12 per cent) compared with 2019 emission levels due to COVID-19, with a smaller drop expected in overall emissions as other greenhouse gases are likely to be less affected. However, atmospheric concentrations of greenhouse gases continue to rise. Studies indicate that the biggest changes have occurred in transport, as some COVID-19 restrictions were targeted to limit mobility, though reductions have also occurred in other sectors.[27] Long-term impacts on emissions are uncertain. The stimulus packages announced by governments to support economic recovery may have a strong impact on long-term emissions, leading to either lower emissions (if investments are combined with decarbonization strategies) or higher emissions (if investments are mostly made in greenhouse gas-intensive technologies).

Climate change amplifies existing risks and creates new risks for natural and human systems. [28,29,30,31,32,33] Restricting global warming to 1.5°C with no or limited overshoot avoids many additional risks compared to a stabilization at 2°C, including reducing the risk of some irreversible impacts.[34] At 2°C of warming and higher, the likelihood and magnitude of impacts rises steeply. For example, substantial further increases in hot temperature extremes in most inhabited land regions are projected at global warming of 2°C or more compared to warming of 1.5°C.[35] There would also be further increases in heavy precipitation in several regions, and a higher probability of drought and precipitation deficits in some regions.[36] Global mean sea level rise is projected to be around 10 centimetres less by the end of the twenty-first century in a 1.5°C warmer world compared to a 2°C warmer world. The probability of a sea ice-free Arctic Ocean during summer is substantially higher at 2°C compared to 1.5°C of global warming. The risks to ocean and terrestrial ecosystems, including the number of species at risk of accelerated extinction, increase more than proportionally to the change in global mean temperature; at 2°C, the number of species at risk is more than 30 per cent higher than for 1.5°C, and higher temperature increases further magnify the threats (see Sections 3.2 and 3.7).

3.2 None of the goals for the protection of life on Earth have been fully met

Worldwide, biodiversity continues to decline at an alarming and accelerating rate. The absolute abundance of wild organisms has decreased over the past half-century, typically by about half across many groups, including birds, mammals and insects. Hotspots of rare and endemic species, which account for a disproportionate fraction of global biodiversity, have on average suffered greater declines in ecosystem structure and biotic integrity than other areas. The global rate of species extinction is already at least tens to hundreds of times higher than the average rate over the past 10 million years and is accelerating. Over 1 million of the estimated 8 million plant and animal species on Earth are at substantially increased risk of extinction in the coming decades and centuries as a direct or indirect consequence of human activities. Only a quarter of their original habitat is largely still functioning in a semi-natural way, and more than a third of terrestrial global plant production is now appropriated by humans for their own use and the use of domesticated species.[37] Climate change exacerbates other threats to biodiversity (see Section 3.7). Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to climate change, and this trend will continue.[38] Half of all warm-water coral reefs have already been lost due to such combined effects.[39] A third of marine fish stocks have declined as a consequence of overharvesting.[40] Fertilisers entering coastal ecosystems have produced more than 400 ocean "dead zones" with a total area greater than 245,000 km² – more than the land area of the United Kingdom.[41] Widespread changes in organismal traits and reductions in genetic diversity are also evident. The diversity of organisms is in decline in both natural and managed environments (such as agricultural landscapes), with negative consequences for their productivity and resilience in the face of stress. The world's major ecosystems vary in both the intensity of the change-inducing factors they face and their ability to withstand them. Some, including arctic ecosystems and tropical coral reefs, are thought to be close to collapse in the form of large-scale regime shifts.[42]

3.1. Relative global impact of direct drivers on major ecosystems

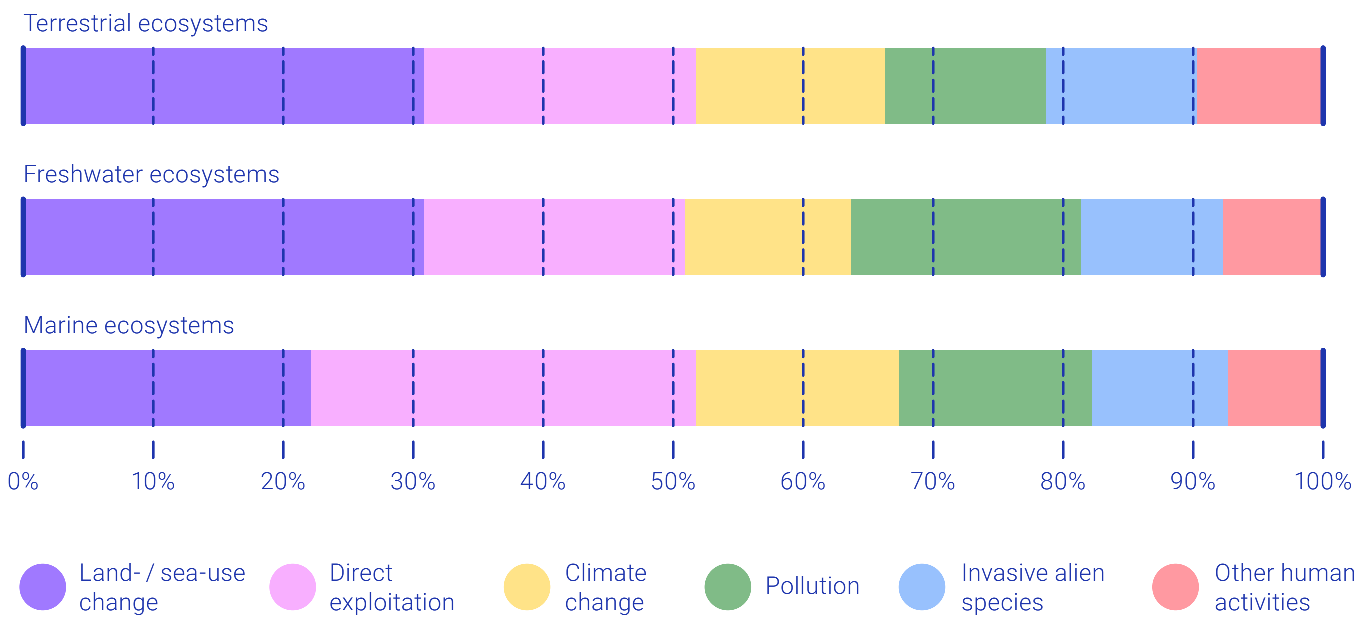


Figure 3.1: Relative global impact of direct drivers on major ecosystems, ranking the past and current causes of declines in biodiversity.
Source: IPBES 2019a, GA SPM, Figure SPM.2

3.2. Assessment of progress towards the Aichi Biodiversity Targets

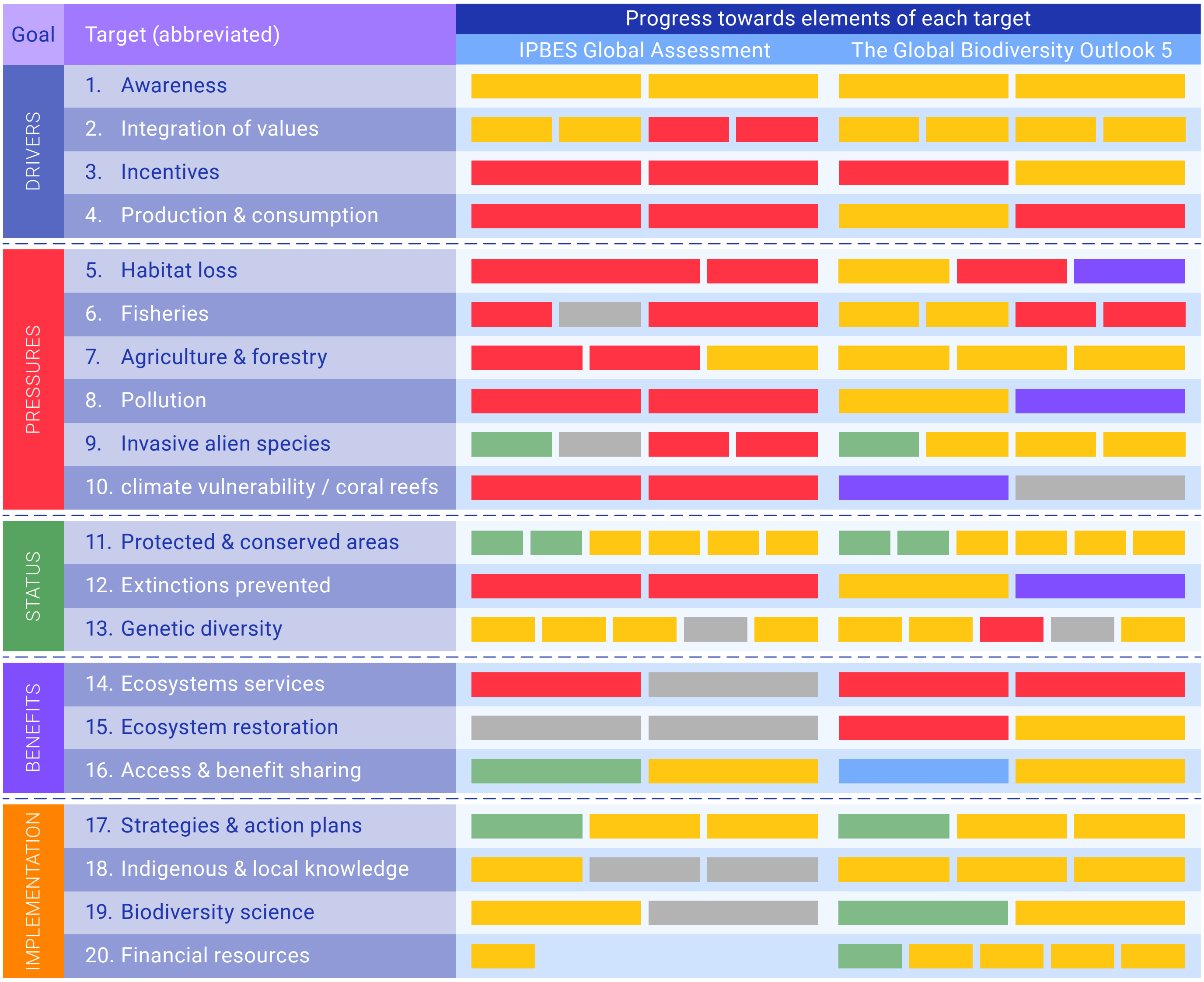


Figure 3.2: A summary of the assessments of progress towards the 20 Aichi Biodiversity Targets and the elements contained in their formulations by the IPBES Global Assessment and the Global Biodiversity Outlook 5. Each segment represents an element of the target. Blue indicates that the element has been exceeded (not used by IPBES), green indicates good progress and that the element has been or is likely to be achieved by 2020, yellow indicates that moderate progress has been made towards the element but that it has not been achieved, red indicates poor progress or no significant change in the element, and purple indicates that the trends are moving away from achieving the element (not used by IPBES). In cases where the element could not be assessed due to insufficient information, the segment is grey. In the left hand column: "Drivers" refers to Strategic Goal A on underlying causes of biodiversity loss; "Pressures" refers to Strategic Goal B on the direct pressures on biodiversity; "Status" refers to Strategic Goal C on improving the status of biodiversity; "Benefits" refers to Strategic Goal D on enhancing benefits from biodiversity; and "Implementation" refers to Strategic Goal E on enhancing implementation.

Source: IPBES 2019a, GA SPM, Figure SPM.6; CBD 2020a, GBO-5 SPM

None of the goals in the international agreements intended to slow the rate of biodiversity loss have been fully met, including those in the strategic plan for biodiversity 2011–2020 and its Aichi Biodiversity Targets. Across six international agreements[43] whose objectives include slowing or reversing biodiversity loss, only one in five of the strategic objectives and goals are on track to be achieved. Nearly a third of the goals are not being met or in some cases even becoming further out of reach.[44] For example, none of the targets agreed under the CBD in 2010 (known as the "Aichi Biodiversity Targets") were fully met by the target deadline of 2020. One assessment of progress found partial progress in just four of the 20 targets.[45] A subsequent assessment that also took into account reports by countries implementing the targets concluded that six of the targets were partially achieved[46] (see figure 3.2). Areas of progress included increases in the proportion of land and oceans designated as protected areas and improved international financial flows to developing countries. Little or no progress has been made on others, including the elimination of harmful subsidies.[47] Both analyses show that there has been moderate or poor progress for most of the targets aimed at addressing the causes of biodiversity loss (see figure 3.1). As a result, the state of biodiversity overall continues to decline. Even though conservation actions have likely reduced the number of species becoming extinct by between two and four times, the number of species threatened with extinction continues to increase. There has been moderate or poor progress on maintaining genetic diversity of cultivated plants and their wild relatives, restoring ecosystem services and no progress overall in enhancing carbon storage. Some progress has been made in adopting policy responses and actions including raising awareness of the value of biodiversity, sharing benefits equitably, developing national action plans, and improving scientific understanding of the causes and consequences of biodiversity loss.[48]

Lag times and system feedbacks mean that species can be committed to premature extinction decades before the last individuals actually die and that there is a high likelihood that ecosystem thresholds will be crossed, with large and negative consequences. It is estimated that more than half a million terrestrial species have insufficient habitat for their long-term survival, and are committed to early extinction, many within decades, unless their habitats are restored.[49] Deforestation could cross critical thresholds of fragmentation and area loss that undermine forest ecological integrity and ultimately human well-being.[50] Once the world is committed to warming greater than 2–3°C, most warm-water coral reefs will die, boreal forests will not reproduce, and ice-dependent ecosystems (such as permafrost, glacier-fed and seasonal coastal ice sheets) face collapse. Coral reefs are already dying as a result of a warmer world, whereas it will take many decades to see a significant reduction in the area of boreal forests (although leading indicators such as fire and diseases already show change), and centuries to millennia to see a complete destruction of ice-dependent ecosystems.[51,52]

Biodiversity and the benefits it provides are set to decline further because of continued climate and land-use change. Most scenarios project ongoing and often accelerating loss of biodiversity (see figure 3.3) and of many of the regulating and cultural services it supports, largely due to projected changes in climate and continued changes in land use.[53]

3.3 The world is not on course to halt land degradation

Ongoing changes in land use are inevitable due to evolving human needs and the effects of climate change, but they need not, in aggregate, lead to further degradation of a finite but essential resource. To recognize this point while still aiming to halt and then reverse land degradation, the concept of "land degradation neutrality" has been proposed by the UNCCD and is a target in SDG 15. It means that for every hectare newly degraded, a hectare of equal value somewhere else is restored from past degradation.[54]

In 2020, less than a quarter of the global land surface still functions in a nearly natural way, with its biodiversity largely intact. This quarter is mostly located in dry, cold, or mountainous areas, and thus far has a low human population and has undergone little transformation. It also includes much of the terrestrial protected area network, currently covering 15 per cent of the land area. Of the remaining three quarters, a third (i.e. a quarter of the total land surface) has been radically transformed from its natural state. The original ecosystem has been replaced by croplands, plantations, planted pastures, infrastructure such as roads, railways, dams, canalized rivers, human settlements, industrial developments, waste dumps or active or abandoned mining lands. The rate of this transformation has accelerated since the middle of the twentieth century. The other two thirds (i.e. half of the total global land area) retains some level of natural processes and biodiversity but is strongly and increasingly human-dominated. It includes the rangelands of the world that are grazed mostly by domesticated livestock, the semi-natural forests from which wood and other products are harvested, and the freshwater systems where flows are altered by water use.[55] Land degradation has reduced productivity in more than 20 per cent of the global terrestrial area.[56,57] Wetlands are the most transformed and degraded ecosystem type. They have lost about 85 per cent of their area and much of their function.[58]

Although land degradation is ubiquitous, its large and persistent impacts are only now being appreciated. Degradation occurs everywhere in the world, to varying degrees and in many forms, all of which compromise human well-being (see figure 3.4). The economic impact is large, and billions of lives are affected (see Section 4). However, land degradation has been present for so long, and in so many places, that it has often come to be thought of as the natural state or is conceived as an inevitable consequence of progress. The absence of an agreed global definition has

3.3. Projected loss of biodiversity between 2015 and 2050

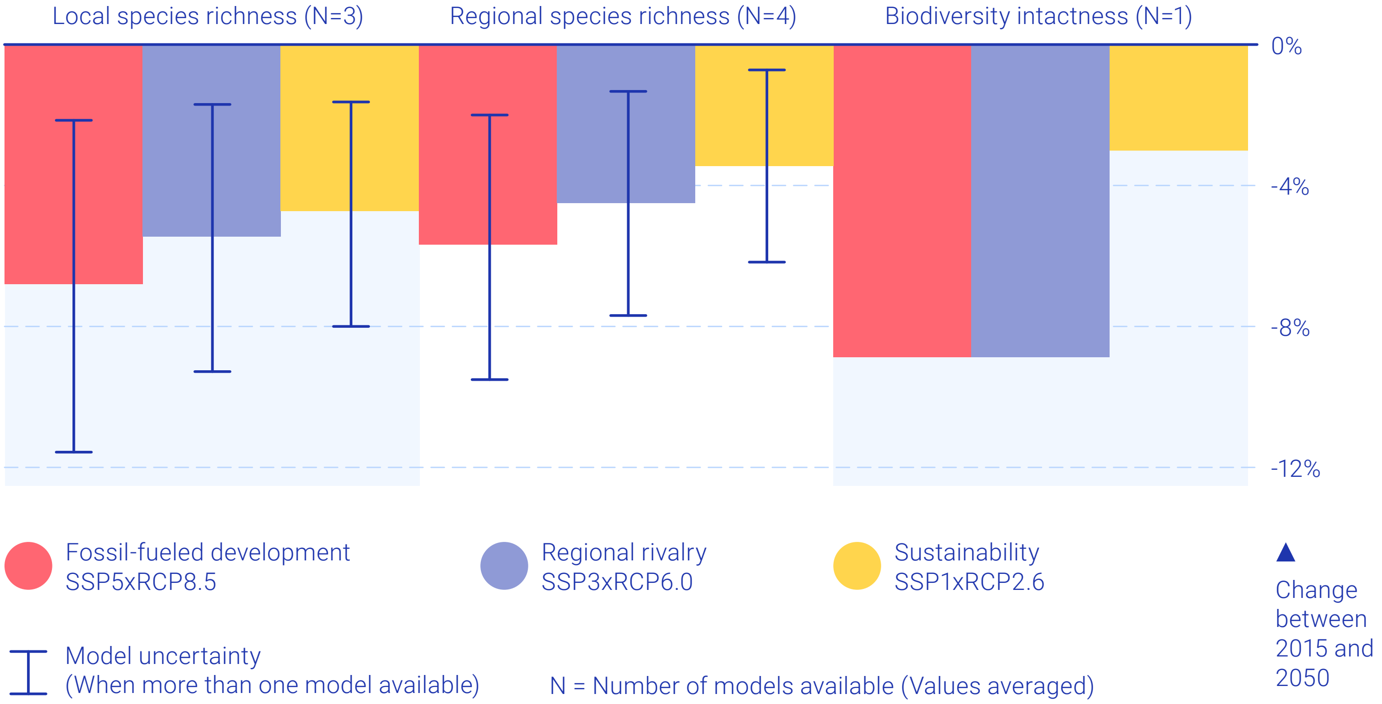


Figure 3.3: Projected loss of Biodiversity between 2015 and 2050 under three different emissions scenarios .

Source: Figure adapted from IPBES 2019b, GA, Figure 4.2.14

been an impediment to quantification of the issue (see box 3.1),[59] but in the past decade there has been a convergence on definitions that can be applied to all terrestrial and freshwater ecosystems, based on a long-term reduction in the capacity of the affected ecosystems to deliver benefits to people, now and in the future. Some definitions also include an accompanying reduction in the diversity, abundance, or health of nature. Of particular concern is degradation where ecological processes have been impaired to the point that the ecosystem is no longer able to recover – unaided, fully and in a reasonable time – once the causes of degradation have been alleviated.[60]

Box 3.1 Teasing apart land degradation and land transformation

A useful distinction is between land transformation and land degradation.[61] *Transformation may be legal or illegal, but it is usually intentional. The ecosystem is deliberately altered for the purpose of increasing the delivery of a particular benefit, or set of benefits to a group of people, often at the expense of other benefits, and almost always with a loss of biodiversity. For instance, a diverse, self-regenerating natural forest may be converted to a managed tree plantation, or a grassland into a cropland. In the developed world, transformation often occurred centuries ago, and is often assumed to be the natural and desired state. In the present time, active transformation is more visible in the developing world, where it attracts much attention, unfairly in the opinion of people living there, since they are following a well-trodden development path. Degradation, on the other hand, is the loss of ecosystem function, in either transformed or natural lands, as a consequence of human actions. It is usually unintentional. The loss of ecological function leads to a reduced (or less reliable) flow of benefits to people, frequently including even the benefits for which the ecosystem was being managed. Degradation, like transformation, is typically accompanied by loss of biodiversity. Degradation is widespread and ongoing (even accelerating) in both the developed and developing world.*[62] *Rehabilitation aims to reverse degradation, but not necessarily to reverse transformation. Restoration, which aims to return both function and biodiversity to some previous state before transformation occurred, is harder to achieve and takes much longer.*

3.4. Land degradation world maps

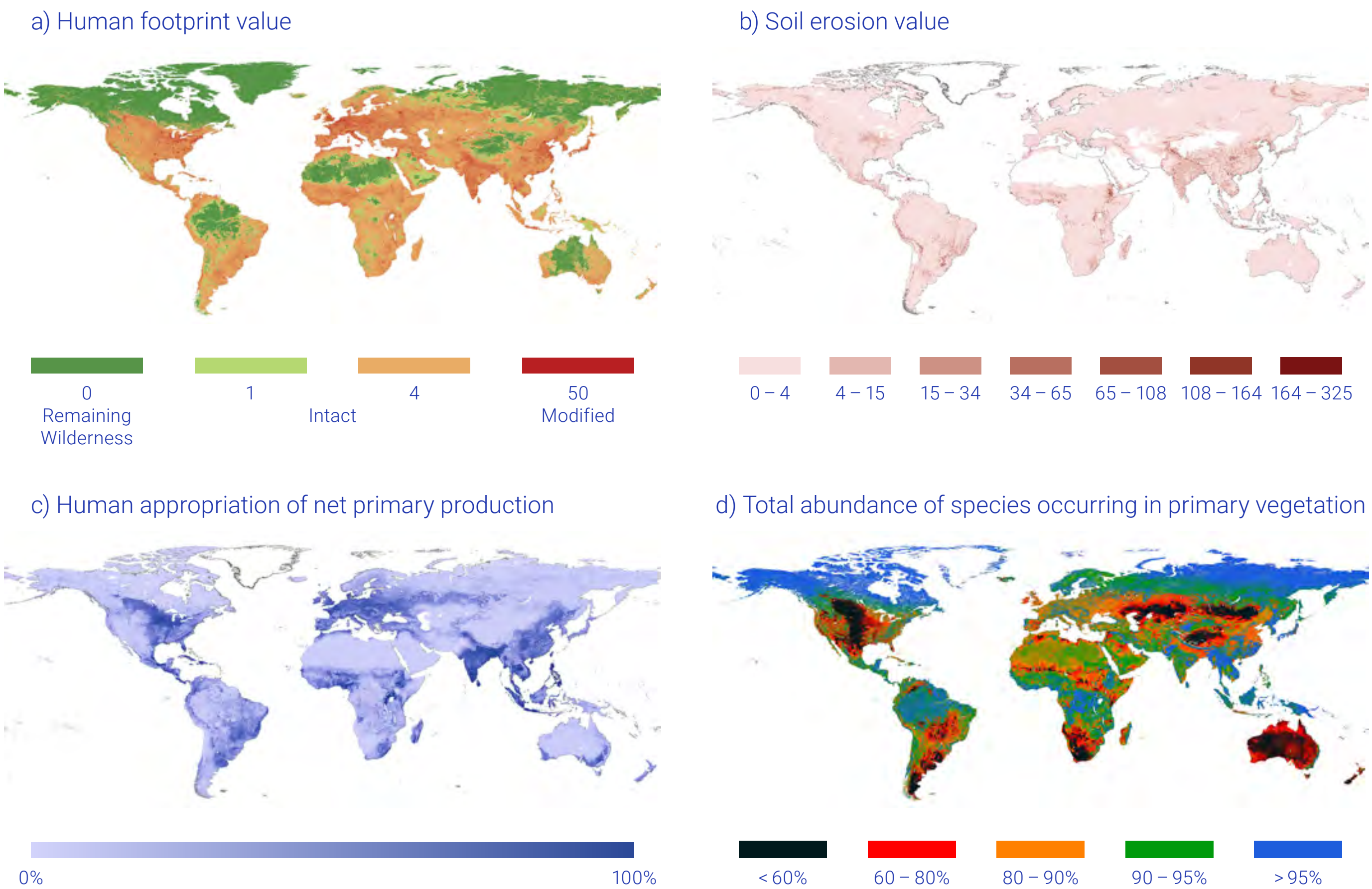


Figure 3.4: Human activities have modified the land surface of the planet as shown through the human footprint value indicating the intactness of terrestrial ecosystems (panel a) the soil erosion value (panel b), the human appropriation of net primary production (panel c) and the total abundance of originally occurring species as a percentage of their total abundance in minimally disturbed primary vegetation, expressed as the Biodiversity Intactness Index (panel d).

Data sources: a) Brooke, *et al.* (2020), b) Borrelli *et al.* (2007), c) Newbold *et al.* (2016), d) Haberl *et al.* (2007)

Data compiled and plotted by Emily Zhang

Land degradation and transformation contributed around a quarter of greenhouse gas emissions in the last decade. Over half of these emissions derive from land transformation (particularly deforestation) and most of the remainder from the loss of soil carbon in cultivated land. Halting land transformation and degradation could contribute 6.6 (range 2–11) GtCO$_2$e per year to greenhouse gas emission reductions between 2020 and 2050, and land restoration-related activities[63] could contribute a further 18.6 (range 1.8–35.5) GtCO$_2$e per year over the same period, while simultaneously restoring ecological function and ecosystem services, and in some cases, biodiversity (see section 5).[64,65,66]

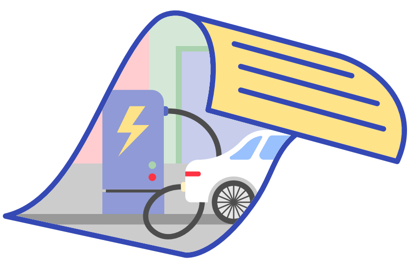
The issue of land degradation is recognized as a global concern, but the approaches to addressing it have been inadequate and fragmented. The UNCCD specifically addresses degradation in drylands. There is no single convention to protect forests, but several treaties address aspects of forest degradation, including the CBD, the UNFCCC, the International Tropical Timber Agreement and some of the rules of the World Trade Organization. Wetlands of international importance are protected under the Ramsar Convention. Sustainable Development Goal 15 (Life on Land) sets out to halt and reverse land degradation by 2030. This builds on the concept of land degradation neutrality, adopted by the UNCCD in 2015, also for achievement by 2030. These constitute the first comprehensive global targets relating to land degradation. There have been other implicit or explicit targets relating to particular aspects of degradation, such as combatting desertification, or soil degradation, or wetland loss. Many countries have national targets related to preventing or reversing land degradation, but in aggregate they have not been sufficient to meet international goals.

Despite the agreed goal of halting land degradation, land degradation is projected to increase in the twenty-first century under all development scenarios (see Section 4).[67] Under scenarios where slowing land transformation is not a priority, the fraction of land remaining in a near-natural state is projected to be as little as 10 per cent by mid-century, while degraded land will reach over 20 per cent. The pace of land degradation depends strongly on the outcome of efforts to mitigate climate change (see Section 3.7). In particular, under scenarios where mitigation actions are weak and slow, degradation in arid lands and polar regions is projected to accelerate. Land-based climate mitigation actions can, if targeted at rehabilitation of degraded lands, achieve both climate and land restoration objectives, but the availability and productive potential of such lands is insufficient to supply more than a small part of the net carbon uptake needed by mid-century. If inappropriately applied, for instance by afforestation of lands not previously forested, or by reforestation using monocultures of species not native to the area under restoration, the co-benefits to land restoration will not be achieved, and net biodiversity harm could result.[68]

3.4 Air pollution is not sufficiently reduced to protect human well-being

Air pollution is the biggest environmental risk factor contributing to the global burden of disease.[69,70] From a health perspective, the most important air pollutants are ground-level ozone and particulate matter,[71] both of which can also act as short-lived climate forcers. An estimated 90 per cent of the world's population lives in an area where annual average outdoor concentrations of the pollutant PM2.5 (fine particulate matter with a diameter of 2.5 micrometres or less) exceeds WHO air quality guidelines.[72,73] Urban areas typically have high levels of pollution; of the 45 megacities with measurements in 2013, only four met the WHO guidelines for PM2.5.[74] Projected increases in urbanization have the potential to negatively impact on local and regional air quality.

Nature contributes to the regulation of air quality but can be degraded in the process.[75] Nature improves air quality through the retention and detoxification of pollutants, though these processes (such as acidic deposition) affect terrestrial and aquatic ecosystems negatively.[76] Loss of biodiversity and ecosystem function, resulting from air pollution and other drivers such as land degradation and climate change, may compromise nature's contributions to moderating air pollution.[77,78,79] Ecosystems can also be sources of pollutants, such as from biomass burning, dust, biogenic volatile organic compounds, and nitrogen emissions, as well as ammonia and methane that contribute to secondary pollutants. These contribute interactively to ambient air pollution and many act as short-lived climate forcers.[80,81,82,83,84,85] Nature also helps prevent emissions of air pollutants, for instance in the way that vegetation modulates dust emissions from soil.[86] Climate-related factors interacting with land-use and land cover changes in many dryland areas have over the last few decades resulted in increased frequency and intensity of dust storms with negative impacts on air quality and human health.[87] The increased occurrence of wildfires as a result of climate change will negatively impact air quality and thus represent a growing health risk.[88] Natural or human-induced increases in the production and release of airborne allergens (pollen or fungal spores) and consequent upsurges in allergy-related respiratory ill health can make people more susceptible to air pollution impacts.[89] Releases of hazardous chemicals from environmental reservoirs such as soil, water and ice due to increasing temperatures are also projected to increase exposures and vulnerabilities for both people and ecosystems.[90]



While there is no global agreement on limiting air pollution, international targets, regional agreements and national policies[91,92,93] aim to decrease air pollution and its negative impacts. The international targets with a bearing on air pollution are SDGs 3.9, 7.1 and 11.6 and Aichi Biodiversity Target 8. The Montreal Protocol and the Paris Agreement also impact air pollution; their implementation will affect air quality, both directly through changes in emissions and atmospheric chemistry, and indirectly by mitigating climate change and its subsequent impacts on air quality.[94,95] The United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution (CLRTAP)[96] is an example of a successful regional agreement that has led to marked improvements in air quality. In Europe, the abatement of pollutant emissions under CLRTAP has helped to increase average life expectancy by 12 months and decreased the exceedance of critical loads (i.e. the exposure ecosystems can sustain without being degraded) for acidification by a factor of 30 and nitrogen by a factor of three.[97]

Progress on reducing air pollution is mixed, with air quality improving in high-income countries but continuing to degrade in low-income countries.[98,99,100,101,102,103] Globally, health impacts from exposure to ambient PM2.5 and ozone, and household PM2.5 have decreased significantly (by about 25 per cent) between 2006 and 2016.[104,105] However, these trends are highly variable from place to place.[106,107,108,109,110] For example, North America and Europe have seen decreases of about 75 per cent in sulphur dioxide emissions (which contribute to ambient sulphur dioxide concentrations and particulate matter pollution) since 1990, while increases have been seen elsewhere, including of 50 per cent in Asia.[111] The regional differences in progress towards targets are striking and cause for concern. Quantifying these trends in middle- and low-income countries is greatly hindered by lack of data. Large data gaps for quantifying and characterizing air pollution and its impacts can be addressed through actions that expand the knowledge base as well as improve monitoring and reporting; these include improving emission inventories, increasing sampling coverage of a range of pollutants and impacts, as well as improving availability and accessibility of data and information.[112,113]

While air pollution levels are impacted by activities in many sectors, action to decrease emissions in the energy sector is critical to achieve air quality targets.[114] Energy production and use is the main source of anthropogenic emissions for many pollutants, accounting for 85 per cent of primary PM emissions and almost all of the emissions of sulphur dioxide and nitrogen oxides.[115] Air quality related SDG targets will not be fully met with current energy policies alone, but rather a transformation of the energy sector is needed.[116,117] As air quality has linkages across sectors, more holistic and integrated assessments are needed to develop policies and interventions that avoid potential unintended trade-offs. [118,119,120]

3.5 Chemicals and waste are not always managed safely

A wide range of hazardous human-produced chemicals are accumulating in the biosphere, in the environment in which humans live, and in the human food chain, which adversely affect ecosystems and human health. The production and use of chemicals are increasing (see figure 3.5). Hazardous and toxic chemicals have adverse effects on terrestrial and aquatic life. Large quantities of human-manufactured chemicals continue to be released to the air, water and soil. In many parts of the world, emissions and releases of hazardous chemicals are increasing. Not only do these emissions pose risks to human health and the environment, they also represent lost opportunities to realize economic benefits from repurposing the waste stream. Significant progress has been made in reducing releases of some chemicals of concern, including ozone-depleting substances (see Section 3.6) and some persistent organic pollutants. Global warming leads to the remobilization of some pollutants such as persistent organic pollutants due to melting glaciers and thawing permafrost. Atmospheric long-range transport of pollutants is responsible for their occurrence in remote areas. Supply chains involving trans- or inter-continental shipping of hazardous chemicals potentially increase the risk of their accidental release into the environment.[121]

The Millennium Development Goals set in 2002 to minimize the adverse impacts of chemicals and waste by 2020 will not be achieved. Solutions exist (see Section 5), but more ambitious worldwide action by all stakeholders is urgently required. There has been good progress in addressing the legacy of persistent organic pollutants, such as the pesticide DDT, under the Stockholm Convention, where a global monitoring programme has been in place for more than 10 years. The levels and trends of selected persistent organic pollutants in air and mother's milk are monitored around the globe. On several continents there has been a reduction in concentration of a range of persistent organic pollutants of high concern, even in remote areas. The levels of contaminants newly added to this convention, such as brominated and fluorinated chemicals, have not yet shown a decline. The results of the monitoring programme suggest that targeted regulations, including those that predated the convention in some regions, are working to reduce levels of

3.5. Chemical Intensification 1955 – 2015

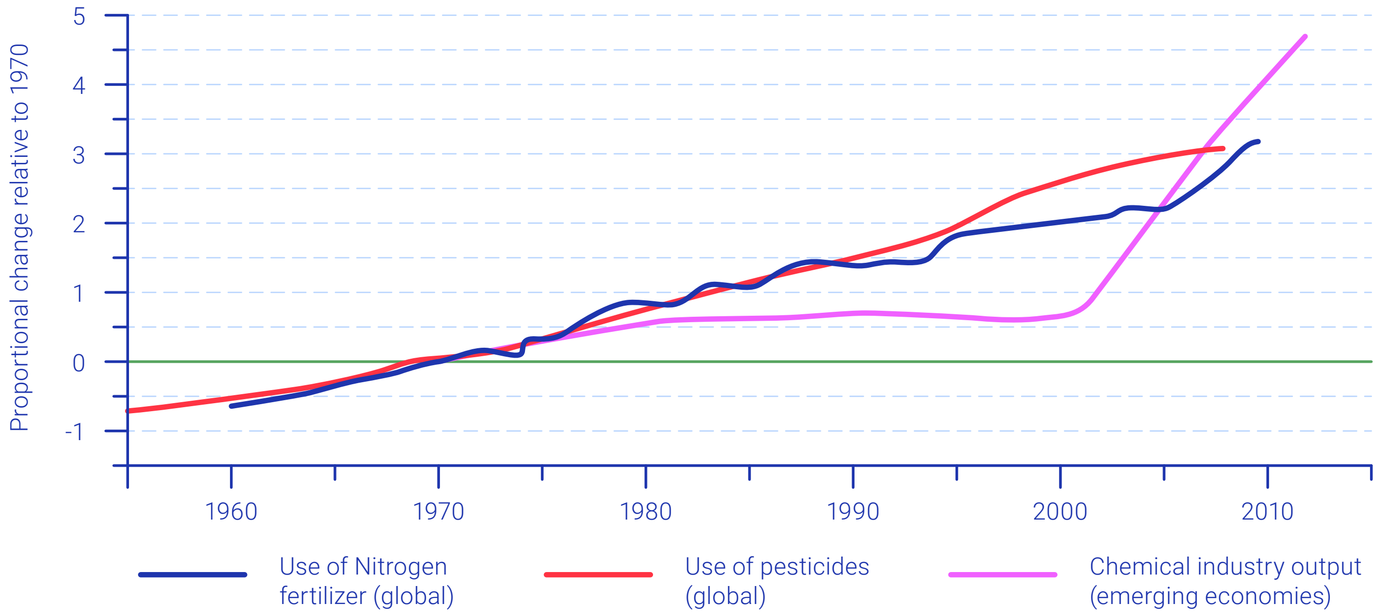


Figure 3.5: Examples of growth in the global use of chemicals and in the output of the chemical industry in emerging economies in the period 1955–2015
Source: Figure adapted from UNEP 2019a, GEO-6, Figure 4.4

persistent organic pollutants in the environment and in human populations. Effective regulatory actions at the global level since the entry into force of the Convention in 2004, particularly for listed persistent organic pollutants that are still commercially available, are expected to lower environmental concentrations in the long term.[122,123]

Chemical-related multilateral agreements have improved the management of the whole life cycle of chemicals. Agreements including the Rotterdam, Stockholm and Basel Conventions address the life cycle of chemicals, including their sources, commerce (use), transport, and disposal. The Minamata Convention on mercury covers the entire life cycle of mercury and mercury-added products. A multi-stakeholder voluntary agreement known as the Strategic Approach to International Chemicals Management (SAICM) addresses emerging policy issues and other concerns in global chemicals management such as: lead in paint; chemicals in products; hazardous substances within the life cycle of electrical and electronic products; nanotechnology and manufactured nanomaterials; endocrine-disrupting chemicals; environmentally persistent pharmaceutical pollutants; perfluorinated chemicals and the transition to safer alternatives; and highly hazardous pesticides. Work to strengthen the science-policy interface and prepare recommendations regarding the Strategic Approach and the sound management of chemicals and waste beyond 2020 are still ongoing.[124]

3.6 Strong international coordinated action is restoring Earth‘s protective ozone layer

Human-made chemicals have caused the depletion of the ozone layer in the stratosphere, exposing people and other organisms to harmful ultraviolet radiation. The reduction in the concentration of ozone in the stratosphere, first detected in the late 1980s, is directly due to the release of human-made chemical compounds including chlorofluorocarbons (CFCs) and bromine-containing halons. The impact of these ozone-depleting substances is manifest as an ozone “hole” above Antarctica and a thinning of the ozone layer in the Arctic and in mid-latitudes. This has increased the amount of ultraviolet radiation reaching the Earth’s surface, which is harmful to both people and other organisms.

Concern about the threat to the ozone layer prompted pioneering scientific research, assessments and international agreements to address a complex global environmental problem. Meetings of international experts beginning in 1979[125] produced the first of a series of in-depth scientific assessments of ozone depletion.[126] With the threat identified, UNEP formed an expert working group to develop a framework to protect the ozone layer. The resulting Vienna Convention for the Protection of the Ozone Layer was adopted by 21 countries in March 1985.[127] This Convention called for Parties to take measures to protect human health and the

3.6. Milestones in the History of Stratospheric Ozone Depletion

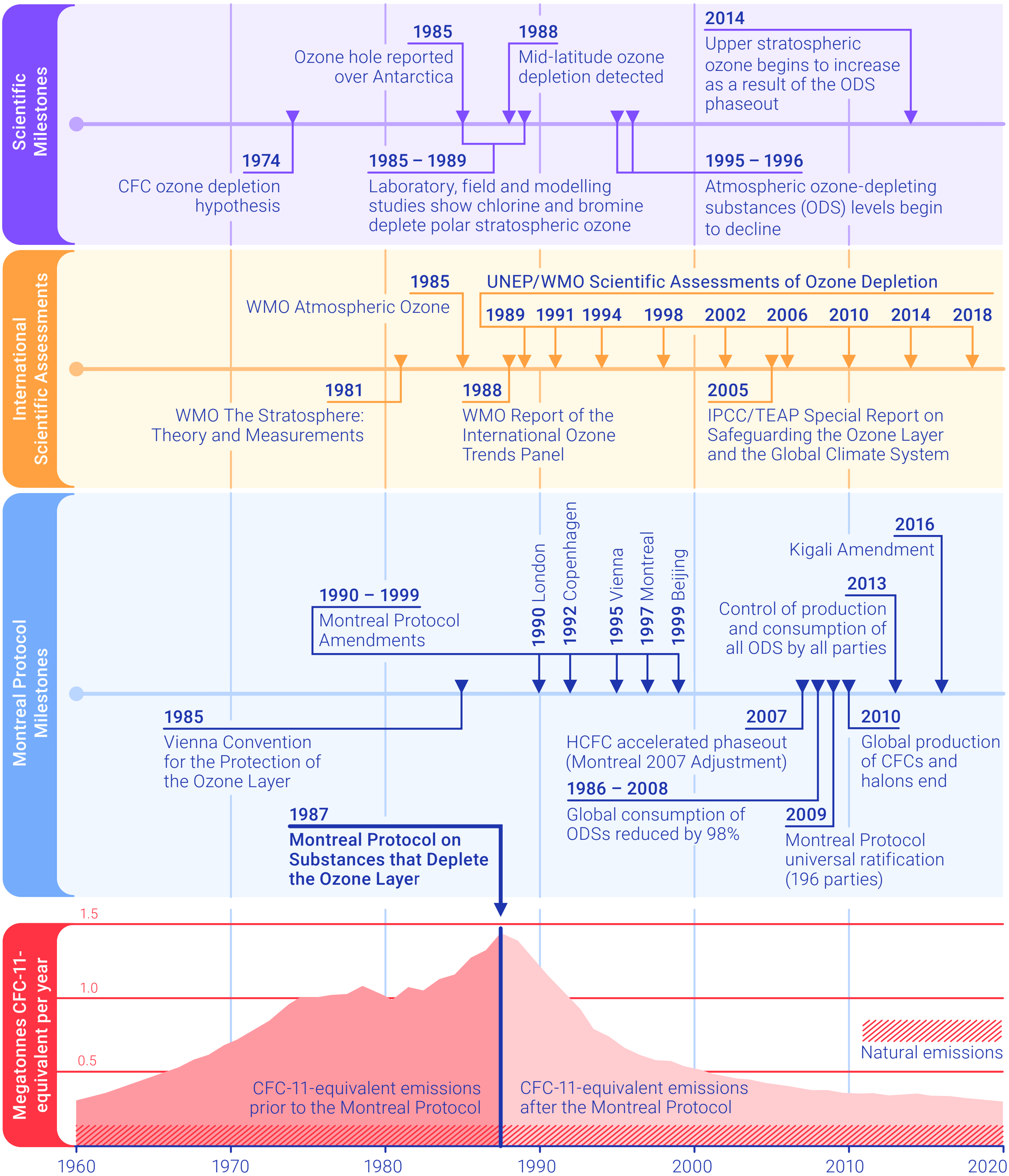


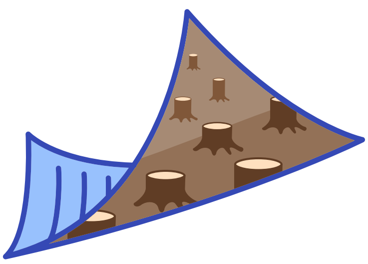
Figure 3.6: Evolution of the interaction between science and policy in identifying the depletion of the life-protecting stratospheric ozone layer and the generation of knowledge and actions needed to curb emissions of ozone-depleting substances. Emissions are presented in CFC-11 (trichlorofluoromethane) equivalents.

Source: figure adapted from Salawitch *et al.* (2019)

environment from ozone depletion, but to also cooperate on scientific research and observations. The full scientific assessment report published in late 1985 was the first of its kind, in the sense of being international, comprehensive, peer-reviewed, and including a summary for policymakers.[128] The summary noted the first evidence of the Antarctic ozone hole, albeit without an understanding of its cause. Two years later, the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted to control, at least partially, the production and consumption of ozone-depleting substances. It established technical committees and mandated scientific assessments every four years, starting in 1990.[129,130,131]

Stratospheric ozone has begun to recover because of concerted international action. In the late 1980s, laboratory, field and modelling studies established the cause of the Antarctic ozone hole and mid-latitude ozone depletion. The scientific assessments since 1988 have provided the scientific foundation for strengthening the Montreal Protocol through a series of amendments and adjustments limiting the consumption and production of ozone-depleting substances. The levels of chlorine- and bromine-containing substances at the surface peaked in about 1995 and most are now steadily decreasing. It is now projected that the Antarctic ozone hole will disappear in the 2060s[132] (see figure 3.6).

Hydrochlorofluorocarbons (HFCs) used to replace some ozone-depleting substances have been shown to be potent greenhouse gases and subsequently controlled through international action. CFCs, which were widely used as refrigerants, propellants and solvents, have been replaced in some applications by hydrofluorcarbons (HFCs). The ozone-depleting CFCs were also potent greenhouse gases, hence eliminating their emission into the atmosphere was greatly beneficial for the climate system. While HFCs have a very small impact on ozone levels, they are also powerful greenhouse gases. Recognition of this unintended consequence led to the 2016 Kigali Amendment controlling the production and consumption of several HFCs.[133] As a result, their projected climate impact in 2100 has been reduced from 0.3–0.5°C to less than 0.05°C.[134]



3.7 The different forms of environmental change are intertwined

Climate change, land-use change, land degradation, and air and water pollution act synergistically to cause pervasive, extensive and systemic damage to biodiversity and ecosystem services on land and in the ocean[135,136,137,138,139,140] (figure 3.9). The abundance of wild organisms worldwide in 2010, as measured by the mean species abundance, is estimated to have reduced by 34 per cent relative to pre-industrial levels, and projections driven by future land use and climate change suggest losses of 38–46 per cent by 2050 (figure 3.9, pale pink and dark orange arrows).[141] Many land and ocean ecosystems and some of the services they provide have already changed due to global warming[142,143] (figure 3.8b).The projected terrestrial area where the ecosystem will shift from one biome to another as a result of climate change is 7–8 per cent for 1.5°C warming, 13 per cent (range 8–20 per cent) at 2°C warming, 28 per cent (range 20–38 per cent) at 3°C warming, and 35 per cent at 4°C warming[144] (figure 3.9, dark orange arrow). Climate change increases extinction risk, with 20–30 per cent of plant and animal species assessed globally at greater risk of extinction under 2°C warming,[145,146] and progressively higher numbers are risk with greater warming (figure 3.9, dark orange arrow). The global fraction of insects, vertebrates and plants for which more than half of their current range would no longer be climatically suitable by 2100 is 4–8 per cent for 1.5°C warming, 8–18 per cent for 2°C, 26–49 per cent for 3.2°C and 44–67 per cent for 4.5°C (figure 3.7). Such extensive range losses would undermine the provision of ecosystem services such as pollination at the global scale (figure 3.9, magenta arrow; figure 1.1 (d)). Terrestrial species on all continents have already been observed to have variously changed in abundance, seasonal activity or geographic range in response to climate change. Risks posed by climate change to terrestrial ecosystems in general, which include biome shifts, species range loss and phenological mismatches, are considered already moderate and are projected to transition to high even below 2°C of global warming and to very high with 3°C.[147] A summary of risks to unique and threatened systems including coral reefs and the Arctic concludes that the risk level transitions globally from high to very high at 1.5°C warming (figure 1.1 (a)).[148] Climate change and associated sea ice loss and biogeochemical changes such as oxygen loss have caused poleward shifts in distributions of marine species since the 1950s of 52 km ± 33 km per decade for epipelagic species and 29 ± 16 km per decade for seafloor species, altering species composition, ecosystem function, abundance and biomass of systems from the equator to the poles, and reducing fisheries catches.[149] A decrease in the biomass of marine animal communities and

3.7. Species projected to lose over 50% of their climatically determined geographic range

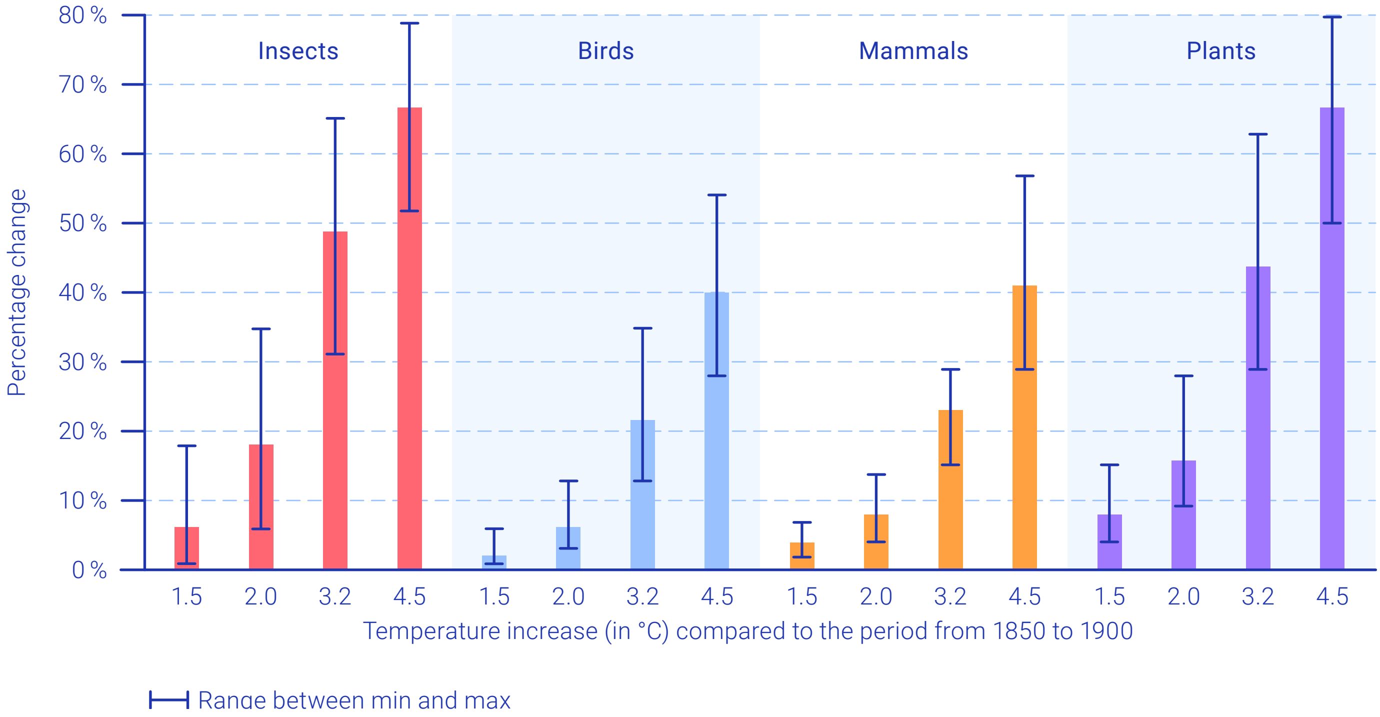


Figure 3.7: Species projected to lose over 50 per cent of their climatically determined geographic range. The proportions of species in four broad groups of organisms that are projected to lose over half of their climatically determined geographic range by 2100 under climate change scenarios in which global warming reaches 1.5°C, 2°C, 3.2°C or 4.5°C above pre-industrial levels by that time. The models used to make these projections assume that species move at realistic rates while attempting to track their geographically shifting climate envelope. The uncertainty range is the 10–90 per cent confidence interval across the various regional climate patterns explored. This study is based on the assessment of 19,848 insect species, 12,429 vertebrate species and 73,224 plant species.

Data source: IPCC 2018a, SR1.5, 3.4.3

their production, and a shift in marine species composition are also projected over the twenty-first century.[150] The effort required for humans to adapt to the effects of climate-driven species redistribution on economic development, livelihoods, food security, health and culture will be far-reaching and substantial (figure 3.9).[151]

Land-use change and unsustainable land use leading to land degradation contribute to climate change. The transformation and disturbance of natural ecosystems that has occurred since 1750 has reduced global soil organic carbon by 176 Gt. If current trends continue, human-caused emissions from soil and vegetation will roughly add another 80 Gt of carbon to the atmosphere over the 2010–2050 period[152] (figure 3.9, light orange arrow). A fifth of vegetated areas showed declines in productivity between 1998 and 2013 due to poor land or water management practices.[153] Such land-use change and land degradation deplete terrestrial carbon stocks, accelerating climate change (figure 3.9, dark purple arrow) and depleting biodiversity[154] (light pink arrow).

Land-use change also affects the climate system through altered albedo, evaporation and plant transpiration. In regions with seasonal snow cover, such as boreal regions and some temperate regions, increased tree and shrub cover has a wintertime warming influence due to an increase in the solar radiation absorbed by the less reflective vegetation.[155] This means that afforestation can locally induce warming in these regions and thus counteract cooling associated with added carbon uptake from trees. Land-use changes can also induce local to regional cooling, for instance through increased evaporation of water and plant transpiration in regions with irrigation,[156] but the global effect is zero since the water re-condenses in the atmosphere, emitting the energy it absorbed during evaporation.

Climate change and biodiversity loss jeopardize the health and productivity of land. Loss of biodiversity and vegetation cover accelerates soil erosion and land degradation (figure 3.9, dark pink arrow). Global warming has already led to shifts in climate zones in many parts of the world, including

3.8. Impacts and Risks to Humans and Ecosystems from Climate Change

a) Risks to humans and ecosystems from changes in land-based processes as a result of climate change

Increases in global mean surface temperature (GMST), relative to pre-industrial levels, affect processes involved in **desertification** (water scarcity), **land degradation** (soil erosion, vegetation loss, wildfire, permafrost thaw) and **food security** (crop yield and food supply instabilities).

Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health. Changes in one process (e.g. wildfire or water scarcity) may result in compound risks. Risks are location-specific and differ by region.

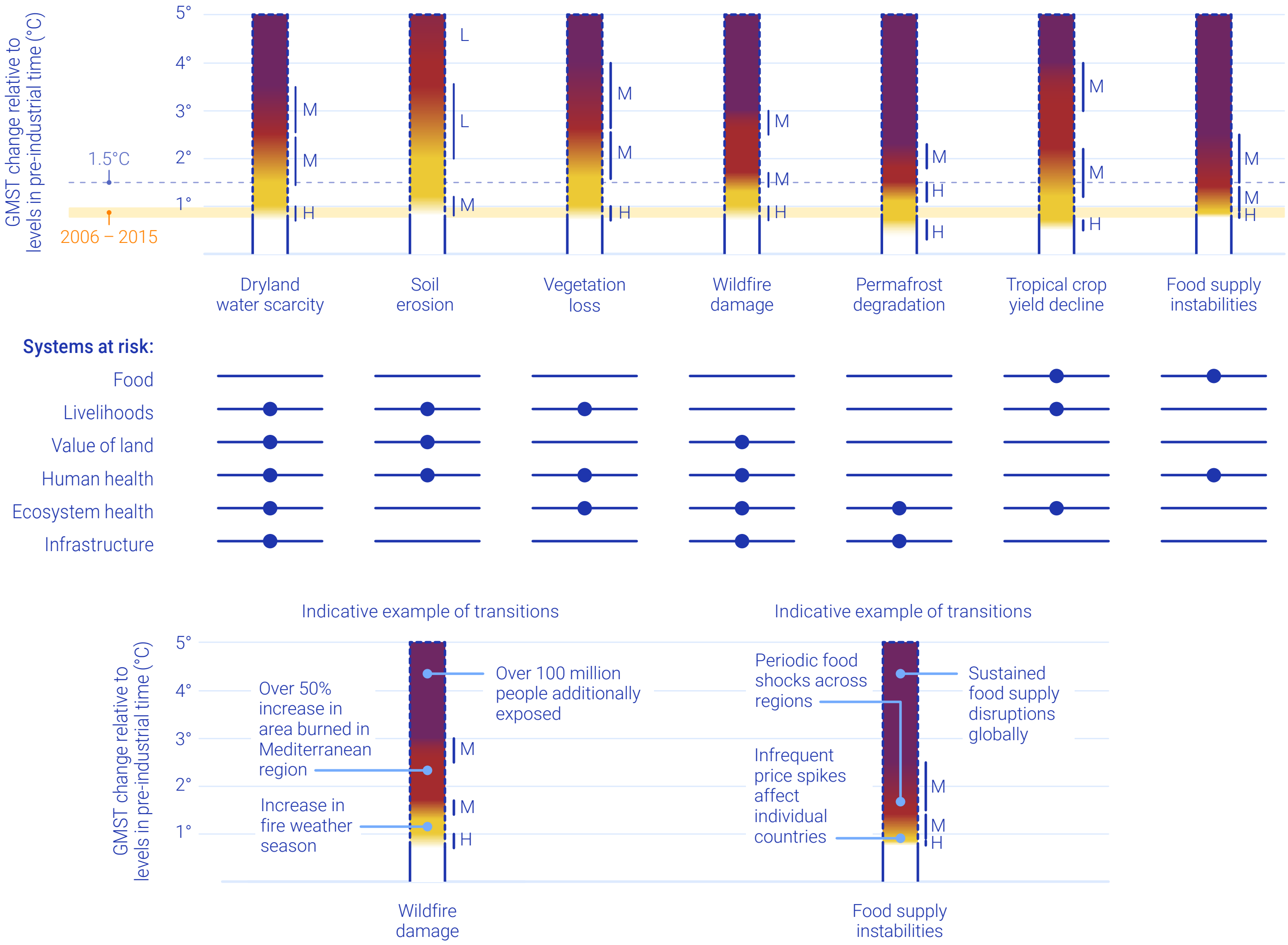


Figure 3.8: Assessment of projected risks to (a) land-related human systems and ecosystems arising from the combination of global climate change, socioeconomic development and mitigation choices in terrestrial ecosystems (b) coastal and open ocean based on observed and projected climate impacts on ecosystem structure, functioning and biodiversity. Impacts and risks are shown in relation to changes in global mean surface temperature relative to pre-industrial level. The literature was used to make expert judgements to assess the levels of global warming at which levels of risk are undetectable, moderate, high or very high. As part of the assessment, literature was compiled and data extracted into a summary table. A formal expert elicitation protocol (based on modified-Delphi technique and the Sheffield Elicitation Framework), was followed to identify risk transition thresholds in panel, including a multi-round elicitation process with two rounds of independent anonymous threshold judgement, and a final consensus discussion.

Panel (a) indicates risks to selected elements of the land system as a function of global mean surface temperature. Links to broader systems are illustrative and not intended to be comprehensive. Risk levels are estimated assuming medium exposure and vulnerability driven by moderate trends in socioeconomic conditions broadly consistent with an SSP2 pathway.

b) Impacts and risks to ocean ecosystems from climate change

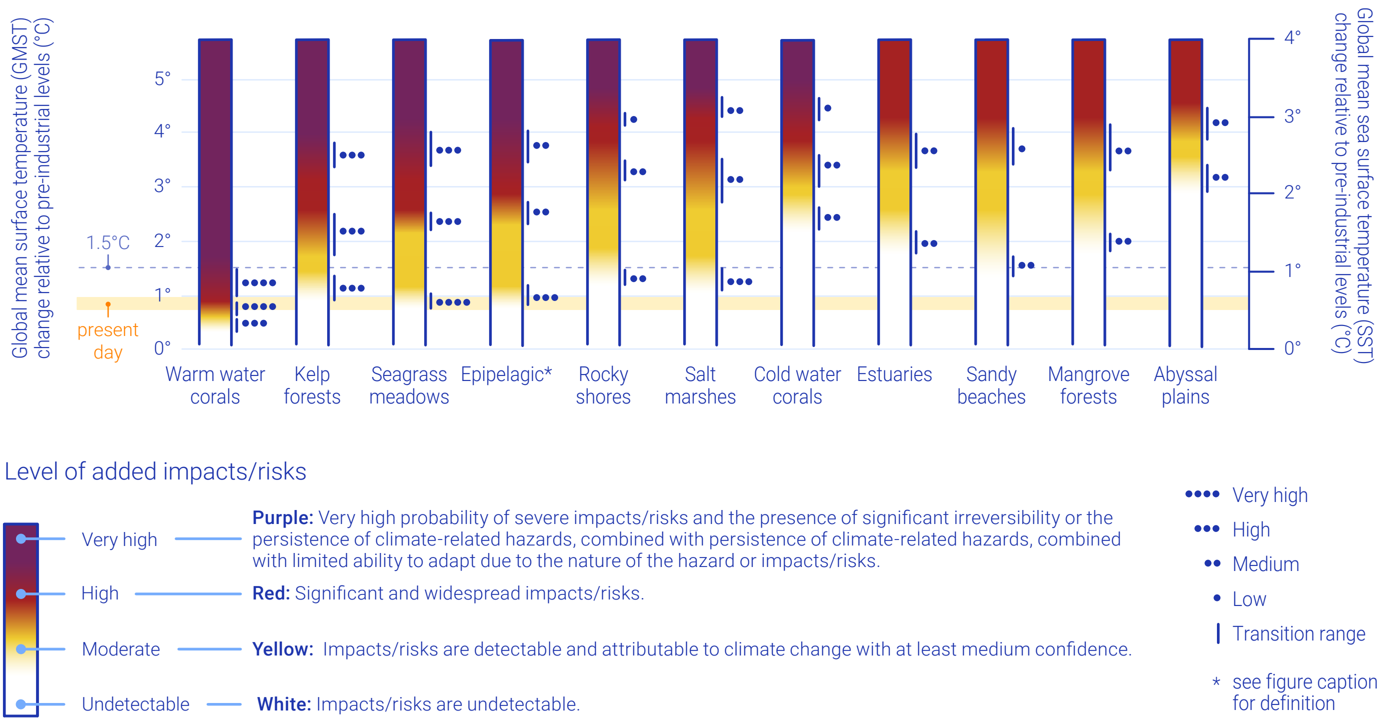


Figure 3.8 (continued): Panel (b) indicates assessed risks at approximate warming levels and increasing climate-related hazards in the ocean: ocean warming, acidification, deoxygenation, increased density stratification, changes in carbon fluxes, sea level rise, and increased frequency and/or intensity of extreme events. The assessment considers the natural adaptive capacity of the ecosystems, their exposure and vulnerability. Impact and risk levels do not consider risk reduction strategies such as human interventions, or future changes in non-climatic drivers. Risks for ecosystems were assessed by considering biological, biogeochemical, geomorphological and physical aspects. Higher risks associated with compound effects of climate hazards include habitat and biodiversity loss, changes in species composition and distribution ranges, and impacts/risks for ecosystem structure and functioning, including changes in animal/plant biomass and density, productivity, carbon fluxes and sediment transport. Since assessments of risks and impacts in panel (b) are based on global mean sea surface temperature, the corresponding sea surface temperature levels are shown.

Sources: Figure adapted from IPCC 2019b, SRCCL SPM, Figure SPM.2 and IPCC 2019a, SROCC SPM, Figure SPM.3

expansion of arid zones and contraction of polar zones.[157] In Sub-Saharan Africa, parts of Central and East Asia, and Australia, warming and reduced precipitation have contributed to desertification (figure 3.9, light purple arrow).[158] Loss of glacier mass and snow cover is higher with greater global warming.[159] Widespread near-surface permafrost thaw is projected to occur during the twenty-first century, with losses of 69 +20 per cent by 2100 in the absence of climate change mitigation, reducing to 24+16 per cent for high-mitigation scenarios. A regional-scale threshold between 1.5°C and 2°C of warming has been identified in the Mediterranean above which biome shifts unprecedented in the last 10,000 years and associated with extreme drought are projected. In Southern Africa, much greater water stress and increased drought are anticipated for warming above 1.5–2°C. [160,161] Globally, risks from water scarcity, wildfire damage and permafrost degradation are projected to be already high at 1.5°C; for warming of 3°C, risks arising from water scarcity, wildfire damage and vegetation loss become very high (figure 3.8a).

Climate change risks to food security are expected to become increasingly severe with increased global warming. The risk is expected to become high between 1.2°C and 3.5°C of warming depending on socioeconomic development pathways, and very high risks could be incurred with only 2°C warming in some pathways.[162] At 3–4°C warming, very high risks of declines in low-latitude crop yields are expected whilst 4°C warming is considered catastrophic for food supply stability and access.[163] Rising carbon dioxide concentrations are projected to reduce the protein and micronutrient content of major cereal crops, which is expected to further reduce food and nutritional security.[164]

Climate change, biodiversity loss and water pollution affect oceanic and coastal ecosystems. Without action to limit global warming, marine heatwaves, coupled with ocean acidification and loss of oxygen, will result in the crossing of critical thresholds in the ocean and in coastal systems, beyond which ecosystem functioning will be impaired (figure 3.7). Marine

3.9. The interactions between climate change, land use and biodiversity

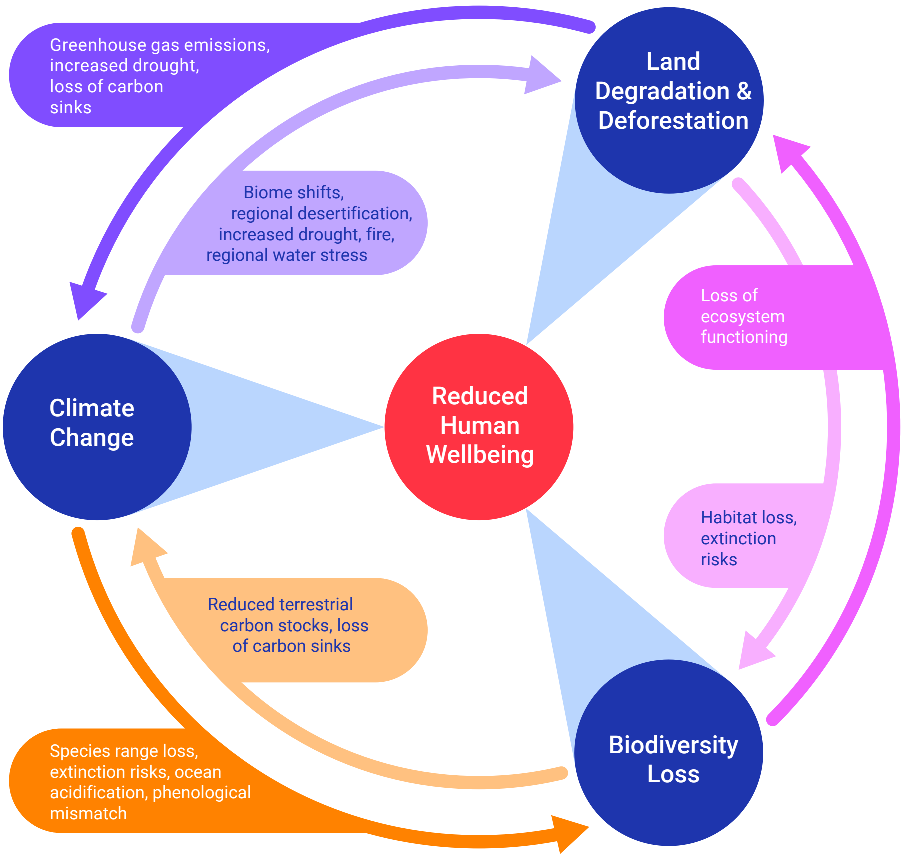


Figure 3.9: The interactions between climate change, land use and biodiversity.

heatwaves have already resulted in large-scale coral bleaching events at increasing frequency, causing worldwide reef degradation. Recovery is slow (more than 15 years), if it occurs at all.[165] There are many potential limits to adaptation in marine ecosystems,[166] and these limits are projected to be exceeded well before the end of the century in many coral reef environments, urban atoll islands and low-lying Arctic locations. Marine heatwaves are projected to become 50 times more frequent and 10 times more intense in the absence of strenuous climate change mitigation.[167] Ocean acidification, which inevitably results from increasing atmospheric carbon dioxide concentrations, amplifies the adverse effects of warming, impacting the growth, development, calcification, survival and abundance of a broad range of species, from algae to fish.[168] Warm-water coral reefs are projected to decline by 70–90 per cent at 1.5°C warming and by more than 99 per cent at 2°C,[169,170] compromising food provision, tourism, coastal protection and the diversity of coral reef-associated species (figure 3.8b). Cold-water coral reefs, similarly highly biodiverse, are also projected to be harmed. Unless efforts to mitigate climate change are successful, by the end of the century the biomass of marine animals is projected to decline by 10–20 per cent and the maximum potential catch of fisheries by 20.5–24.1 per cent relative to 1986–2005.[171] In the Arctic, the chances of the sea being ice-free in September by the end of the century rise from about 1 per cent each year for stabilized global warming of 1.5°C, to 10–35 per cent for a stabilized 2°C increase.[172] A sea ice-free Arctic Ocean would disrupt the functioning of the Arctic ecosystem.

Coastal ecosystems face high to very high risks unless climate change is halted. The risk of irreversible loss of many already declining coastal ecosystems, such as seagrass meadows and kelp forests, increases with further global warming (figure 3.8b). Increased salinization and hypoxia in estuaries contribute to their decline.[173] Global mean sea level is rising, with acceleration in recent decades due to increasing rates of ice loss from the Greenland and Antarctic ice sheets[174] as well as continued glacier mass loss and ocean thermal expansion, and is accompanied by increased wave heights in the Atlantic Ocean.[175] Irreversible loss of the Greenland ice sheet and instability in the West Antarctic ice sheet may occur between 1.5°C and 2°C.[176] A high risk of potential collapse of the West Antarctic ice sheet is considered to exist for 2.5°C warming (figure 1.1 (e)). Depending on the amount of sea level rise, 20–90 per cent of current coastal wetlands are projected to be lost by the end of the century, including mangrove forests and salt marshes (figure 3.8b).[177] Local sea levels that historically occurred once per century are projected to become at least annual events at most locations during the twenty-first century.[178] Extreme sea levels and coastal hazards will be exacerbated by projected increases in tropical cyclone winds and associated heavy rainfall.[179]

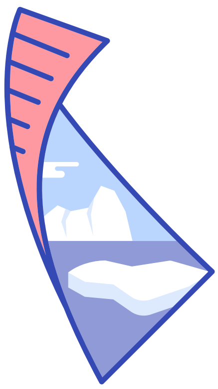
Reducing the emissions of greenhouse gases typically also reduces air pollution. The greenhouse gases and aerosols responsible for anthropogenic climate change are in some cases also air pollutants, and even when they are not themselves toxic at ambient levels, they are often associated with chemicals that are. For instance, carbon dioxide is not poisonous at current elevated levels, but reducing carbon dioxide emissions from industrial processes typically reduces the emissions of gases that cause human and ecosystem health problems, including tropospheric ozone precursors. Similarly, methane is not toxic at normal levels, but combines with oxides of nitrogen emitted from industry and vehicles to form tropospheric ozone, which as a result frequently exceeds damage-causing levels. Particulate matter affects both the Earth's radiation balance and human health (see Section 3.4).

Water pollution is a leading cause of the loss of biodiversity and ecosystem services in freshwater and coastal aquatic systems (figure 3.1). Key water pollutants include excess nutrients, salts and sediments resulting from agriculture, human settlements and land degradation. Water pollution and air pollution are often linked, since diversion of waste from one pathway can simply displace it into another pathway. For instance, excess nitrogen in water is often removed by anaerobic denitrification, which results in emissions of nitrous oxide. The solution is to reduce nitrogen waste overall.

Plastics and chemical waste entering the biosphere contributes to both biodiversity loss and to land degradation. The accumulation of plastics in the oceans and pesticide residues in soils and sediments are examples. On the other hand, plastic and other chemicals can reduce food waste through spoilage, and pesticides reduce the loss of crops before and after harvest.[180]

Most human-created substances implicated in stratospheric ozone depletion are also greenhouse gases, as are some of the substances that replace them. While the state of stratospheric ozone is improving as a result of concerted international efforts to reduce the production and emission of ozone-depleting chemicals, a degree of depletion of this life-protecting layer will persist well into the middle of the twenty-first century (Section 3.6). This reduction in emissions also reduces the contributions of these gases to climate change.[181]

The multiple interactions between environmental problems mean that uncoordinated single-issue solutions are inefficient and likely to fail. An integrated approach that addresses the underlying root causes of interlinked environmental problems and pays attention to unintended consequences of actions is both more cost-effective and more likely to be successful than treating the issues as if they were independent of one another. It further allows synergies to be identified and exploited, while steering away from the worst trade-offs.



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2 WMO 2020
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4 IPCC 2019c, SRCCL, 2.2.5
5 IPCC 2018a, SR1.5, 3.3.4
6 IPCC 2019d, SROCC, 3.2.1; 3.4.1
7 IPCC 2018a, SR1.5, 3.3.2
8 IPCC 2012, SREX, 3.1
9 IPCC 2019b, SRCCL SPM, A.2.6
10 IPCC 2014c, AR5 SYR, 1.2.1
11 IPCC 2019d, SROCC, TS.3
12 IPCC 2019d, SROCC, Cross-Chapter Box 8
13 IPCC 2019d, SROCC, Table 6.1
14 IPCC 2018a, SR1.5, 3.2
15 IPCC 2019d, SROCC, 1.12.3.1-3
16 IPCC 2019d, SROCC, 3.4.1
17 UNFCCC 1992
18 UN 1997, Kyoto Protocol
19 UN 2015, The Paris Agreement
20 IPCC 2018a, SR1.5, Cross-Chapter Box 2
21 At the Climate Ambition Summit 12 December 2020 45 countries pledged significant emissions reductions by 2030, and 24 countries committed to be net zero by the middle of the century. (see https://news.un.org/en/story/2020/12/1079862)
22 UNEP 2020a, EGR ES, 6
23 IPCC 2018a, SR1.5, TS.2
24 IPCC 2018a, SR1.5, 2.1
25 IPCC 2018a, SR1.5, 3.6.1, 3.6.2
26 Work is ongoing in preparation for the 6th assessment report of the Working Group 1 of IPCC, expected to be released in 2021
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35 IPCC 2018a, SR1.5, 3.3
36 IPCC 2018a, SR1.5, 3.3.4
37 IPBES 2019a, GA SPM, A5
38 IPCC 2019b, SRCCL SPM, A.2.6
39 IPBES 2019a, GA SPM, A4
40 IPBES 2019a, GA SPM, 5
41 IPBES 2019a, GA SPM, B10
42 IPBES 2019b, GA, 4.5.5
43 Convention on Biological Diversity, Ramsar Convention on Wetlands of International Importance, Convention on Migratory Species, International Plant Protection Convention, World Heritage Convention and Convention on International Trade in Endangered Species
44 IPBES 2019a, GA SPM, C1
45 IPBES 2019a, GA SPM, Figure SPM.6
46 CBD 2020a, GBO-5 SPM
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49 IPBES 2019a, GA SPM, A6
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80 IPBES 2018c, Africa Regional Assessment, 4.2.2
81 IPBES 2018a, LDRA, 4.2.4
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4

The achievement of the Sustainable Development Goals is threatened by environmental risks

Where Section 2 showed people's dependence on the natural world and their role in shaping it, Section 3 concluded that, under current trends, internationally agreed environmental goals are unlikely to be achieved. People are changing the climate system, polluting air and water and using more land and marine resources than ever before. Life on Earth is rapidly eroding and nearly all of nature's regulating functions are in decline. This section discusses how environmental degradation, including climate change, loss of biodiversity and ecosystem services and pollution of air, land and water, undermines progress towards achieving the economic and social objectives of the SDGs. It explores risks to poverty and economic development (SDG 1 and SDG 8), to food and water security (SDG 2 and SDG 6), to human health (SDG 3), to reducing inequality (SDG 5 and SDG 10), to promoting peaceful and inclusive societies (SDG 16) and to cities and communities (SDG 11). Figure 4.1 provides an overview of selected environmental changes, as discussed in Section 3, and selected impacts on the SDGs, as discussed below.

Ongoing and projected environmental degradation undermines progress towards the SDGs. In many countries in the Global South, poverty levels and thereby people's vulnerability to environmental degradation remain high (see Sections 2.3.1 and 4.1). Most scenarios project clear improvement over time in areas including reducing hunger (SDG 2), increasing access to safe drinking water and adequate sanitation (SDG 6) and increasing access to modern energy services (SDG 7), though not enough to meet the related SDG targets by 2030.[1] Trends in environmental degradation will make reaching these and other goals even more challenging (see figure 4.1).[2,3] Poor and vulnerable communities are most at risk from environmental threats and future generations will be more affected than the current. Poverty is increasingly concentrated in rural dryland areas of South Asia and Sub-Saharan Africa.[4] Socioeconomic developments, such as in population, trade, consumption and inequality, determine the vulnerability and exposure of people and thus related impacts on their well-being. For instance, a scenario with low population growth, reduced inequalities, land-use regulation, low meat consumption, increased trade and few barriers to adaptation or mitigation (SSP1) shows much lower climate-related risks of, for example, water scarcity, flooding and food security than scenarios with opposite characteristics (SSP3), given the same level of global mean temperature increase (see figure 4.2).[5,6]

The COVID-19 pandemic has impacted human well-being, disrupted implementation towards many of the SDGs and, in some cases, turned back decades of progress.[7] In 2020, global per capita GDP is expected to decline by 4.2 per cent (SDG 8), pushing an estimated 71 million more people into extreme poverty (SDG 1) and resulting in hundreds of thousands of additional under-5 deaths (SDG 3). The disruption caused by the pandemic is also a threat to food security, with the World Food Programme estimating an almost doubling of the number of people facing acute food insecurity in 2020 compared to 2019 (SDG 2) (see Section 2.3.1).[8] Due to lockdowns, school closures have kept 90 per cent of all students out of school for some period of time (SDG 4) and, in some countries, cases of domestic violence have increased by 30 per cent (SDG 5). Poor and disadvantaged people have been affected most (SDG 10), while all these impacts can further threaten global peace and security (SDG 16).

4.1 Environmental decline impedes progress on economic development and ending poverty (SDGs 1 and 8)

While economic poverty has decreased (SDG 1.1), multidimensional poverty remains high (SDG 1.2). Absolute poverty, as indicated by the number of people living on less than US$1.90 per day, fell from 1.85 billion in 1990 to 736 million in 2015.[9] Recent estimates indicate that nearly 700 million people lived in extreme poverty in 2017, but that the COVID-19 pandemic may push at least another 70 million into extreme poverty. Around 1.3 billion people are still poor according to the Multidimensional Poverty Index, which captures deprivations in education, health and nutrition, access to services, and security, in addition to income poverty

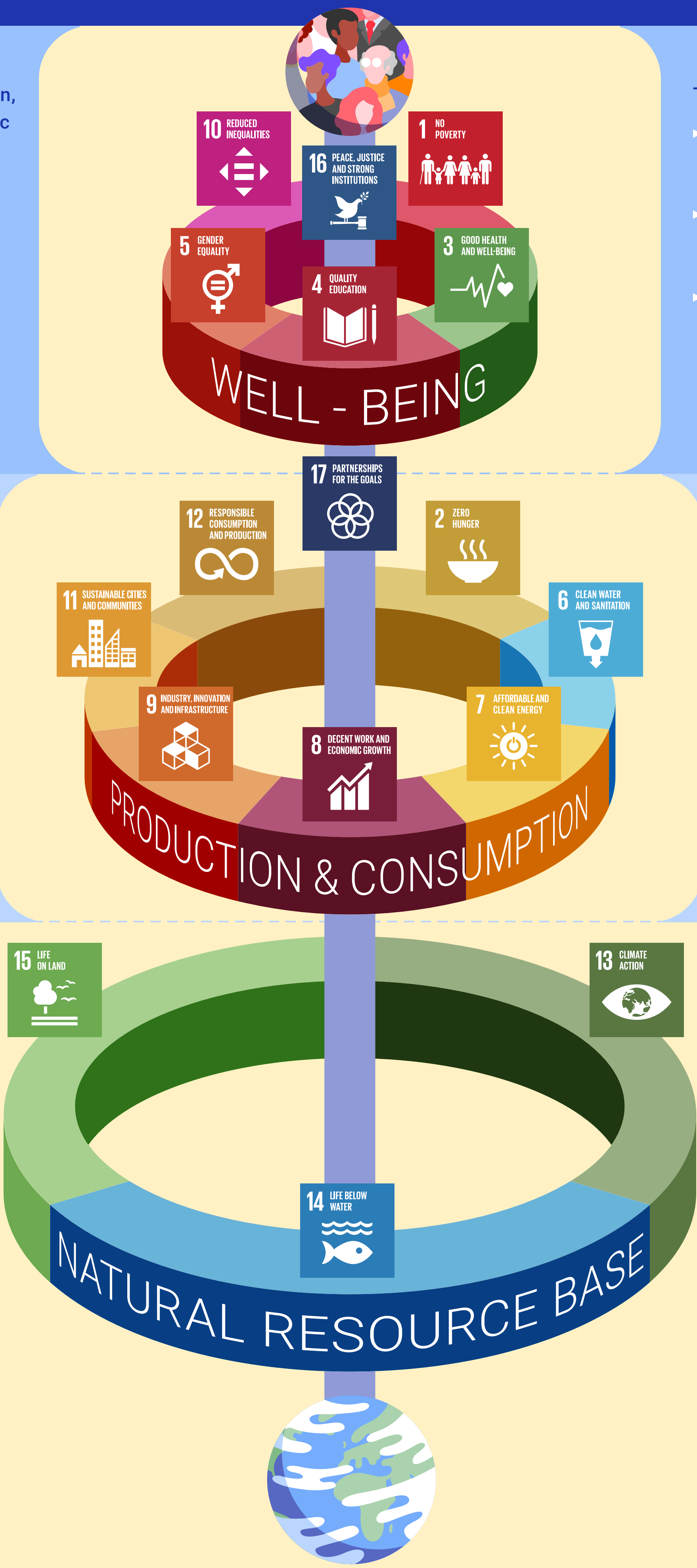
Environmental degradation threatens the achievement of the SDGs

Impeding poverty elimination, inequity reduction, economic development and peace

- Exacerbated multi-dimensional poverty
- Accentuated inequality, including gender inequality
- Lost income opportunities
- Increased risk of conflict over resources
- Increased risk of displacement and outmigration

Threatening human health

- Increased undernutrition, heat stress and air pollution-related diseases
- Exacerbated food- and water-borne infections and zoonotic diseases
- Reduced ability of nature to provide medicines and support physical and mental well-being



Hampering efforts to make cities and communities sustainable

- Increased vulnerability to natural disasters
- Stresses on urban infrastructure
- Rising air and water pollution
- Rising waste disposal problems

Weakening food and water security

- Increased food-system vulnerability
- Reduced agricultural productivity
- Reduced nutritional value of crops
- Lower catch in fisheries
- Increased water scarcity

Changing climate

- Higher temperatures
- More extreme weather events, e.g. flooding, droughts, storm surges and heatwaves
- Rising sea level
- Changing precipitation patterns
- Ocean acidification

Biodiversity loss and ecosystem degradation

- Loss of species richness and accelerated species extinction
- Loss of genetic resources in domestic and wild species
- Loss of ecosystem functions, such as pollination, seed dispersal, soil formation and biological productivity

Figure 4.1: Selected environmental changes and related impacts on efforts to achieve the SDGs. The clustering of SDGs provides an integrated perspective with the environment as the foundation for economic and social development and, ultimately, human well-being. As a result, unsustainable resource use, waste and pollution impact adversely both the natural resource base and human well-being.

Source: Figure adapted from UNEP 2019a, GEO-6, Figure 20.1

4.2. Different socioeconomic pathways affect levels of climate related risks

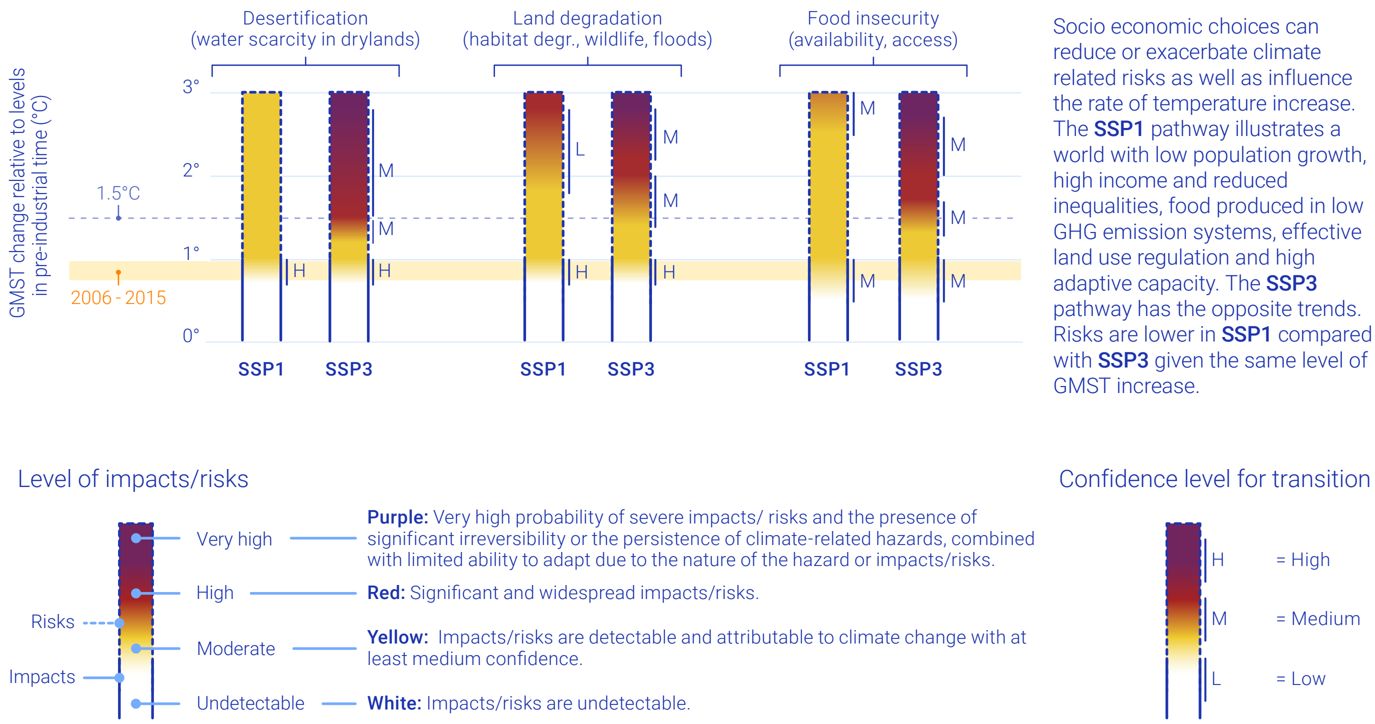


Figure 4.2: As Figure 3.8, but for risks associated with desertification, land degradation and food security due to climate change and patterns of socioeconomic development. Increasing risks associated with desertification include population exposed and vulnerable to water scarcity in drylands. Risks related to land degradation include increased habitat degradation, population exposed to wildfire and floods and costs of floods. Risks to food security include availability and access to food, including population at risk of hunger, food price increases and increases in disability adjusted life years attributable due to childhood underweight. Risks are assessed for two contrasted socioeconomic pathways (SSP1 and SSP3) Risks are not indicated beyond 3°C because SSP1 does not exceed this level of temperature change.

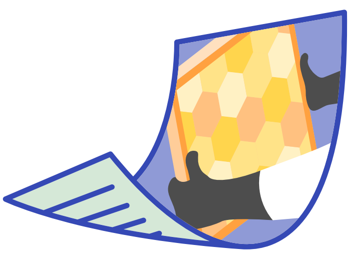
Source: Adapted from IPCC 2019b, SRCCL SPM, Figure SPM.2

(see Section 2.3.1). What is critical is not merely absolute poverty but also relative poverty, especially as income disparities have been increasing worldwide.

Climate change and ecosystem degradation makes poverty reduction more difficult. Climate change impacts are expected to exacerbate poverty in most developing countries and create new pockets of poverty through increasing inequality in both developed and developing countries.[10] Key risks include deteriorating livelihoods, destruction and deterioration of assets, shifts from transient to chronic poverty, declining work productivity, declining agricultural yields and reduced access to water. Ecosystem degradation, including land degradation, negatively impacts people's vulnerability to extreme events, access to resources and small-scale food production and agricultural sustainability, with negative impacts on both the urban and rural poor who are directly reliant on environmental resources.[11] Without rapid and inclusive progress on eradicating multidimensional poverty, climate change can increase the number of the people living in poverty by between 35 million and 122 million people by 2030.[12] Limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050.[13]

Environmental changes are increasingly impacting economic development and employment (SDG 8). Changes in temperature and precipitation patterns, along with changes in extreme events such as heatwaves, heavy precipitation in several regions and droughts in some regions (Section 3.1), are already having an impact on human systems.[14] Key economic sectors being affected include tourism, energy systems and transportation.[15] In 2018 alone, damages from natural disasters, the vast majority of which were climate-related (including droughts, fires, storms and floods), were estimated at US$155 billion.[16] Safe work activity and worker productivity during the hottest months of the year will be increasingly compromised with higher ambient temperatures and climate change.[17] Land degradation has already reduced productivity in 23 per cent of the global terrestrial area,[18] with economic losses as large as 5 per cent of total GDP being observed.[19] Over the past 50 years, the potential of nature to contribute to human well-being has declined in 14 of 18 major categories of contributions that were recently assessed.[20] These changes have decreased the flow of regulating and non-material benefits to people, resulting in a significant loss of non-market values. For example, loss of pollinators puts between US$235 billion and US$577 billion in annual global crop output at risk.[21]

The costs of inaction on limiting environmental change far outweigh the costs of action. Though estimates of future damages to the economy from climate change are uncertain and exclude important categories of damages (e.g. loss of public goods and global commons)[22] global aggregate impacts are estimated to reach high levels with 2.5–3°C of warming (see figure 1.2).[23,24] By the end of the century, inaction on climate change could lead to a 15–25 per cent reduction in per capita output for 2.5–3°C of global warming, relative to a world that did not warm beyond 2000–2010 levels.[25] Estimates of economic damages associated with 2°C of warming reach US$69 trillion,[26] while an estimated US$15–38.5 trillion in economic damage could be avoided by limiting warming to 1.5°C.[27] The global health savings from reduced air pollution could be more than double the costs of implementing the Paris Agreement between 2020 and 2050.[28] Estimates of the costs of reducing emissions, though substantial, are far less than the estimates of damages. Cost estimates for limiting warming to less than 2°C are 2–6 per cent of global GDP in 2050, and 3–11 per cent in 2100.[29] Further delays in climate mitigation action increase the risk of escalating costs, lock-in of carbon-emitting infrastructure, stranded assets and reduced flexibility in future options for reducing emissions.[30] The loss of benefits that people get from nature are also costly. Some benefits, such as wild pollination, are irreplaceable, while for others substitution can be extremely expensive, such as the replacement of coastal mangroves with built flood protection infrastructure.[31] The diversity of nature also maintains humanity's ability to choose between alternative development options in the face of an uncertain future.



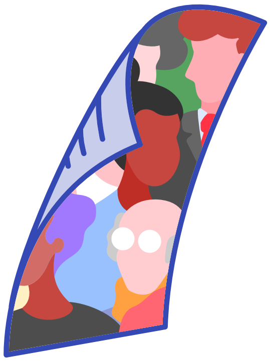
4.2 The Earth's capacity to supply food and water weakens in the face of environmental decline (SDGs 2 and 6)

Though food security has been improving, environmental changes and shocks threaten further progress in ending global hunger (SDG 2). After a period of reductions in the number of people affected by hunger, the world is now facing an alarming situation. In 2019, nearly 700 million people were estimated to be hungry (undernourished), up nearly 60 million in five years. This upward trend is partly due to increasing frequency of extreme weather events, altered environmental conditions and the associated spread of pests and diseases over the last 15 years. Such factors contribute to vicious circles of poverty and hunger, particularly when exacerbated by fragile institutions, conflicts, violence and the widespread displacement of populations. The economic impact of the COVID-19 pandemic may add more than 80 million people to the total number of undernourished in the world in 2020. If recent trends continue, the number of people affected by hunger will surpass 840 million by 2030, which is far from the goal of ending hunger by 2030.[32] Current low levels of biodiversity (species and genetic variability) in agricultural systems increase their vulnerability to stresses and shocks (SDG 2.5), and biodiversity loss, land degradation and climate change jeopardize land productivity, potentially altering the suitability of vast areas for agricultural production and human habitation.[33]

Billions of people face the challenges of inadequate access to drinking water and sanitation, increasing water pollution and water scarcity (SDG 6). In 2017, around 2.2 billion people did not have access to safely managed drinking water (SDG 6.1) and more than 4 billion people did not have access to safely managed sanitation (SDG 6.2). Together, these deprivations were responsible for approximately 8 per cent of all deaths among children under 5. Water pollution (SDG 6.3) has continued to worsen over the last two decades, causing increased threats to freshwater ecosystems, human health and sustainable development.[34] Furthermore, more than

2 billion people globally live in river basins suffering water stress, where total withdrawals exceed 40 per cent of the renewable freshwater available (SDG 6.4). In some countries in Africa and Asia, the proportion withdrawn extends beyond 70 per cent.[35] Irrigation is the primary human use of freshwater resources, and around 71 per cent of the world's irrigated area and 47 per cent of major cities currently experience at least periodic water shortages.[36] In addition, many vulnerable and poor people are dependent on activities such as rainfed agriculture that are highly susceptible to variability in precipitation patterns.[37,38]

Environmental change poses multiple, interacting and mutually reinforcing risks to agricultural productivity and food security (SDG 2). Climate change is affecting crop yields. Yield decreases are already occurring in the tropics and are expected to continue.[39,40] Climate change also reduces the nutritional quality, availability and diversity of crops as well as undermining key ecosystem services that underpin food production.[41] Soil erosion from agricultural fields is estimated to be 10 to 20 times higher (under no-till systems) to more than 100 times higher (with conventional tillage) than the soil formation rate.[42] An estimated 176 Gt of soil organic carbon has been lost historically, mostly from land-use change, and another 27 Gt of soil organic carbon is projected to be lost between 2010 and 2050, affecting agricultural yields through reduced water-holding capacity and loss of nutrients.[43] As the remaining natural land suitable for agriculture is limited, future expansion is projected to take place on more marginal lands with lower yields.[44] Biodiversity loss and declines in regulating ecosystem services pose risks to food production through impacts on pollination services, resistance to more frequently applied pesticides and herbicides in insects and plants, and soil nutrient losses.[45] Animal pollination is critical to more than 75 per cent of global food crop types, including fruits and vegetables and some of the most important cash crops, such as coffee, cocoa and almonds.[46] Ground-level ozone is a strong oxidant that can enter plants through the leaves, affecting photosynthesis and other physiological functions, and thereby affecting forest productivity and agricultural yields.[47] Climate change risks to food security are expected to become high between 1.2°C and 3.5°C of warming depending on socioeconomic development pathways, and very high risks could be incurred with only 2°C warming in some pathways.[48] At 3–4°C of warming, very high risks of declines in crop yield in low latitudes are expected whilst 4°C of warming is considered catastrophic for food stability and access.[49] Rising carbon dioxide concentrations are projected to reduce the protein and micronutrient content of major cereal crops, which is expected to further reduce food and nutritional security.[50]



Water availability, reliability and quality is being threatened by climate change, pollution and ecosystem degradation (SDG 6). Water stress is mostly driven by water demand, and demand from agriculture and irrigation – already the largest user – is expected to increase further in a changing climate.[51,52,53] All assessed scenarios project an increase in water demand and water scarcity.[54,55] Climate change is projected to reduce water availability significantly in most dry subtropical regions and increase water availability at high latitudes.[56] Projections of the number of people exposed and vulnerable to water stress by 2050 under climate change vary widely. The number increases from an average of 496 (range 103–1159) million people at 1.5°C to 662 (range 146–1480) million people at 3°C,[57] distributed unequally between regions. Climate-driven sea level rise will exacerbate coastal water stress due to changes to the salinity of coastal groundwater and damage to infrastructure.[58] Combined with scarcity of water in river channels and excess pumping of groundwater, sea level rise has caused intrusion of highly saline seawater inland, posing a threat to coastal water resources and an emerging challenge to land managers and policymakers.[59,60] Water quality is negatively affected by waste discharges, including pathogens from wastewater, nutrients from untreated sewage discharges and agriculture, and heavy metals and organic chemical from industrial and agricultural sectors.[61] New pollutants not easily removed by current wastewater treatment technologies are of emerging concern, including certain veterinary and human pharmaceuticals, pesticides, antimicrobial disinfectants, flame retardants, detergent metabolites and microplastics.[62]

Biodiversity loss in agriculture threatens the resilience of food systems (SDG 2). The decline in pollinators, crop and livestock diversity and soil organic matter, threatens the agricultural yields of the few main crops that feed the world. Biodiversity in agricultural systems, whether at the genetic, species or ecosystem level, decreases vulnerability to stresses and shocks, reducing their impacts and supporting recovery and adaptation in the face of climate change and other environmental shifts.[63] Diversity increases the choices available to producers in their efforts to adapt production systems and to breeders in their search for better-adapted plant and animal populations. While more than 6,000 plant species have been cultivated for food, fewer than 200 make substantial contributions to global food output, with only nine (sugar cane, maize, rice, wheat, potatoes, soybeans, oil-palm fruit, sugar beet and cassava) accounting for 66 per cent of total crop production in 2014. The world's livestock production is based on about 40 animal species, but only a handful provide most of the global output of meat, milk and eggs. Among extant local breeds, 26 per cent are classed as being at risk of extinction. A third of freshwater fish species assessed are considered threatened.[64] Pollinators, natural enemies of pests, and beneficial soil organisms are under pressure from threats including habitat degradation and pollution.

Climate change accelerates damage to ocean and coastal ecosystem integrity and functioning, impacting fishery catch and coastal livelihoods (SDG 2). Climate change, biodiversity loss and ocean acidification are increasing risks to fisheries and aquaculture via impacts on fish physiology, survivorship, habitat, reproduction and disease incidence, and on invasive species, and these effects will increase at higher levels of warming.[65] One projection suggests a decrease in global annual fishery catch for marine fisheries of more than 3 million tonnes for 2°C of global warming.[66] This threatens benefits for coastal livelihoods, especially for fishing communities in the tropics, sub-tropics and the Arctic.[67,68] In the oceans, nearly a third of fish stocks are already overfished[69] and over 55 per cent of the total ocean area has been subject to industrial fishing.[70]

4.3. Environmental Risks and Human Health

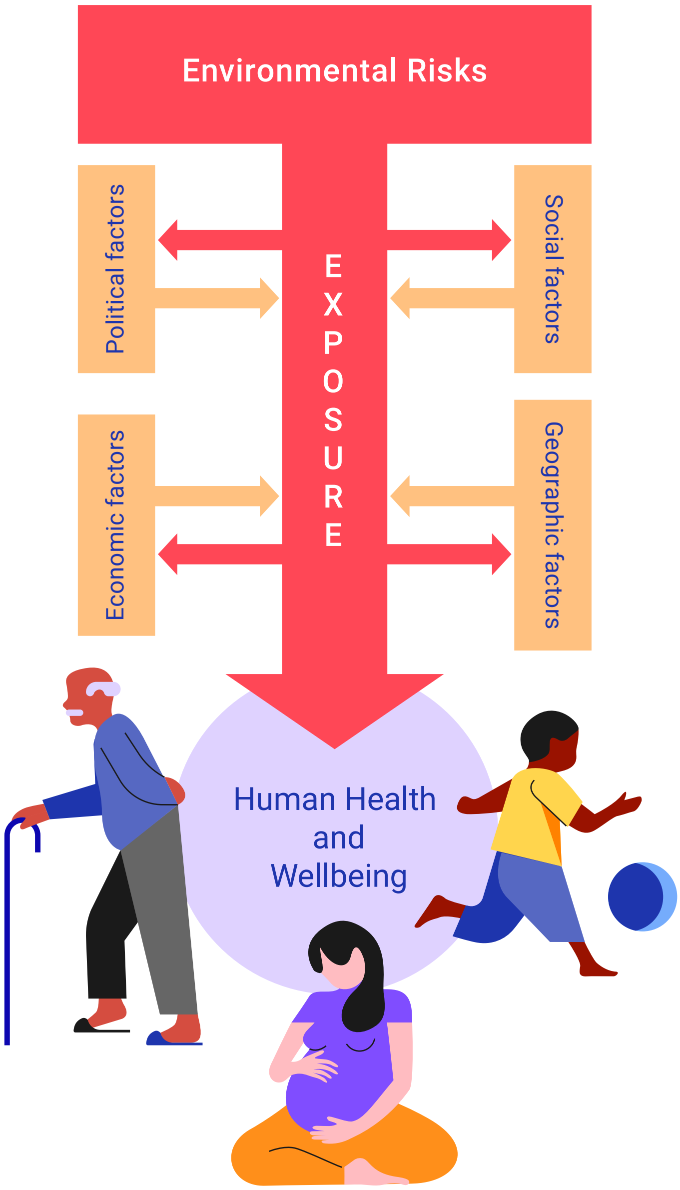


Figure 4.3: Connections between environmental risks and human health and well-being.

4.3 The deteriorating environmental health of the planet undermines human health (SDG 3)

Environmental degradation impacts human physical and mental health and causes millions of deaths annually (SDG 3). In 2012, almost a quarter of all deaths were attributable to modifiable environmental health risks, including air, water and land pollution; heatwaves, flooding and other weather extremes due to climate change; spread of pathogens; desertification; reduced biodiversity; and food insecurity.[71] The SDGs address many of these risks, including vector and water-borne diseases (SDG 3.3), non-communicable diseases and mental health (SDG 3.4) and exposure to hazardous chemicals and air, water and soil contamination (SDG 3.9). The incidence of non-communicable diseases is on the rise globally and will continue to be affected by the state of the environment in relation to pollution, diet and physical (in)activity. Furthermore, emerging impacts and challenges for human health and well-being include threats from antimicrobial resistance, industrial chemicals, multiple exposures and newly emerging diseases.[72]

Environmental pressures disproportionately affect the health of vulnerable and disadvantaged groups. The young, the elderly, women, people living in poverty and or with chronic health conditions, indigenous people and those targeted by racial profiling are some of the groups whose health is most vulnerable to the impacts of environmental decline.[73] Diarrhoeal disease, mostly caused by faeces-contaminated water, is responsible for around 1.7 million deaths every year, many of them children under 5 in sub-Saharan Africa and South Asia.[74] This is a prime example of how environmental pressures can disproportionately affect the young, especially as a significant proportion of these deaths can be prevented through safe drinking water, adequate sanitation and handwashing (SDGs 6.1 and 6.2).[75] The multifaceted relationship between the environment and human health should be framed within the context of social determinants of health as illustrated in figure 4.3. Socioeconomic and cultural factors have significant impacts on human health, through lifestyle choices and agency, inequalities, and damaging practices such as war, violence, unsafe working conditions and child labour.[76] Social and wealth inequalities as well as complex interrelations between health, socioeconomic and environmental factors, must be considered when striving to achieve SDG 3.

Climate change increases health risks through undernutrition, disease, mental health stressors and violence, extreme weather events, heat stress and pollution. Health impacts from climate change depend on population vulnerability, individual livelihood status, cultural identity, income level and living area. Low-lying coastal zones and small island states, for example, will be more exposed to storm surges, coastal flooding and sea level rise.[77] Increases in ambient temperature are linearly related to hospitalizations and deaths once specific thresholds are exceeded. Risks associated with extreme weather events such as heatwaves, heavy precipitation in several regions, and droughts in some regions already become high between 1°C and 1.5°C warming (see figure 1.1, panel b). Tipping points could exist for human systems with increased temperatures and may arise in places in which low human adaptive capacity exists. Warming of ambient temperatures by up to 3°C is projected to see substantial increases in heatwaves causing heat stroke and death.[78,79] Risks of heat-related mortality and morbidity become high between 1°C and 3°C of global mean temperature increase,[80] whilst above 4°C climate-related health impacts will likely increase non-linearly. Increased variability in precipitation patterns (e.g. shifts in monsoon seasons) is projected to increase the incidence of water-related and vector-borne diseases.[81] For example, the Aedes mosquito-borne diseases (dengue, chikungunya, Zika and yellow fever) are expected to expand their ranges, exposing additional populations to the risk of infection.[82] It is estimated that the world will see around 60,000 additional deaths due to climate change-induced malaria for the year 2030 and 30,000 deaths for 2050.[83] There is a lack of projections indicating how climate-sensitive health outcomes such as diarrheal disease and mental health could be affected by climate change.[84]

Ecosystem degradation, biodiversity loss and increased human-animal interactions are eroding nature's contributions to human health and exacerbating the risk of zoonotic diseases. Urbanization, current agricultural practices, land-use change and biodiversity loss are altering ecosystem dynamics and facilitating increased human-animal contact. These changes exacerbate the risk of zoonotic disease emergence and spread.[85] Infectious diseases that develop into epidemics or even into pandemics, as is currently the case for the Coronavirus SARS CoV2 disease (COVID-19; see box 4.1), have major health, economic and social implications that may impact the way society interacts with the environment.

Nature's ability to support the provision of medicines is in decline worldwide. An estimated 4 billion people rely primarily on natural medicines for their health care, with communities living in lower-income settings particularly reliant on largely plant-based traditional medicines. The health of these people is compromised as wild collected medicinal plants become less available. Some 70 per cent of drugs used for cancer are natural or are synthetic products inspired by nature and more than 20 per cent of modern drugs used for all diseases are based on leads from natural molecules, identified by science or based on indigenous local knowledge, including aspirin, vincristine and taxol. Though novel natural medicines are continuously being identified, the potential for future discoveries is critically undermined by biodiversity loss.[86,87]

Pollution is expected to continue to contribute to millions more premature deaths in the coming decades. In 2015, it was estimated that 6.5 million deaths were attributable to ambient and indoor air pollution combined, 1.8 million deaths to water pollution (unsafe water sources and inadequate sanitation) and another 1.3 million deaths to pollution stemming from soil, heavy metals, chemicals and occupational environments.[88] As these three categories have overlapping contributions, total pollution-related mortality is estimated at 9 million deaths (16 per cent of total global mortality), which is three times as many deaths as AIDS, tuberculosis and malaria combined. From a health perspective, the most important outdoor air pollutants are ground-level ozone and fine particulate matter. Due to emissions from industrial, agricultural, vehicular and domestic activities, as well as background dust and wildfires, large proportions of the global population remain exposed to levels of air pollution exceeding WHO guidelines.[89] The frequency and intensity of dust storms due to land degradation have increased over the last few decades in many dryland areas.[90] Scenarios that assume that past trends of stricter air pollution policies, coupled with increasing incomes will continue into the future, still anticipate 4.5 million to 7 million premature deaths globally by mid-century.[91] Ground-level ozone peaks, particularly in urban areas, are projected to increase ozone-related deaths. Total atmospheric mercury concentrations have increased by about 450 per cent above natural levels due to human activity, contributing to high mercury loads in some aquatic food webs and presenting a serious human health concern.[92]

Eliminating emissions of ozone-depleting substances has prevented millions of cases of skin cancer. Ozone in the stratosphere screens out biologically damaging ultraviolet radiation. Excessive ultraviolet radiation exposure leads to melanoma and non-melanoma skin cancer, cataracts and other health problems in humans.[93] If action had not been taken, growing emissions of ozone-depleting substances would have destroyed two thirds of the ozone layer by 2065, leading to millions of cases of skin cancer annually.[94]

Mental health will become increasingly affected by the loss of nature and extreme weather events. Time spent in nature has positive impacts on physical and mental health. Natural and semi-natural ecosystems are spaces for physical exercise, recreational activities and mindfulness, and contribute to well-being, happiness, quality of life and a sense of place and belonging.[95] Other benefits of biodiversity include cultural identity and reduced post-surgery recovery time in patients with trees outside their hospital rooms.[96] Though mental health risk projections for different degrees of warming are lacking, projected increases in environmental health risks such as increased incidences of flooding events, desertification and biodiversity loss can cause diffuse human health effects via conflict and migration, while natural disasters can cause emotional stress, such as post-traumatic stress disorder.[97]

Box 4.1 The risk of pandemics: the case of COVID-19

Several global assessments have highlighted the links between the health of the planet and human health. Infectious human diseases are caused by viruses, bacteria, fungi, or parasites. Zoonotic diseases, or zoonoses, are infectious diseases transmitted between animals and humans. Infection of people occurs through direct or indirect contact and can be vector-borne (for instance by a tick or mosquito), food-borne or water-borne. Nature is the origin of most infectious diseases, but also a source of medicines, including antibiotics, for treatment. Zoonotic diseases have been significant threats to human health throughout human history.[98,99] *About 75 per cent of all new infectious diseases in humans have their origin in animals.*[100] *More than 335 emerging infectious diseases outbreaks were reported worldwide between 1940 and 2004, more than 50 per decade, and the frequency of their emergence is increasing. In the latter part of that period, about half of all emerging infectious disease outbreaks originated in wildlife. Among emerging zoonoses specifically, 72 per cent of outbreaks originated in wildlife, with the rest from domestic animals.*[101] *Populations of wild animals carry a high diversity of potential zoonotic pathogens, especially where the diversity of host animals is higher, as is the case in the world's tropics.*[102]

Most diseases in wild animals remain very poorly studied, many pathogens remain unidentified, and many outbreaks are overlooked.[103] *It is estimated that out of 1.6 million potential viruses in mammals and birds, 700,000 could pose a risk to human health without urgent preventative action.*[104] *Given that human ecological disruption and unsustainable consumption drive the risk of zoonotic spillover, humans' adverse impacts on nature need to be addressed to curb pandemics.*[105]

Emerging zoonoses have significant implications for public health and economic stability, with the costs of recent major outbreaks, such as SARS, MERS and Ebola, estimated in the tens of billions of US dollars each and exceeding 1–2 per cent of GDP in less wealthy countries.[106] *When all is counted, it is expected that the economic devastation caused by COVID-19 will be far greater, measured in trillions to tens of trillions of US dollars.*

COVID-19 was declared a pandemic by the WHO on 11 March 2020.[107] *The disease is a severe acute respiratory syndrome, caused by a coronavirus (SARS-CoV-2). The virus spread quickly across the world via international* *travel. In an effort to reduce mortality rates, avoid over-burdening healthcare services and protect vulnerable groups, most countries around the world put in place strict measures to reduce person-to-person spread through social distancing and restrictions – including shutdowns – of offices, schools, stores and travel. The pandemic has upended people's lives, brought sectors such as international air travel and tourism to a standstill, and caused major health, economic and social impacts around the world. As of December 2020, more than 64 million cases of COVID-19 have been recorded and 1.5 million people have died.*

A temporary positive impact of the pandemic has been seen for some aspects of air quality. Due to a sharp decline in travel and other economic activities, local air pollution and greenhouse gas emissions fell in many places. An unprecedented drop in daily global carbon dioxide emissions was seen from the start of the pandemic to early April 2020. The brief but marked improvement in some aspects of air quality illustrate what could be gained by ambitious action to reduce the environmental impact of transport (see box 8.1).

4.4 Environmental change accentuates inequalities (SDGs 5 and 10)

Inequalities in environmental opportunities and burdens are expressed and interconnected at various levels, arising between and within countries along dimensions of ethnicity, gender, race and income. Environmental burdens associated with pollution, resource scarcity and extreme events accentuate socioeconomic inequalities and are projected to increase under current development trajectories.[108,109,110] For instance, environmental pressures and their impacts on health and well-being fall especially on groups that are already vulnerable or disadvantaged (see Section 4.4). Furthermore, where poor people find work either in industry, agriculture or the informal sector, they are more likely than higher-wage employees to work in dangerous, unregulated settings where risks such as exposures to hazardous chemicals are high.[111]

Climate change accentuates inequality through direct and indirect impacts. Climate change disproportionately affects disadvantaged and vulnerable populations through food insecurity, higher food prices, income losses, lost livelihood opportunities, adverse health impacts and population displacements.[112] Some of the worst impacts are expected to fall on agricultural and coastal livelihoods, indigenous people, women, children and the elderly, poor labourers, poor urban dwellers in the Global South, and people and ecosystems in the Arctic and Small Island Developing States .[113,114] Countries with higher initial temperatures, greater climate change levels and lower levels of development, which often implies greater dependence on climate-sensitive sectors and in particular agriculture, are expected to bear the highest levels of impacts.[115]

Gender inequality accentuates vulnerability to environmental change and differences in access to the social and environmental resources needed for adaptation. Whereas both men and women experience changing demands in productive roles, women experience increasing burdens due to factors such as family care and reproductive responsibilities, and differential access to labour markets, land rights, education, health, and financial resources, as well as, in many contexts, unequal decision-making power.[116,117,118] Gender inequality is particularly marked in agriculture. While agricultural production is increasingly feminized, agricultural and food policies, including training and research and development, do not consider the specific needs of women. Furthermore, women have limited access to decision-making processes for resource management and have less access to resources that increase agricultural output, including financial resources, land, education, health and other basic rights. Women's relatively higher vulnerability to weather-related disasters is documented in terms of number of deaths and in how socially constructed gender differences affect exposure to extreme events, leading to differential patterns of mortality for both men and women.[119,120]

4.5 Environmental degradation impedes efforts to promote peace (SDG 16)

Many conflicts are linked to the exploitation of natural resources (SDG 16). Competition over land and resources can spark conflicts, including between actors with different levels of power where indigenous peoples or local communities often are vulnerable. Since the mid-twentieth century, at least 40 per cent of all intrastate conflicts have been linked to the exploitation of natural resources, whether high-value resources like timber, diamonds, gold, minerals and oil, or scarce ones like fertile land and water.[121] More than 2,500 conflicts linked to fossil fuels, water, food and land are currently occurring across the planet, and at least 1,000 environmental activists and journalists were killed between 2002 and 2013. Violence is also used to discourage resistance to large-scale degradation.[122]

Environmental degradation can intensify disputes within and between countries. Land degradation, exacerbated by climate change, reduces land availability and livelihood safety nets, which may increase competition for land potentially leading to migration and/or conflict, especially in drylands.[123,124] Water crises, involving a significant decline in the availability, quality and quantity of fresh water, have been identified as among the top global risks for the coming decade.[125] Water scarcity is exacerbated by increasing demand (including from agriculture), climate change and local contamination as well as the construction of large dams and changes in resource rights. Water disputes (including cross-border disputes) can contribute to political instability, disrupt institutions and weaken natural resource governance, fuelling insecurities and distrust among stakeholders that can lead to conflict.[126]

Linkages between environmental degradation, migration and conflict occur within a larger context of multiscale interaction of environmental and non-environmental drivers and processes. In an increasingly connected world, consumption, production and governance decisions in one country increasingly influence materials, waste, energy and information flows in other countries. Decisions taken by powerful actors in order to generate economic gains can shift economic and environmental costs in ways that lead to or exacerbate conflicts. Least developed countries, often rich in and more dependent upon natural resources, have suffered the greatest land degradation, experienced more conflict and lower economic growth and contributed to environmental outmigration by several million people.[127] Indigenous peoples and local communities have directly experienced threats and expulsion from their lands to make way for mining, agricultural expansion and industrial logging for export.[128] While the relationship between climate change and conflict is relatively weak, there is a positive and statistically significant effect between climate change and outmigration for agriculture-dependent communities. Furthermore, drought significantly increases the likelihood of sustained conflict for particularly vulnerable nations or groups, owing to the dependence of their livelihood on agriculture and natural resources.[129]

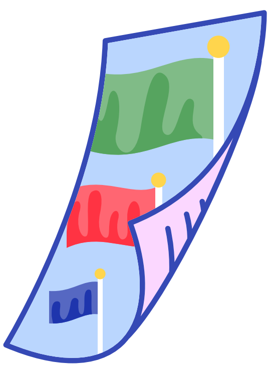
4.6 Environmental degradation hampers efforts to make cities and communities sustainable (SDG 11)

Cities and communities are negatively affected by climate change, loss of nature and pollution, hindering them in becoming inclusive, safe, resilient and sustainable (SDG 11). Climate change and ecosystem degradation are impacting the provision of basis services to urban populations living in informal settlements (SDG 11.1) and can accentuate extreme weather events and their impacts (SDG 11.5). With around 6.5 million deaths annually related to ambient and indoor air pollution and 3 billion people lacking access to adequate waste disposal facilities, air pollution and waste management remain challenging in many cities (SDG 11.6). Compared to high-income neighbourhoods, informal settlements are more vulnerable to environmental degradation as they are often in areas prone to flooding, landslides and other natural disasters and close to landfills.

Climate change is projected to increase risks for urban populations, assets and economies. Key risks to settlements from climate change that span sectors and regions and are projected to increase include heat stress, heavy precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges. Coastal communities are exposed to additional climate-related hazards, including tropical cyclones, marine heatwaves, sea-ice loss and permafrost thaw.[130,131] Cities, especially large landlocked cities, will be exposed to increased heat stress due to the urban heat island effect, which increases the intensity of heatwaves by an estimated 1.22°C to 4°C.[132,133] This is particularly relevant as the number of mega-cities grows.[134] Urbanization also increases extreme rainfall events over or downwind of cities.[135] Key urban risks associated with housing[136] include poor quality and inappropriate location, making them more vulnerable to extreme events. Climate-related risks will be amplified for those lacking essential infrastructure and services or living in exposed areas.[137,138]

Climate change and ecosystem degradation will impact coastal communities through submergence, coastal flooding and erosion. The population and assets projected to be exposed to coastal risks as well as human pressures on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development and urbanization. The costs of coastal adaptation vary strongly among and within regions and countries. Some low-lying developing countries and small island states are expected to face very high impacts that, in some cases, could have associated damage and adaptation costs of several percentage points of GDP (on low lying urban islands and urban atoll islands).[139,140] The vulnerability of coastal cities to natural disaster is exacerbated by loss of ecosystems such as mangroves that reduce the risks from storm surges.[141] In the absence of more ambitious adaptation efforts and under current trends of increasing exposure and vulnerability of coastal communities, annual coastal flood damages are projected to increase by 2–3 orders of magnitude by 2100 compared to today.[142]

Rapid development and urbanization combined with insufficient environmental governance in many regions suggest a likely worsening of air pollution and rising solid waste. Traffic, residential fuel burning, electricity generation, industry and agriculture all contribute to urban air pollution, with varying contributions of sectors in individual cities. In growing cities across Africa, Asia and other developing regions, there has been a rapid increase in the number of vehicles, driven by population growth and economic development. The impacts of pollution from megacities extend far beyond the urban area with effects at local, regional and global scales.[143] Solid waste is mostly generated in and disposed of in cities and its volume correlates with purchasing power. Cities produce 1.3 billion tons of solid waste per year. Solid waste per capita has doubled over the last decade.[144] Many low-income cities still have waste collection coverage in the range of 30–60 per cent.[145] With increasing incomes, global waste volumes are going to increase further, which will increase the pressure for policies that decouple economic development and human well-being from resource consumption. For example, without global intervention, the quantity of plastic in the ocean alone could increase to 100–250 million tons by 2025.[146] Waste has also become a global economic sector, with large quantities of often hazardous waste being unlawfully exported to developing countries, with the potential to cause significant impacts.[147] As developed countries pursue the goals of reduced waste, a circular economy and greater resource efficiency, developing countries must not be left behind.[148]



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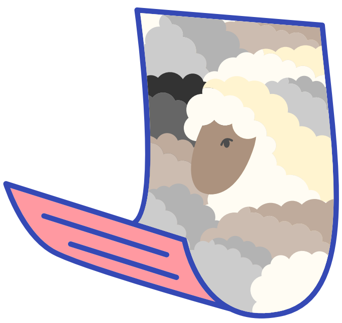
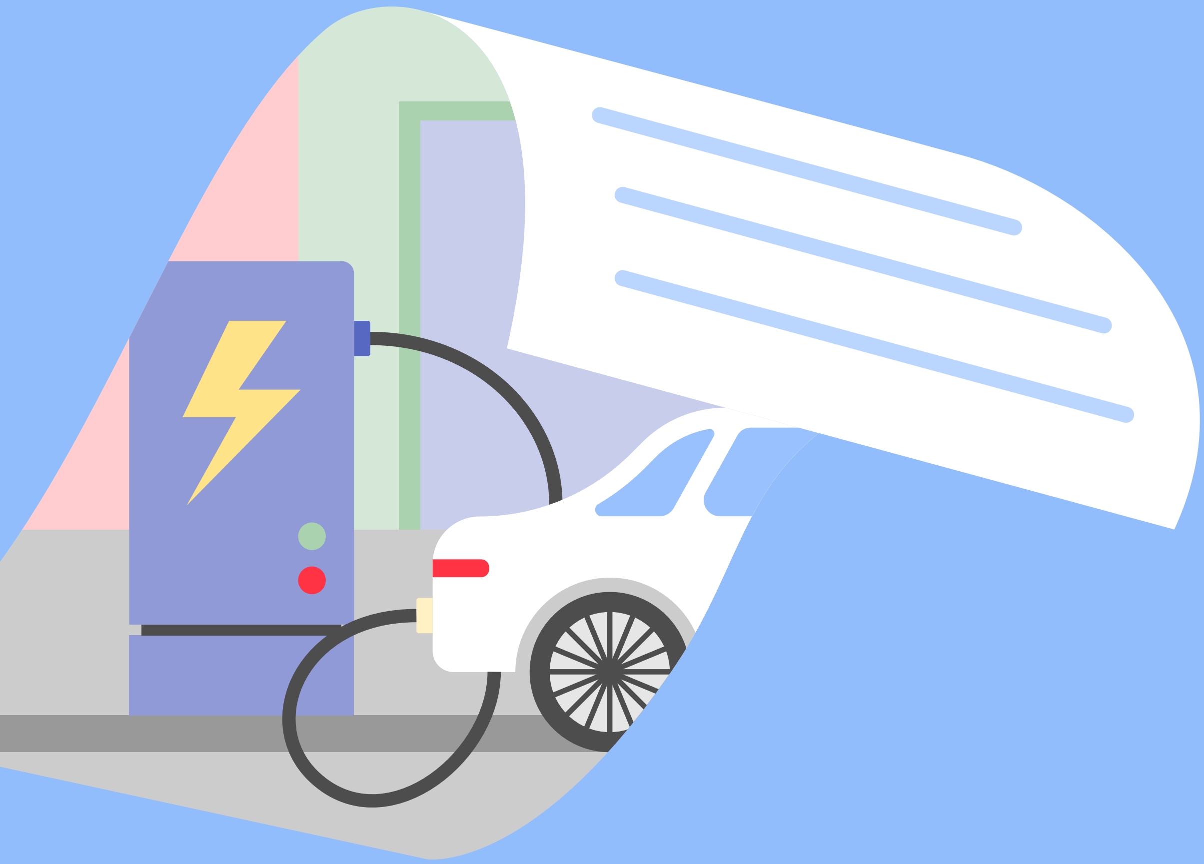





II. Transforming humankind's relationship with nature is the key to a sustainable future

5

Human knowledge, ingenuity, technology and cooperation can transform societies and economies and secure a sustainable future

Only transformative change will enable humanity to fulfil international environmental agreements and achieve the Sustainable Development Goals. Only a "fundamental, system-wide transformation across technological, economic and social factors, including paradigms, goals and values" can reverse the current trends that threaten the well-being of present and future generations and the survival of other species.[1,2,3] Transformation can also enable the realization of the collective vision of a sustainable future for humanity, one that involves a rapid and thorough decarbonization, food security for all, an end to poverty, harmony with life on land and beneath the water, and substantial improvements in justice and fairness.[4,5]

5.1 Transformative systemic change is a prerequisite for a sustainable future

Mitigating climate change, conserving biodiversity and meeting other environmental challenges requires fundamental and systemic changes in social and economic systems. Current responses to these challenges have included sectoral interventions and increasing cross-sectoral cooperation, but these have fallen short of the systemic change required to transform the underlying drivers of environmental change.[6]

Transformative societal change would affect not only the subsystems described below (including economic and financial systems, energy systems, food systems, water systems, health systems, and systems for infrastructure and settlement), but rather simultaneously and holistically reshape these systems and the interactions between them. Human attention and political will are often exhausted after addressing system issues, including controversies involving trade-offs between different interests, whereas the emphasis should be on the possible synergies and multiple benefits of change. The magnitude of the problems hampering change requires larger-scale and more fundamental actions addressing the rules and dynamics of systems.[7]

Transformation does not necessarily entail changing everything massively and quickly. Transformative change can be a product of incremental but cumulative changes – especially if those changes affect key drivers, such as structural elements or fundamental processes.[8] Each individual and organization has a role to play in moving society along pathways toward a sustainable future that will vary across nations, regions and contexts, including through existing institutions and policy approaches.

Fundamental, system-wide reorganization requires significant upfront investment but can generate large positive returns. For example, studies of greenhouse gas emissions reduction show that the costs of doing nothing, measured in terms of damages from future climate change, far exceeds the costs of investing in mitigation (see Section 4.2). Some emissions reduction strategies pay for themselves, such as investments in energy efficiency that can deliver cost savings of US$2.9–3.7 trillion per year by 2030 or switching to low-cost renewable energy sources.[9] Other interventions may need to be accompanied by structural changes so that the positive returns for society also generate positive economic returns for a business or household and encourage widespread adoption. This often requires the reform of subsidies and incentive structures (see Sections 5.1.2, 5.2). To guide and measure the outcomes of government action, more inclusive measures of wealth and economic performance can address the limitations of conventional metrics such as GDP, which fail to properly reflect the benefits of change because they exclude important non-market social or environmental benefits or damages such as negative externalities (see Section 5.2).

5.2 The levers and leverage points for transformative change

Transformative change towards sustainability can result from strategic intervention at key points of leverage within systems. Implemented globally, transformative change would result in a world that operates differently in many important respects. To envision change on this scale, it can be helpful to identify elements of the destination of transformative change, or leverage points and describe the change needed in these elements. It is also possible to pinpoint key "levers" of a strategy to bring such change about, including a "carrots and sticks" approach. The elements and levers are outlined below. Constantly recalling the elements of the destination and adaptively managing systems can help to realize this vision.

The elements of the "destination" and the strategy for transformative change are derived from several recent reports. Reviewing a wide range of assessments and other scenario and pathways analyses at global and regional scales, the IPBES Global Assessment proposed a framework for categorizing actions and strategies toward transformative change in terms of eight leverage points and five levers (recognizing that the metaphor of leverage is an imperfect one and that changes to complex systems are not straightforward). The UN Global Sustainable Development Report focuses on a set of four levers for achieving sustainable development [(i) governance, (ii) economy and finance, (iii) individual and collective action and (iv) science and technology] and six entry points to sustainability transformation [(i) human well-being and capabilities, (ii) sustainable and just economies, (iii) energy decarbonization and access, (iv) food systems and nutrition patterns, (v) urban and peri-urban development and (vi) global environmental commons.[10]] This report lists eight leverage points in global, regional and local systems, and simplifies the five IPBES and four UN levers into three kinds of governance interventions. This is not a suite of options, but rather a checklist of constituents: each element likely must change in the transformation to sustainability, whereby some elements substantially enable others.[11]

Key areas for transformative change:

1. **Paradigms and visions of a good life:** Move towards paradigms that emphasize relationships with people and nature over material consumption, including many existing visions of good lives as those lived in accordance with principles and virtues of responsibility to people and nature.

2. **Consumption, population and waste:** Reduce the negative global effect of human needs and demand – a function of consumption and production rates, population size, and waste – by reducing per capita consumption and production in some regions and human population growth in others.

3. **Latent values of responsibility:** Unleash existing capabilities and relational values of responsibility to enable widespread human and organizational action.

4. **Inequalities:** Systematically reduce inequalities in income and other forms, including across gender, race and class.

5. **Participation in governance of environmental action and resource use:** Practice justice for and inclusion in decision-making of those most affected by it, especially including indigenous peoples and local communities.

6. **Externalities:** Understand and internalize the distant, delayed and diffuse negative effects of actions, including economic activity.

7. **Technology, innovation and investment:** Transform regimes of investment and technological and social innovation, such that technologies and their use produce net-positive impacts on people and nature (for example, by transitioning to a circular economy and eliminating waste).

8. Education and knowledge generation and sharing: Promote the broad base of knowledge and capability that is fundamental to well-functioning and just societies, and increase and spread knowledge specific to sustainability.

The strategy and levers for transformative change:

A. Fix the "carrots" and build capacity: Change the incentive structure facing individuals and organizations, including by broadly reforming subsidies to shift from harmful production-enhancing ones towards those that directly improve well-being and a suite of social and environmental capacities and outcomes. Simply adding new incentives to balance the negative effects of existing subsidies is not sufficient because of a lack of underlying capacity for environmental stewardship and because existing subsidies have systemic perverse effects.

B. Manage better: Reform management organizations, programmes and policies to make them pre-emptive, inclusive, integrated across sectors and jurisdictions, robust to uncertainty, and geared towards system resilience or transformation as needed. Existing management systems are largely historical artefacts of the nineteenth and twentieth centuries, geared towards underpopulated lands and lightly used waters, imagining linear relationships between causes and their effects. Sustainable pathways through the twenty-first century will require management systems designed to accommodate the complexity of social and ecological systems and pervasive and long-distance effects in space and time of local actions. Management would include unilateral action within states as well as bilateral and multilateral action across them.

C. Strengthen the "sticks": Bolster environmental laws and policies and strengthen the rule of law by ensuring consistent enforcement of all laws, including by eliminating corruption and strengthening institutions such as independent judiciaries.

Change in organizational and individual behaviour pervades every element of transformative change. Every lever applied at every leverage point entails and effects changes in human action, including by policymakers, politicians and a diverse set of actors in business and civil society. These changes can be top-down and/or bottom-up and can be accelerated when pressure for change emanates from multiple sources. Each lever can be applied at each leverage point by managers and decision makers at local, regional, national and international level, triggering broader social and industrial change. Government action may follow pressure from businesses and industry associations, public opinion and protest or advocacy from civil society organizations. Thus, these levers and leverage points are available both to those designing policy and practices and to those seeking to shape policy and practice via grassroots or other bottom-up actions.

Six systems are key entry points for transformations towards sustainability. Synthesizing the six foci of the IPBES Global Assessment,[12] the Global Sustainable Development Report's six entry points, and the six transformations of The World in 2050 initiative, it is possible to identify six areas for system transformation: economy and finance; food and water; energy; human settlements; health, equity and peace; and environment (see table 5.1).

Applying the levers to the leverage points fosters system transformations that move society toward sustainability. All three levers at the heart of a strategy for transformative change can be applied to each of the leverage points identified (see table 5.1). Similarly, pressure applied at the leverage points can drive transformational change in key systems. Bi-directional relationships between some systems and leverage points mean that systemic change can help shift the leverage points closer to the destination of sustainability. For instance, paradigms and visions of a good life (1) impact all systems. They are in turn shaped by changes especially in economy and finance, human settlements and health, equity and peace. Patterns of consumption, population and waste (2) both shape and are shaped by all six systems. Latent values of responsibility (3) are relevant to the actions of all players within the system (such as consumers, farmers and food distributors), and the configuration of systems can unleash action by all actors in line with latent values. Addressing inequalities (4) and enhancing participation (5) can enable system transformations; all six system transformations can lessen inequalities and enable participation. Similarly, addressing externalities (6) could enable the six system transformations, while the transformations within each system should substantially reduce externalities. All six system transformations could be driven partly by appropriate technology, innovation and investment (7); meanwhile economy and finance, energy and human settlements could also drive needed changes in technology, innovation and investment. Education and knowledge generation and sharing (8) could be a driver of all system transformations via specific knowledge systems and general societal education; only transformations in human health, equity and peace can really advance this leverage point.

Transformative change can result from the culmination of many seemingly small but strategic actions, while some attractive and feasible actions can impede transformation. Global systems are multiscalar and complex and actions intended to generate change face risk from co-option, unintended effects and unforeseen feedbacks. By acknowledging these risks and uncertainties, actions can be characterized in terms of their contribution to transformative change.

- *Transformative enablers* are important actions that facilitate broader systemic change (e.g. the replacement of GDP by better measures of sustainability such as inclusive wealth).
- *Incremental enablers* are actions that yield small changes whose accumulated impact contributes to transformative change (e.g. slowly shifting and reorienting subsidies, wholesale subsidy reform would be a transformative enabler).
- *Necessary* measures are actions to protect nature and its contributions to people in the short term, but which may not contribute to transformative change (e.g. the expansion of protected areas).
- *Insufficient measures* are interventions that may contribute somewhat to environmental protection in the short term, but detract from longer-term efforts towards transformative change (e.g. incentive programs for biodiversity and ecosystem services not accompanied by wider reform of harmful subsidies or environmental law).

Feasibility may vary widely across strategies and actions, but transformative enablers may only become feasible after intervention via incremental enablers or the triggering of tipping points. The changes that appear most feasible may be those that do not contribute to, or even impede, transformative change, for instance by retaining or even consolidating the power of interests vested in the status quo (see Section 5.3).

5.3 Implementing transformations and overcoming barriers from inertia and vested interests

Participatory and equitable processes can raise public acceptance of transformative change (leverage point 5). While the appropriate level and nature of inclusion of rights-holders and stakeholders varies across contexts, broad participation and the perception of fairness in decision-making processes and outcomes is key to generating public acceptance of transformative change (leverage point 5).[13,14]

Systemic opposition, friction and inertia can thwart transformative change.[15] Existing infrastructure and built capital create system inertia by making change difficult and costly. In addition, individuals and organizations have habits, procedures and ways of doing business. These norms yield a reluctance and resistance to change. Some individuals and organizations also have substantial stakes in maintaining the status quo. These vested interests may oppose change that disrupts their livelihoods, market share and future revenues. These barriers can be overcome with investments to overhaul infrastructure and built capital, directly confronting regressive habits and norms, and enabling the reorganization of labour by, for example, providing financial incentives and training to shift businesses and labour away from unsustainable industries and practices towards sustainable ones.

Societies have demonstrated both potential and limitations in the capacity to undertake widespread systemic change in the face of the COVID-19 pandemic. The 2020 mobilization in response to the COVID-19 pandemic indicates how societies are capable of systemic change, but also how parts of society may resist change. The rapid design, implementation and relatively widespread acceptance of physical-distancing measures, restrictions on movement and economic activities, despite the resulting economic and social dislocation in many nations, demonstrate how shifts in norms and priorities (leverage points 1 and 3) can reshape multiple systems.

Widespread systemic change is needed to address the global environmental emergencies through mitigation, restoration and adaptation. Transformative change must begin now to avoid imposing huge and potentially irreversible environmental declines on today's youth and future generations. A sustainable future is achievable, and it can be a just and prosperous one, full of human ingenuity and opportunity, nourished by and caring for a vibrant natural world. The following sections on the key systems for transformation detail specific changes that can enable society to collectively realize this ambitious but essential vision for humanity and the Earth.

1 IPBES 2019a, GA SPM, C
2 IPCC 2018b, SR1.5 SPM, C2
3 UNEP 2019b, GEO-6 SPM, 4.2
4 IPBES 2019b, GA, 5
5 TWI 2050, 2019
6 UNEP 2019a, GEO-6, 12, 17
7 IPBES 2019b, GA, 5
8 IPBES 2019b, GA, 5
9 IRP 2017
10 GSDR 2019, II
11 IPBES 2019b, GA, 5
12 IPBES 2019b, GA, 5.4.3
13 IPCC 2018a, SR1.5, 2
14 IPBES 2019b, GA, 5
15 IPBES 2019b, GA, 5

Table 5.1. The action of the levers and leverage points in fostering the six key system transformations

Levers	Leverage points	System transformations					
Governance and individual actions		Economy and finance	Food and water	Energy	Human settlements	Human health, equity and peace	Environ-ment
A. Fix the "Carrots"; B. Manage Better; C. Strengthen the "sticks"	1. Paradigms and visions of a good life	●	○	○	●	●	○
	2. Consumpti-on, population, and waste	●	●	●	●	●	●
	3. Latent values of responsibility	●	●	●	●	●	●
	4. Inequalities	●	●	●	●	●	●
	5. Participation in environmen-tal action and resource use	●	●	●	●	●	●
	6. Externalities	●	●	●	●	●	●
	7. Technology, innovation and investment	●	○	●	●	○	○
	8. Education and know-ledge generati-on and sharing	○	○	○	○	●	○

Direct actions that can foster the system transformations,·

● = Both levers and leverage points can apply

○ = Leverage points can primarily influence the system transformations

6

Earth's environmental emergencies must be addressed together to achieve sustainability

Climate change, loss of biodiversity, land degradation, and air and water pollution are highly interconnected. This section examines how these interconnected systems can be transformed individually and collectively to be sustainable, assessing which actions are synergistic and which involve trade-offs, emphasizing actions needed in the short-term.

Protecting life on Earth, including human life, requires actions that are significantly more effective than those taken thus far. Action to halt the loss of biodiversity and land degradation, avoid dangerous climate change and keep the effects of chemicals on the biosphere within tolerable limits must be coordinated to be effective. All these forms of degradation are primarily driven by the unsustainable level of consumption by the well-off, while the poor are left behind, characterizing contemporary civilization. Achieving transformative change requires that the fundamental drivers of overconsumption are addressed, through changes in personal values, norms, economic and social operating rules, technologies and regulations.

Given the interconnected nature of climate change, loss of biodiversity, land degradation, and air and water pollution, it is essential that these problems are tackled together urgently. Actions needs to be taken now even where the benefits may not be realized for years due to the long-lasting nature of environmental effects or to inertia in the socioeconomic system. Essential actions with delayed effects include reforestation and restoration of degraded lands. Response options that can address multiple environmental issues, mitigate multidimensional vulnerability and help minimize trade-offs and maximize synergies, need to be implemented. Numerous response options that can preserve and restore the environment and contribute to achieving some of the other SDGs have already been identified. For example, large-scale reforestation with native vegetation can simultaneously help address climate change, biodiversity loss, land degradation and water security. A key challenge is to avoid unintended consequences. For instance, large-scale afforestation schemes that replace native vegetation with monoculture crops to supply bioenergy can be detrimental to biodiversity and water resources.

6.1 Scaled-up and accelerated actions to address climate change in this decade are essential

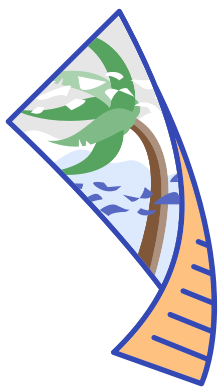
Mitigation and adaptation are both urgently needed to reduce the risks of climate change.[1] Mitigation is insufficient to remove all the risks from climate change since adverse climate impacts are already apparent and more are projected at 1.5°C of warming and beyond. Some impacts, such as sea level rise, will continue for centuries after the global temperature has stabilized.[2] Without meaningful climate mitigation, adaptation also will be insufficient to limit all the risks associated with climate change. Limits to adaptation already exist for the most sensitive human and natural systems at 1.5°C of warming, and further limits exist at higher levels of warming. A slower rate and magnitude of climate change creates additional opportunities for adaptation.[3]

Governments must scale up and accelerate action to meet the Paris Agreement goals and limit dangerous climate change. Evidence shows that the risks associated with climate change, including risks of extreme weather events, of impacts on unique and threatened ecosystems, and of large-scale discontinuities such as the disintegration of the Greenland and Antarctic ice sheets (see figure 1.1), are generally higher than previously understood. There is a near-linear relationship between future temperature change and cumulative carbon dioxide emissions. This relationship implies that net emissions would need to be reduced to zero within only a few decades if the Paris Agreement goals are to be met. Limiting the global mean temperature increase to well below 2°C and pursuing efforts to stay below 1.5°C, in line with the Paris Agreement requires significant strengthening and rapid implementation of existing national pledges to reduce greenhouse gas emissions. To limit global warming to 1.5°C, with a probability of about 50 per cent, net emissions of carbon dioxide will need to be reduced by 45 per cent by 2030 compared to 2010 levels and reach zero by 2050. To limit global warming to 2°C, emissions need to decline by about 25 per cent by 2030 compared to 2010 levels and reach net zero by around 2070.[4] Emissions of other greenhouse gases must also be reduced rapidly. The target year for net-zero emissions for other greenhouse gases is generally projected to occur about one or two decades later than that for carbon dioxide. More ambitious reductions would be necessary for higher certainty of avoiding dangerous climate change, as indicated in the emissions gap presented in figure 6.1, which shows pathways with about 66 per cent chance of limiting global warming to 1.5°C and 2°C.[5] Delaying action exacerbates difficulties and incurs greater costs.[6]

An important determinant in climate change mitigation is the timing of emission reductions, affecting both short-term and long-term technology choices. Slower emission reductions in the short term will require very rapid reductions later in the century, followed by the large-scale removal of carbon dioxide from the atmosphere, if the Paris Agreement goals are to be met. Carbon dioxide removal technologies differ widely in terms of maturity, potential and risks, while several technologies have significant negative impacts on land, energy, water and nutrients when deployed on a large scale. In contrast, the sequestration of carbon in restored natural ecosystems and soil do not require land-use change and can have co-benefits, such as improved biodiversity, soil quality and local food security. Effective governance is needed to limit trade-offs and ensure the permanence of carbon storage in terrestrial, geological and ocean reservoirs. If negative emission technologies become practical at scale and affordable in the second half of the century, they would allow for a slightly slower energy system transition to low-carbon technologies. Even in this scenario, net-zero emissions would need to be achieved around the middle of the century. If the deployment of large-scale carbon dioxide removal is to be limited, deeper near-term emission reductions are required, combined with measures that lower demand for energy and land.[7,8]

Limiting global warming requires rapid and far-reaching transformation of energy systems, land use, infrastructure and industrial processes. Emissions of carbon dioxide in both the land-use and energy systems can be reduced to zero or below based on a portfolio of mitigation measures, striking different balances between lowering energy and resource intensity, decarbonizing energy supply, and the reliance on carbon dioxide removal and behavioural change. For non-carbon dioxide emissions such as methane and nitrous oxide, measures have been identified to significantly reduce emissions from the energy sector (such as fugitive emissions of methane from mining) and agriculture (including methane from livestock and rice production), but it will be hard to reduce emissions to zero based on only technical measures. Immediate reductions in the emissions of short-lived climate forcers such as black carbon and methane are an important contribution in limiting warming. It should be noted that reductions in the use of fossil fuels also reduce cooling aerosol emissions, leading to less air pollution but also reducing the amount of climate change avoided.[9]

Adaptation involves both preparations for and responses to climate change impacts, with nature-based solutions playing a vital role. Mitigating climate change is vital, urgent and cost saving: the lower the degree of warming the easier and cheaper it will be to adapt. Societies, economies and ecosystems must adapt to changing temperature and precipitation patterns, including more heatwaves, heavy precipitation in several regions, droughts in some regions and higher sea levels. There has been significant progress in climate change preparedness over the last two decades. Adaptation options, if well-designed and managed in a participatory manner, can reduce the vulnerability of human and natural systems, and have many synergies with achieving the SDGs, including those related to food and water security, though potential trade-offs must be recognized. Adaptation is place- and context-specific and can be enhanced through complementary actions across all levels from individuals to governments. Increasing investment in social and physical infrastructure is vital to enhance the resilience and adaptive capacity of societies. Specific interventions can include climate-resilient agriculture, land-use planning, nature-based solutions such as conserving and restoring ecosystems, coastal defence systems and social safety nets. Nature-based solutions have gained prominence, given the close interlinkages between climate change and biodiversity loss, and the potential to deliver co-benefits. Nature-based adaptation options include restoration or protection of coral reefs, seagrass meadows, coastal wetlands, mangroves, and beaches to reduce coastal flooding and erosion; green and blue spaces to reduce urban flooding and heat-related risks; and protecting and restoring floodplains, peatlands, and riparian vegetation to reduce river flooding.[10,11,12,13]



6.1. The Emissions Gap

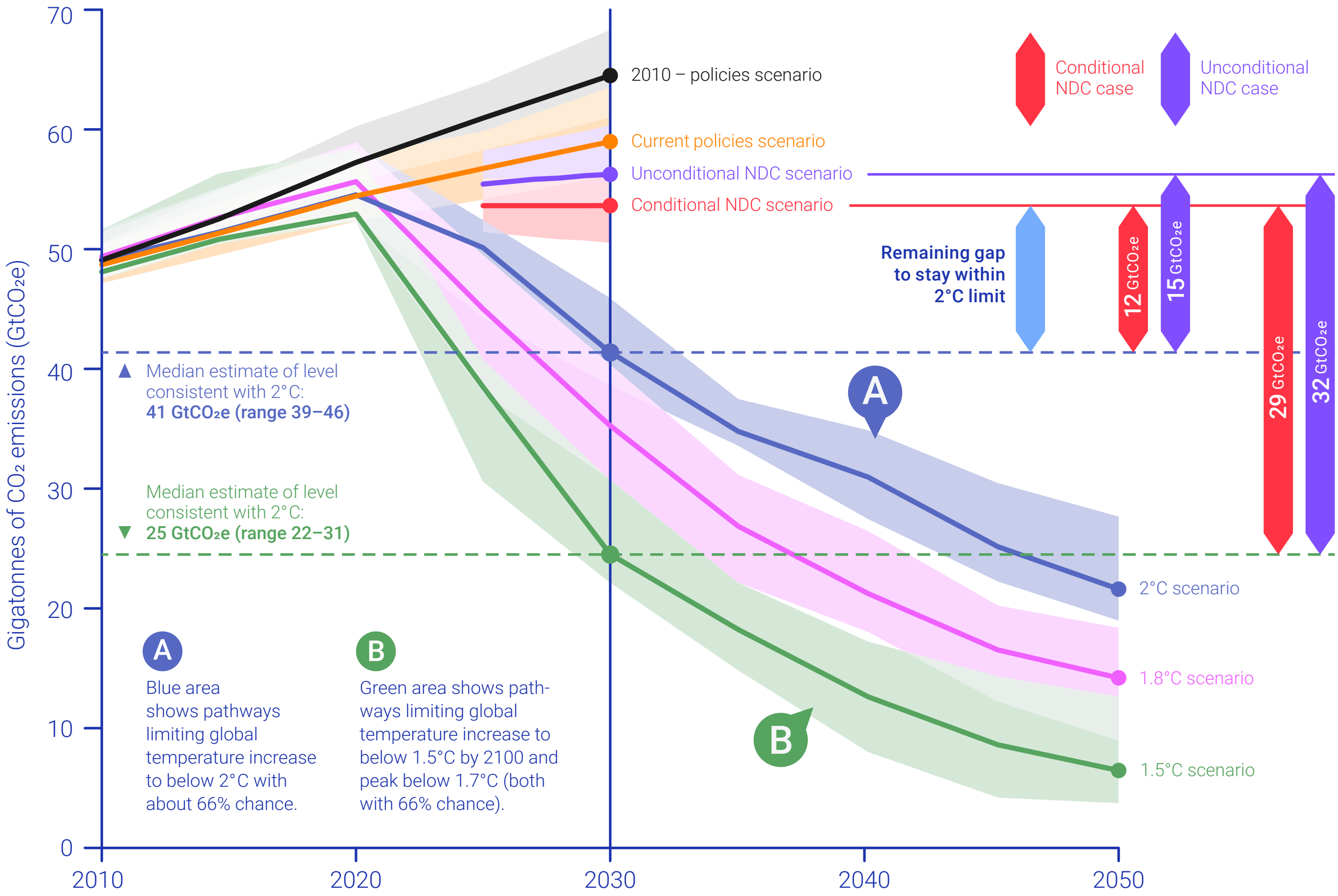


Figure 6.1: Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 for unconditional and conditional nationally determined contributions (NDCs) scenarios (median and 10th to 90th percentile range, based on the pre-COVID-19 current policies scenario).

Source: Figure adapted from UNEP 2020a, EGR, ES, Figure ES.5

6.2 Scaling up and accelerating the conservation, sustainable use and restoration of biodiversity is critical

Substantial gains in the protection of nature can be achieved through the sustainable management and restoration of landscapes and seascapes that are productive and often inhabited. Transformative actions to reduce the drivers of biodiversity loss must necessarily occur mostly in human-populated and production-oriented landscapes and seascapes outside of protected areas. This requires the development of new land- and resource-use rules and objectives that are beneficial, neutral or at least much less harmful to biodiversity, while permitting uses benefitting humans.[14] Effective management of land and sea resources and their biodiversity requires a situation-appropriate combination of: security and clarity of land tenure and responsibility; financial and non-financial incentives to resource owners and custodians; and regulations and agencies to monitor and enforce them, working at ecosystem scale and coordinating actions across the various agencies and jurisdictions involved. Recognition of the custodial traditions and knowledge of indigenous peoples and local communities, and the use of participatory approaches to resource management, are key success factors. A multiple land-use approach includes the promotion of pastoral, cropping and forestry practices that sustain biodiversity and support local livelihoods, while avoiding land degradation. It includes the strategic and widespread restoration of degraded lands and ecosystems.[15] An integrated approach to action is needed to bend the curve of biodiversity loss (figure 6.2).

6.2. Bending the curve of biodiversity loss

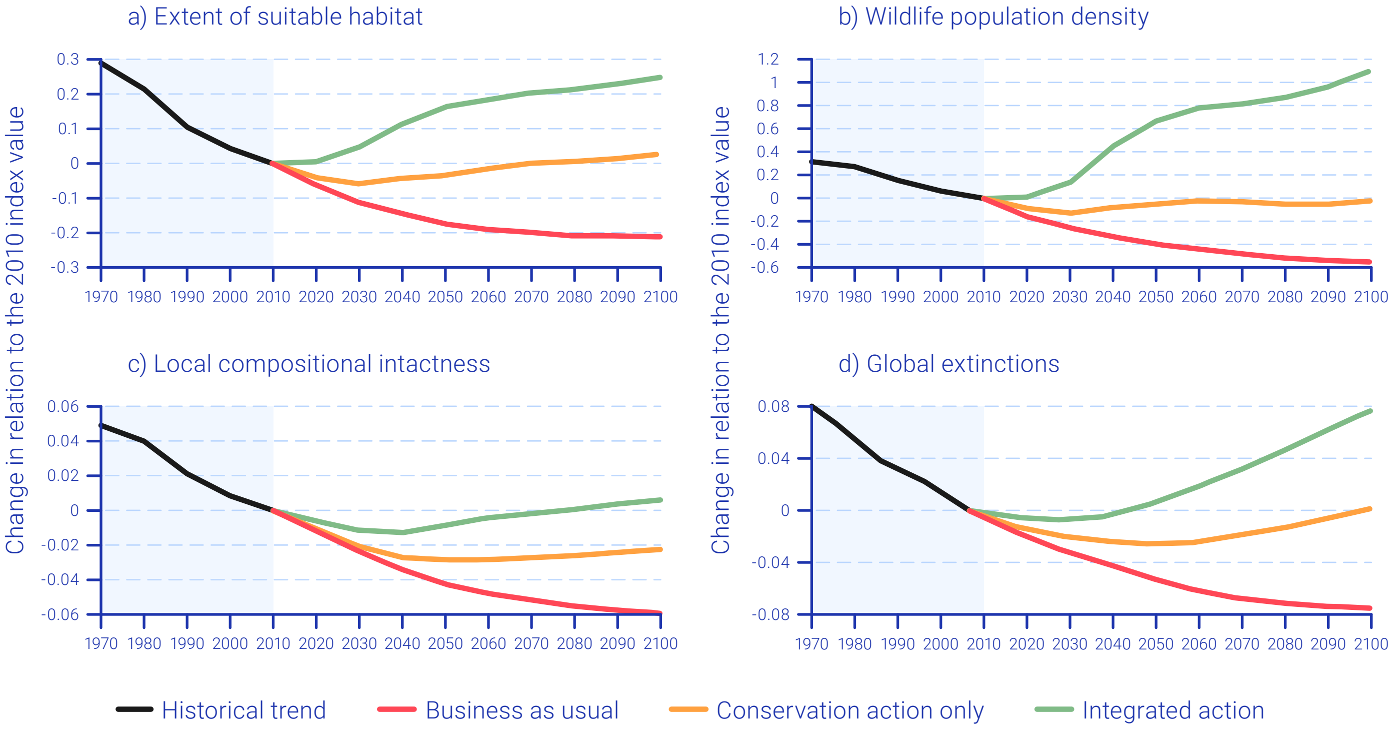


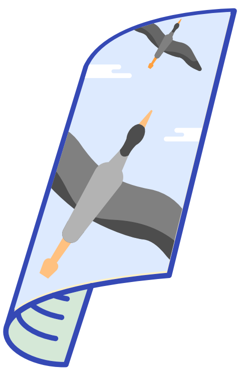
Figure 6.2: Historical and modelled future trends in four selected terrestrial biodiversity indicators, based on a "business as usual" approach, a package of bold conservation and restoration measures ("conservation action only"), and an integrated package combining such conservation and restoration action with additional measures to address both supply-side and demand-side pressures on habitat conversion for food production ("integrated action").[62]

Source: CBD 2020b, GBO-5, Figure 22.1

Fisheries reform, integrated spatial planning, conservation, climate mitigation and reduced pollution are all key to restoring marine life. Sustainable fish quotas are essential to reform fisheries, end overfishing and restore marine biodiversity. Integrated spatial planning covering multiple uses of marine resources can help advance sustainable development in oceans and coastal areas.[16,17] Trade negotiations are ongoing to craft new rules on the elimination of harmful fisheries subsidies.[18] Expansion of protected areas and strict no-take areas in both territorial waters and the open ocean can conserve and rebuild stocks of commercial and non-commercial species and protect aquatic ecosystems. No-take areas have been demonstrated to be an effective and practical solution to overfishing. The deep seas mostly fall outside of national sovereignty and thus have no pre-existing formal ownership rights. Consequently, only 5.3–7.4 per cent of the deep seas are currently protected. Catch and effort restrictions, regulation of fishing capacity and gear, and co-management of fisheries resources can all help conserve fish stocks. Restoring marine life in both the open oceans and in coastal areas is achievable using a combination of proven approaches, but only if global warming is limited to 1.5°C (which would hold the acidification of the oceans below critical thresholds) and the contamination of the oceans with chemicals, plastics, sewage and sediment (from land degradation) is halted.[19]

Key actions to conserve biodiversity such as reversing the net loss of habitat, halting overharvesting, reducing pollution and slowing the spread of invasive alien species will help nature adapt to climate change. The relative importance and impact of the main drivers of biodiversity loss differ across different biomes. For example, habitat transformation is the major threat for tropical forests, while invasive alien species have their most severe impacts on islands and freshwater ecosystems.[20] Many species are endangered by overharvesting and poaching for human consumption in local or international markets, practices that also increase the risk of the emergence of novel zoonotic diseases like COVID-19. Alleviating these pressures will permit many populations and communities of wild organisms to remain viable as they track the moving location of their preferred climate zone.[21] Such adaptation strategies are consistent with the objectives and programmes of action of the conventions and other international undertakings on biodiversity, desertification, forest protection, air pollution, chemical management and ozone protection. Some solutions are beneficial to more than one issue; for example, the protection of intact forests reduces carbon emissions and also conserves biodiversity.[22,23] Such solutions are also consistent with nature-based adaptation strategies under the climate convention but are potentially undermined by unrestricted use of land-based climate mitigation options such as biofuel production or afforestation.[24,25,26]

The private sector can help protect biodiversity by ensuring that the products it trades are sustainably sourced, and that benefits accrue in both local and distant locations. The removal by governments of implicit or explicit subsidies that have the unintentional effect of driving the loss of biodiversity or its habitats, including some forms of subsidies for farming, fishing, mining and industries exporting commodities will assist the private sector in achieving sustainable use. Beneficial market-based actions include positive incentives for protecting biodiversity or generating ecosystem services for the use of others. Consumer education, product traceability to source and certification as being climate, ecosystem and biodiversity-friendly permit consumers to make informed choices between harmful and sustainable products. Some companies, such as those trading and processing commodities like palm oil and cocoa, have adopted policies to reduce their environmental footprint, for instance by purchasing supplies from deforestation-free farmers or fisheries that reduce damage to non-target species.[27]



Protected area networks need to be expanded, interconnected and better managed to conserve biodiversity in a changing climate. The expansion of formally protected areas, such as national parks, has been the main pillar of biodiversity conservation action for over a century. Despite significant progress (protected areas now cover more than 14 per cent of land, and almost 6 per cent of the ocean),[28] there are still important gaps in the representation of some ecosystems.[29] Wetlands are an example of a functionally critical, highly threatened and biodiversity-rich ecosystem needing urgent protection.[30] Many protected areas are too small or isolated to be effective in the long term, given the impacts of climate change. Increasing connectivity between fully or partly protected areas makes them more resilient to climate change and more able to sustain viable populations of threatened species.[31] Some ostensibly protected areas have weak management and governance and need increased investment, including for surveillance and law enforcement. Expansion of the protected area network continues to be beneficial. When the true value of natural capital and the services it provides are not considered (see Section 6.2), protected area expansion can seem politically and economically costly. Taking into account the risks of not protecting ecosystems, and strategic prioritization of locating new protected areas where the benefits are greatest in relation to the cost, greatly outperforms an ad hoc approach.

6.3 Transforming land management can meet human needs, while helping biodiversity and the climate

Diverting land exclusively to climate mitigation adds to pressures on land use from food and fibre production. Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio.[32] Land-use transitions as part of mitigation pathways could slow the achievement of other SDGs, such as those relating to life on land and in the oceans, food and water security, and equity; but there are also climate-oriented land-use transformation measures that could assist in reaching non-climate SDGs. The degree to which land use-based mitigation approaches such as afforestation and bioenergy are required depends on the mitigation portfolio that is pursued, but could potentially result (by 2050, relative to 2010) in an increase of up to 2.5 million km² in non-pasture agricultural land for food and feed crops, 6 million km² more agricultural land for energy crops, and a 9.5 million km² increase in planted forests. This magnitude of change would compromise the sustainable management of land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and other ecosystem services.[33,34] On the other hand, mitigation options limiting the demand for land include sustainable intensification of land-use practices, ecosystem restoration and changes towards less resource-intensive diets.

Transforming land use can contribute to climate change mitigation while minimizing trade-offs. Relevant transformative actions include sustainable intensification, ecosystem restoration, dietary changes and food waste reduction. By maximizing the potential of transformative actions, it is possible to shift land use to a net greenhouse gas sink rather than a source. These options can contribute to climate change mitigation without driving detrimental land-cover change. They create strong direct and indirect co-benefits and have synergies with SDGs such as eradicating poverty, eliminating hunger, promoting good health and well-being, provision of clean water and sanitation, and life on land.[35] The practical actions include improved cropland and grazing management, dietary choices that minimize the requirement of new croplands, and the reduction of food waste. Transformation of diets and reduction of food waste can help to significantly reduce emissions resulting from the food system. At present about a quarter (12 $GtCO_2e$ per year) of net anthropogenic greenhouse gas emissions arise from the agriculture, forestry and other land-use sectors,[36] while the global food system as a whole emits 21–37 per cent of global greenhouse gases, much of it from deforestation to create new agricultural lands.[37] Transformation of diets such that protein needs are derived more from plants and less from animals has the potential to reduce annual greenhouse gas emissions by 0.7–8 $GtCO_2e$ by 2050 (2–20 per cent of current emissions).[38] Co-benefits include improvements in human health and well-being, conservation of biodiversity and enhanced ecosystem services.[39] Reducing post-harvest losses, where a part of agricultural output never reaches the market, can be reduced by better storage and transport, and post-consumer loss can be reduced by education and change in consumer behaviour.

Sustainable land management, coordinated and optimized at the scale of whole landscapes, can enable the multiple objectives of agricultural production, climate mitigation, climate adaptation and biodiversity protection to be realized simultaneously. Sustainable land-use strategies form a continuum, with end points dubbed "land sparing" and "land sharing." Land sparing reduces the need to transform natural ecosystems to agricultural lands by increasing productivity on already-converted lands. Land sharing attempts to meet production, biodiversity conservation and climate mitigation objectives on the same land parcel. Different types of biodiversity and ecosystem services fare better with each approach.[40] There is increasing consensus that most multi-benefit, sustainable land-use systems will lie between these contrasting models, taking into consideration the specific social, economic, ecological and technological context of the landscape.[41]

Sustainable agricultural intensification can help to avoid further loss of natural ecosystems while also creating space for land-based mitigation and can have synergies with biodiversity conservation and restoration. Careful and appropriate agricultural intensification can reduce the loss of natural ecosystems, including by avoiding deforestation, and create space on former agricultural lands for land-based mitigation or biodiversity protection. To deliver the promised biodiversity and ecosystem services benefits, the spared land (i.e. land not used for agriculture thanks to intensification) must be used for ecosystem restoration and protection. Landscapes where the use-intensity already exceeds sustainability limits, on the other hand, would benefit from de-intensification. Many landscapes have both under- and over-intensive elements, and the optimal solution involves both land-sparing and land-sharing, along with other novel approaches.[42]

Land- and ocean-based climate mitigation approaches, including ecosystem restoration, could provide a third of the mitigation effort needed in the next decade. Nature-based solutions, such as reforestation with native trees, restoration of degraded lands, improved soil management and agroforestry, can contribute significantly to reducing the atmospheric abundance of carbon dioxide. Such solutions have been estimated to be able to provide 37 per cent of the mitigation effort needed until 2030 to limit warming to 2°C,[43,44] and coastal areas hold additional potential (see below).

Ecosystem restoration can involve returning agricultural land to its natural state, or the rehabilitation of ecosystems on degraded land. Ecosystem restoration is a cost-effective way of achieving multiple benefits.[45] The potential for ecosystem restoration depends on the degree to which other transformative enablers such as sustainable intensification, dietary changes and food waste reduction are implemented, as there is potential competition between the use of land and water for ecosystem restoration, pastureland, and agricultural cropping for food and energy feedstocks.[46] To maximize the co-benefits, policies aimed at increasing land carbon sinks need to restrict activities to ecosystem restoration specifically, as opposed to the more general reforestation or afforestation, which might otherwise encourage the planting of monocultures of non-native trees[47] or the conversion of carbon- and species-rich peatland, grassland or savannas to less rich forests. Ecosystem restoration also helps biodiversity adapt to climate change.

Ecosystem restoration can simultaneously mitigate climate change, slow and reverse biodiversity decline and increase the benefits that people get from nature. Restoration can deliver multiple benefits in all ecosystems. It offers particularly important benefits in dryland regions where climate change and desertification are projected to cause reductions in crop and livestock productivity. Avoiding, reducing and reversing land degradation, including desertification, would enhance soil fertility, increase carbon storage in soils and biomass, and increase agricultural productivity and food security.[48,49] Ecosystem restoration makes a cost-effective contribution to the timely action to avoid, reduce and reverse land degradation that can increase food and water security whilst contributing to climate change mitigation and adaptation.[50] This includes restoration of vegetated coastal ecosystems, such as mangroves, tidal marshes and seagrass meadows (coastal "blue carbon" ecosystems), that could provide climate change mitigation through increased carbon uptake and storage of around 0.5 per cent of current global emissions, with co-benefits for local ecosystems and livelihoods.[51]

6.4 Science-based management can reduce the adverse effects of chemicals on human health and the environment

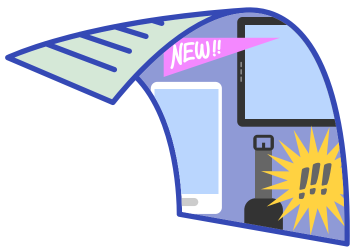
The existing regulatory and legislative framework for the management of chemicals must be comprehensively implemented, taking into account the scale, complexity and pace of the issue. The development of basic legislation and institutional capacity has been recognized as critical to the attainment of sound chemicals and waste management. Many countries have already made important headway in enacting laws, creating programmes, and implementing policies to this end, in particular in the developed world, such as the REACH program in Europe and the Canadian Challenge Program on chemical substances. Further steps, particularly in developing countries and economies in transition, could include the following: intensification of action at all levels to strengthen legislative and institutional capacities to regulate chemicals and waste during their full life cycle; the development of national chemicals management profiles and action plans on the sound management of chemicals and waste; advancing the alignment and harmonization of policies between countries, mutual learning regarding effective approaches, and the maximization of opportunities for regional cooperation, drawing on existing institutional structures.[52]

Science-based approaches to the sound management of chemicals are available. Established approaches for the management of chemicals that are available to governments and regulators include: accelerating chemical hazard assessment and harmonized classifications of substances; refining chemical risk assessment and risk management decision-making processes; and advancing alternative assessments and informed substitution of chemicals of concern, including through non-chemical alternatives. At the same time, concerns have been expressed that current approaches are at times complex and slow. Over the past decades, valuable lessons have been learned in the practical application of these approaches, and opportunities have emerged to enhance their effectiveness, streamline their use, and employ them more systematically in all countries. Developing countries and economies in transition in particular stand to benefit from progress in these areas.[53]

Data gaps can be filled if priorities are established. Opportunities to strengthen the engagement of scientists and the science-policy interface include: taking steps towards the cost-effective harmonization of data generation and collection, strengthening monitoring and surveillance capacities, and sharing data more systematically at all levels; scaling up industry engagement in generating and disseminating relevant data; strengthening two-way communication, and supporting collaboration between scientists and policymakers; and exploring methodologies that facilitate more systematic identification of future priorities at the international level. Although a wealth of data and knowledge has been generated, many data gaps and unknowns remain. These include gaps in regard to: chemical hazard data for a range of chemicals on the market; environmental, health and safety data; outdoor and indoor chemical releases; exposures and concentrations in humans and the environment; and adverse impacts of chemicals. Disparities remain in data collection and availability across time and countries, making the identification of baselines, trends, and emerging issues and priorities challenging. While a diverse set of mechanisms has been established at the international level to identify emerging issues and to set priorities for action (for example, the SAICM mechanism), opportunities exist to explore the complementarity of processes and the use of science-based criteria for prioritization. Various barriers pose challenges to making policy-relevant knowledge available for informed decision-making.[54]

Innovation and new business models may help to reduce global and local chemical pollution. The implementation of new business models (such as chemical leasing) aimed at reducing the use of chemicals of concern, the scaling up of efforts to develop green and sustainable chemistry alternatives, and commitments to phase out chemicals of concern in consumer products, can all help to reduce chemical pollution. Despite these efforts, voluntary actions and sustainability strategies that go beyond compliance and advance sound chemicals management are not yet being sufficiently developed and replicated, particularly in developing countries. Furthermore, important private sector stakeholders are not yet fully engaged in relevant discussions at the national and international level. Strengthening corporate commitment at the highest level is therefore essential. From a design perspective, incentives to develop green and sustainable chemistry solutions are needed. Responsible production should be encouraged, and consumer information related to chemicals should be clear, transparent and reliable. As an important contribution to a sustainable future, chemistry and its products must be adapted to a circular economy – a system aimed at eliminating waste, circulating and recycling products, and saving resources and the environment. The increasing trade in chemicals and related products, and the quest to recycle products and materials, create opportunities but also raise concerns regarding the fate of chemicals and chemicals in products once they reach the waste stage or become secondary raw materials. Challenges include the chemical content of products becoming secondary raw materials, as well as the global flows of recycled products often being unknown, potentially impeding management intervention that could ensure undesired chemicals re-entering supply chains are not causing health and safety problems at various stages of the material flow.[55]

Multi-stakeholder partnerships will help protect human health and the environment from the adverse effects of chemicals and waste. The engagement of all relevant stakeholders at the national, regional and global levels is needed to protect human health and the environment from the adverse effect of chemicals and waste. This includes not only the chemicals and waste community, such as ministries of environment and health, intergovernmental organizations, civil society organizations engaged in chemicals and waste, the chemical industry and trade unions, but also actors in key economic and enabling sectors, some of which have so far not been sufficiently engaged. To advance ambitious and concerted commitment, a global collaborative framework for the sound management of chemicals and waste would need to create mechanisms and incentives to foster the commitment and engagement of sectoral ministries, retailers, downstream manufacturers and academia, as well as the broader global community.[56]



6.3. Aligned actions for protecting and restoring life on Earth

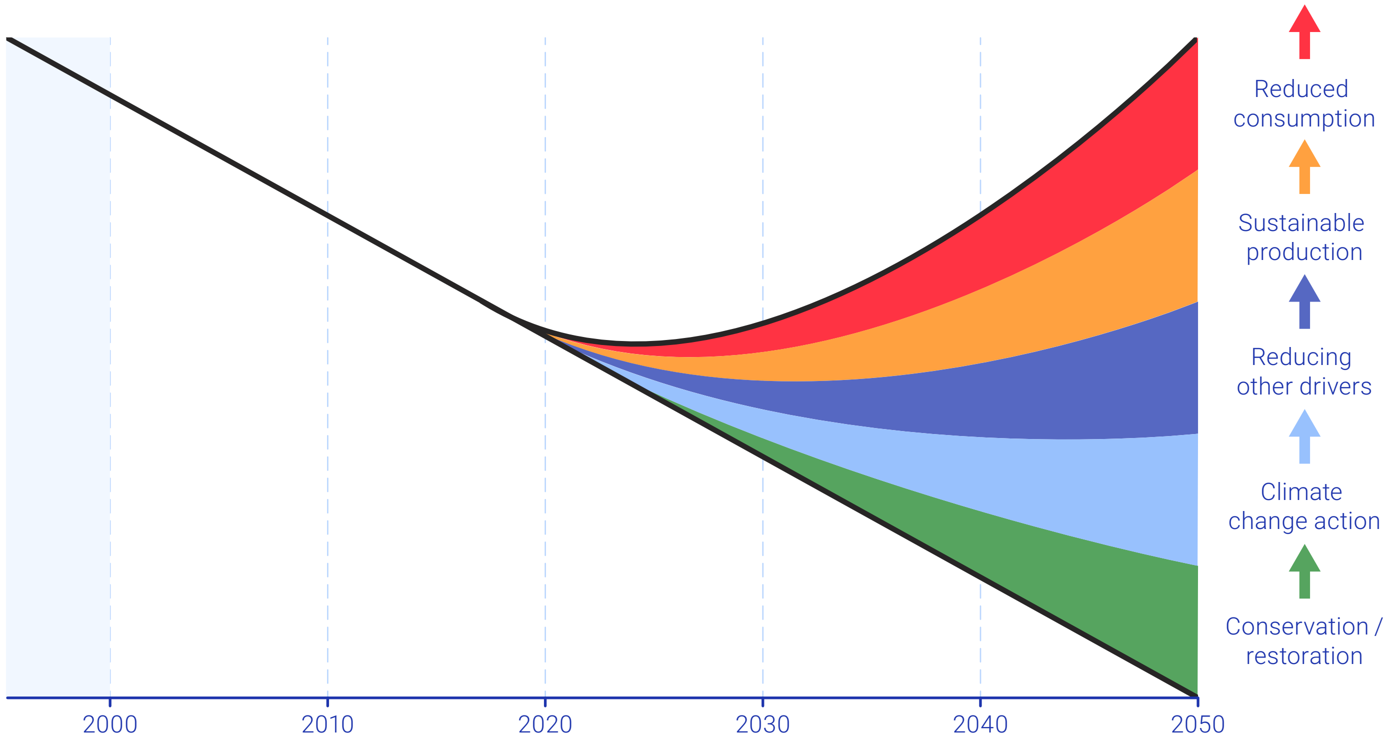


Figure 6.3: The left axis schematically indicates the trends in the diversity of life on Earth which by various metrics have been declining and are projected to continue to do so under business as usual scenarios (trend line). Various areas of action could reduce the rate of biodiversity decline, and the full portfolio of aligned actions could in combination halt and reverse the decline (bend the curve), potentially leading to net biodiversity gains after 2030. These are, from bottom to top: (1) Enhanced conservation and restoration of ecosystems; (2) climate change mitigation; (3) action on pollution, invasive alien species and overexploitation; (4) more sustainable production of goods and services, especially food; and (5) reduced consumption and waste.

Source: Source: CBD 2020a, GBO-5 SPM

6.5 Aligning objectives and actions can deliver transformative change for both the environment and human development

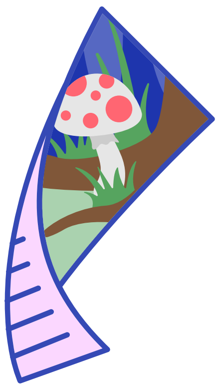
Key international environmental agreements need to be aligned and become more mutually supportive. The further development of the goals, targets, commitments and mechanisms under multilateral agreements in the areas of climate change, biodiversity, land degradation, oceans and pollution needs to be aligned and become more synergistic and mutually supportive. There needs to be enhanced harmonization in the implementation, monitoring and financing of the agreements. Sustainable policies, technologies and management practices need to be implemented within the interconnected food-forestry-water-energy systems given their impact on climate, biodiversity and land degradation.

Adaptation actions that reduce the vulnerability of human and natural systems to climate change have many potential synergies with sustainable development. Vulnerability to environmental change can be reduced by adaptation measures to ensure food and water security, reduce disaster risks, improve health conditions, maintain ecosystem services and reduce poverty and inequality.[57] However, if poorly designed or implemented, adaptation can also result in unacceptable trade-offs or even maladaptation, with adverse impacts for sustainable development such as increasing greenhouse gas emissions or water use, or encroachment on natural ecosystems. Adaptation options that also mitigate emissions can provide synergies and cost savings, such as when land management reduces emissions while simultaneously reducing disaster risk, or when low-carbon buildings are also designed for efficient cooling.

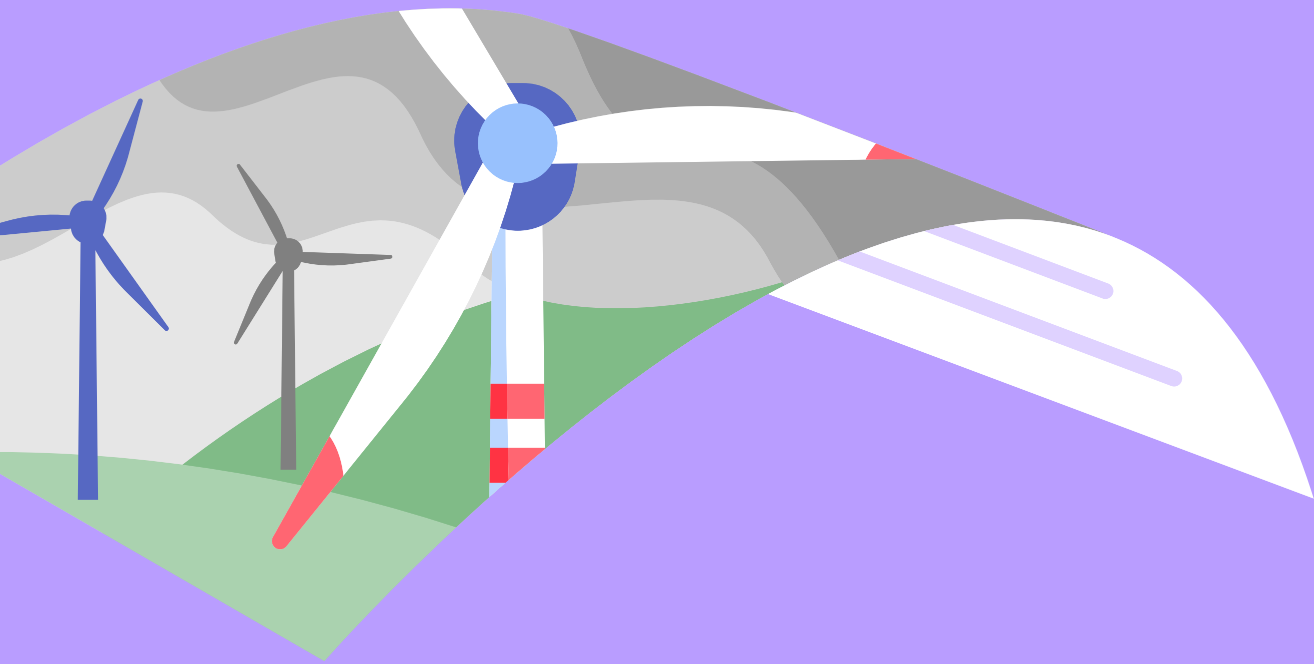
Given the interaction between sustainable development, climate action and biodiversity protection, a greater alignment of policies can deliver transformative change. There are both synergies and trade-offs between environment and development policies. For instance, climate stabilization at warming of 2°C or less would make it easier to achieve many aspects of sustainable development and biodiversity conservation. Efforts to advance the SDGs can accelerate progress on the Paris Agreement, and vice versa. The manner of integrating adaptation, mitigation, biodiversity and sustainable development in policy is dependent on context-specific conditions where synergies are achieved and trade-offs are made, involving "winners" and "losers" across governance levels and time scales.[58] Reconciling trade-offs between development needs and emissions reductions requires an understanding of the dynamics between adaptation, mitigation and sustainable development, and of the specific roles that different actors play at particular points in time. Enhancing synergies and avoiding trade-offs is essential for achieving multiple benefits and transformative change for people and the planet.

Multilevel governance is key for systemic transformation and for reconciling environmental and development objectives.[59] Governance approaches that coordinate and monitor multiscale policy actions and trade-offs across sectoral, local, national, regional and international levels are best suited for the implementation of environmental goals, such as those for climate change, biodiversity, land degradation, and air and water pollution, while simultaneously promoting sustainable development.[60] This is because vertical and horizontal policy integration and coordination enables the interplay and trade-offs between sectors and spatial scales, and the dialogue between local communities, institutional bodies and non-state actors.

Policies that support the achievement of the SDGs, such as those for poverty alleviation, clean water and universal energy access, need to align constructively with environmental policies in order to realize potential synergies. Aligning policies synergistically increases their efficiency and effectiveness, whilst increasing societal support. For example, integrated landscape governance entails a mix of policies and instruments that together ensure nature conservation, ecological restoration and sustainable use, sustainable production (including of food, materials and energy), and sustainable forest management and infrastructure planning.[61] As a further example, the nature of legal rights to land ownership and of international forest certification systems can be reformed so that rural development and poverty alleviation can be aligned with carbon sequestration and biodiversity conservation, thus avoiding deforestation and increasing the resilience of human and natural systems to environmental change. Such an approach can address and reverse the drivers of deforestation and prove transformative during the UN Decade on Ecosystem Restoration that begins in 2021. Better alignment of measures can create the portfolio of actions needed to protect and restore life on Earth (figure 6.3).



1 IPCC 2018b, SR1.5 SPM, A.3
2 IPCC 2018b, SR1.5 SPM, B.2
3 IPCC 2018b, SR1.5 SPM, B.2.3
4 IPCC 2018b, SR1.5 SPM, C.1
5 UNEP 2020a, EGR, ES6
6 IPCC 2018b, SR1.5 SPM, D.3
7 IPCC 2018b, SR1.5 SPM, C.3
8 IPBES 2019a, GA SPM, 25
9 IPCC 2018b, SR1.5 SPM, C.2
10 IPCC 2018b, SR1.5 SPM, D
11 IPCC 2019b, SRCCL SPM, D
12 IPCC 2019a, SROCC SPM, C
13 IPBES 2019a, GA SPM, D
14 IPBES 2018a, LDRA, 2, 8
15 IPBES 2018a, LDRA, 5
16 IPBES 2019a, GA SPM, D6
17 IPCC 2019a, SROCC SPM, C.2
18 WTO 2020
19 Duarte *et al.* 2020
20 IPBES 2018a, LDRA, 4.3
21 IPCC 2014b, AR5 WGII, 4
22 IPCC 2019c, SRCCL, 6
23 IPBES 2018a, LDRA, 6.3
24 PBES 2018a, LDRA, 6
25 IPCC 2019c, SRCCL, 2.6
26 IPCC 2018a, SR1.5, 1
27 IPBES 2018a, LDRA, 8
28 IPBES 2019a, GA SPM, C1
29 IPBES 2019a, GA SPM, Appendix 4
30 Ramsar Convention on Wetlands 2018, Global Wetland Outlook
31 IPCC 2014b, AR5 WGII, 4
32 IPCC 2018b, SR1.5 SPM, C.2.5
33 IPCC 2018b, SR1.5 SPM, C.2.5
34 IPCC 2018a, SR1.5, 2.4.4, 4.3
35 IPCC 2019b, SRCCL SPM, C.3, C.4
36 IPCC 2019c, SRCCL, Table 2.2
37 IPCC 2019c, SRCCL, 5 ES
38 IPCC 2019b, SRCCL SPM, B.6
39 IPBES 2019b, GA, 5
40 CBD 2020b, GBO-5, Box 22.2
41 IPBES 2019b, GA, 6.3.2
42 Finch *et al.* 2019
43 IPBES 2019a, GA SPM, D8
44 IPBES 2018b, LDRA SPM, A14
45 IPBES 2018a, LDRA, 5
46 IPCC 2019c, SRCCL, 4
47 IPBES 2019a, GA SPM, D8
48 IPCC 2019c, SRCCL, 2, 4, 6
49 IPBES 2019b, GA, 2.3, 5
50 IPBES 2018a, LDRA, 5
51 IPCC 2019d, SROCC, 5
52 UNEP 2019c, GCO-II, Part II
53 UNEP 2019c, GCO-II, Part III
54 UNEP 2019c, GCO-II
55 UNEP 2019c, GCO-II, Part I, 4
56 UNEP 2019c, GCO-II, Part V, 3
57 IPCC 2018a, SR1.5, 5
58 IPCC 2018a, SR1.5, 5.5.1
59 IPCC 2014e, AR5 WGIII, 4
60 IPCC 2018a, SR1.5, 5.5
61 IPBES 2019a, GA SPM, 35
62 Leclère *et al.* 2020

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7

Earth's environmental emergencies must be addressed together to achieve sustainability

Economic, financial and productive systems profoundly shape society's relationship with nature. This section examines how those systems can be transformed to lead and power the path to a sustainable future. It explores how the food, water and energy systems can be transformed to meet growing human needs in an equitable, resilient and environmentally friendly manner.

7.1 Transforming economic and financial systems to become sustainable and just

Achieving a just and prosperous future for all on a safe and resilient planet requires the transformation of economic and financial systems. Current economic and financial systems focus on a narrow set of financial returns from market activities. Achieving the SDGs will require economic and financial systems that simultaneously support economic well-being, social inclusion and environmental sustainability – sometimes called the "triple bottom line." Economic well-being means that all basic needs are met, meaning an end to poverty and hunger, and the provision of education, water and sanitation, clean energy, decent jobs and modern infrastructure for all (SDGs 1, 2, 3, 4, 6, 7, 8 and 9). Social inclusion means gender equality, reduced inequalities and freedom from violence (SDGs 5, 10 and 16). Environmental sustainability means that dangerous climate change is averted, having clean air to breath and clean water to drink, life on land and in the water is protected and critical ecosystems functions preserved (SDGs 6, 7, 11, 12, 13, 14, 15).[1,2,3] This all requires systemic change in economic and financial systems to assure freshwater availability, sustainable cities, sustainable production and consumption, climate stability, and protection of marine and terrestrial ecosystems (SDGs 6, 11, 12, 13, 14 and 15).

Achieving all of the Sustainable Development Goals will require large changes in economic activities, national accounts, financial systems and governance.[4] Securing equitable access to goods and services while averting dangerous climate change and avoiding environmental harm will require major structural changes in economic activities. Such a shift is unlikely without reforming economic and financial systems to better align market incentives and national accounts with the protection of global commons and common-pool resources.

Measures of economic performance should include the value of nature's contributions to human well-being. Including the value of nature's contributions to human well-being in measures of economic performance is vital for aligning economic incentives with more sustainable outcomes. The UN-led initiative on the System of Environmental Economic Accounting is working to expand the accounting rules to incorporate the value of nature. The framework integrates economic and environmental data to provide a more comprehensive view of the interrelationships between the economy and the environment and the stocks and changes in stocks of environmental assets. It is a flexible multipurpose system which generates outputs that can be adapted to countries' priorities and policy needs while at the same time producing internationally comparable statistics.[I] China is working to develop and report a measure of Gross Ecosystem Product along with GDP.[5]

Governments should use measures of inclusive wealth to track progress towards sustainable development. Sustainable development requires leaving future generations with sufficient capital assets, including natural capital, to allow them to meet their needs.[6] Governments should develop measures of inclusive wealth to inform policy and track progress towards sustainable development. Improved data collection, methods, and reporting of changes in natural capital along with other capital assets (produced and human) is needed in order to accurately measure inclusive wealth.[7,8,9,10] Measures of inclusive wealth may be supplemented by science-based environmental sustainability standards for critical natural capital that cannot be effectively substituted by other forms of capital.

Making economic systems more sustainable requires policies that align private incentives with social and environmental objectives. Eliminating incentives for environ-

I SEEA web page: https://seea.un.org/content/about-seea mentally harmful activity and promoting more sustainable alternatives can align private and social goals. Policy tools that internalize environmental costs include taxes on environmentally harmful activities and cap-and-trade systems targeted at emissions of pollutants. Policy tools that promote environmentally friendly alternatives include payments for ecosystem services, tax breaks for environmentally benign economic activities and feed-in tariffs for renewable energy. Policy reforms also include the abolition of perverse subsidies (especially in agriculture, energy and transportation) that damage global commons and common-pool resources, such as subsidies for fossil fuels that lead to climate change and air pollution.[11,12]

Policies that reward the reduction, reuse and recycling of materials in production or that penalize waste generation can accelerate the shift to a circular economy.[13] A circular economy reduces pressures on natural resources and the pollution of land, water and air caused by waste disposal and inefficient use. Moving to a circular economy is one way to decouple economic growth from increasing environmental degradation. Putting a tax on the extraction of virgin raw resources and the disposal of waste to reflect their full costs increases the relative attractiveness of reducing, recycling and reusing existing materials. Product design and purchasing guidelines such as performance labels are another important policy lever. Achieving a circular economy requires changes in the practices of businesses and households. A key element is the notion that well-being does not necessarily increase with the consumption of resources, especially at high levels, but is rather derived from the services and amenities that resources help provide.[14] Efficiency and sufficiency reduce the needs for resources while increasing well-being.[15] A shift away from individual ownership towards a sharing economy can further increase economic efficiency and sufficiency.[16,17]

Achieving sustainability will require major shifts in patterns and large flows of investment. In energy, accomplishing a transition from a fossil fuel-dominated supply to a low-carbon system consistent with Paris Agreement climate objectives will require investments in renewable energy, nuclear energy, transmission, distribution, storage and energy efficiency of US$0.8–2.9 trillion per year through 2050.[18] Global financing for biodiversity is estimated at about US$80–90 billion annually,[19] far below the conservatively estimated hundreds of billions of US dollars needed.[20] Biodiversity, climate and other environmental finance could be ramped up by redirecting some of the estimated more than US$5 trillion in annual subsidies on fossil fuels, non-sustainable agriculture and fishing, non-renewable energy, mining and transportation (see Section 2.2). Large investments are also required to make water, food and other economic sectors sustainable (see Section 7.2). The investments pledged by governments around the world to restart economies stalled by the COVID-19 pandemic should be directed toward sustainable economic structures and lifestyles that increase the inclusive wealth of society.

Substantial private sector investment is needed to complement public financing to achieve the SDGs and assure resilient management of risk and natural disasters. The investments required to reach the SDGs exceed the capacity of public funding, therefore substantial private sector financing is essential. Socially- and environmentally- oriented investment funds that provide low-cost financing for sustainable projects can close part of the financing gap. Currently there is an estimated US$500 billion of assets in impact investing.[21] However, achieving large-scale financial flows on the scale needed to achieve the SDGs will likely require making such investments more financially attractive. New tools and approaches that can leverage and incentivize private sector funding include the use of capital markets to unlock private sector investment in sustainable infrastructure. The Global South needs increased access to low-interest finance in order to achieve the SDGs. The Global North has exacerbated the shortfall by failing to meet its commitments under environmental conventions and on international development assistance.

Good governance is at the core of a well-functioning economy able to provide a good quality of life for all. Good governance, which involves interaction between state and non-state actors to assure the rule of law, the absence of corruption and global cooperation, is key in building inclusive and just economic and financial systems for transformative change. Economic growth directed towards increasing access to food, water, energy, good health and education, and a clean and healthy environment, improves quality of life, but with diminishing returns at high levels of income and consumption. A well-functioning sustainable economic system will "meet the needs of the present, without compromising the ability of future generations to meet their own needs."[22]

7.2 Transforming food and water systems to make them equitable and resilient

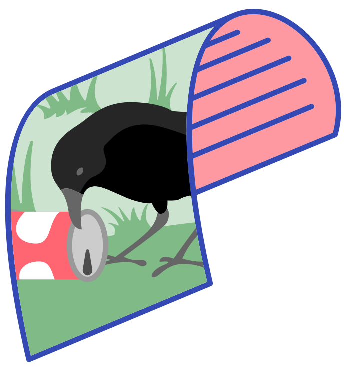
Feeding humanity, ensuring water security, and enhancing the conservation and sustainable use of nature are complementary and closely interdependent goals. Achieving them requires actions on the ground to improve food production and water supply systems, in conjunction with changes in demand and in the systems that connect production and consumption. Pressures and context vary regionally, so sustainable solutions must be context-appropriate and based on various knowledge systems, including science and indigenous and local knowledge.

7.2.1 Approaches for transforming food and water systems

Sustainable food systems work with nature, adapt to a warming world, minimize environmental impacts, eliminate hunger and improve human health. Sustainable food production is vital to protecting nature and human well-being. It can be achieved through a range of overlapping approaches, including conservation agriculture, organic farming, agroecology, integrated pest and nutrient management, soil and water conservation, conservation aquaculture, sustainable grazing, agroforestry, silvopastoral systems, irrigation management, small or patch systems and practices to improve animal welfare. Sustainable agriculture requires a reduction in nitrogen and phosphorus imbalances to reduce pollution of freshwater, groundwater and coastal zones. Ensuring the adaptive capacity of food production requires measures to conserve the diversity of genes, varieties, cultivars, breeds, landraces and species, which also contribute to diversified, healthy and culturally relevant nutrition. In addition to sustainable practices, climate-smart agriculture requires the development of crops that are more tolerant of heat, drought, salinity, pests and disease.

Sustainable agriculture requires strategies and technologies to increase the productivity of land and the nutritional value of food while reducing water use intensity and the release of pollutants. Sustainably intensifying agriculture while reducing water scarcity requires more efficient use of water, increasing water storage and avoiding salinization. Technologies to increase the yield of nutritious food need to be adapted to specific agroecological zones to conserve soils and reduce fertilizer application, such as reactive nitrogen and phosphorous. Genetically modified organisms could potentially increase the efficiency of food production with crop varieties that are tolerant of pests, diseases, drought, floods and salinity. However, biosafety and social considerations must be taken into account (see Section 2.3.2). Organic farming and other forms of agroecology may make a significant contribution to the food system transformation, although further research is needed to increase yields. In some cases, sustainable intensification and precision agriculture may be the best approaches, while organic or agroecological systems may be appropriate elsewhere. Managing pollution from agricultural chemicals will be critical, as will reducing waste by limiting post-harvest and consumer losses.[23]

Making freshwater systems sustainable in the face of climate change, increasing demand and pollution requires steps to improve supply and use efficiency, reduce pollution, and restore natural habitats and flow regimes. Impacts on freshwater systems from climate change, rising demand for extraction from agriculture, households and industry, and increasing pollution, require both cross-sectoral and sector-specific interventions that improve water use efficiency, increase storage, reduce contamination, minimize disruption and restore aquatic habitats and natural flow regimes. Water used for irrigated agriculture will remain the largest consumptive use of water, so sustainable water futures will include a range of solutions to manage irrigation water demand and increase agricultural water use productivity. Increased water use productivity in agriculture could be achieved through crop breeding and shifts in crop planting.[24] This will include improved irrigation techniques such as micro-irrigation, moisture conservation methods such as rainwater harvesting, which may include using indigenous and local practices, and maintaining vegetation and mulch cover.[25] Drought-resilient ecologically appropriate plants and other agroecological and ecosystem-based adaptation practices will also be important.[26] Some adaptation options can become maladaptive due to their environmental impacts, such as irrigation causing soil salinization or overextraction leading to groundwater depletion, so response options should be tailored to the context.[27] Improved management of urban and other water uses will also be necessary. Investment in wastewater treatment as well as in distribution and supply infrastructure are necessary for equitable access to clean water.[28] Renewable energy sources can be made less water-intensive with present technology, and existing hydropower dams can be managed to integrate ecological water requirements. Increased water storage can be achieved through policies that implement a mix of groundwater recharge, integrated management of surface and groundwater, wetland conservation, low-impact dams and decentralized (for example, household-based) rainwater collection.[29]



Technical assistance and economic incentive programs can encourage sustainable farm practices and reduce pre- and post-harvest losses of food. Technical assistance is important to enable farmers to adopt more sustainable practices, especially for smallholders. Policies with incentives for sustainable practices include standards, certification schemes and payments for ecosystem services such as direct payments through agri-environmental schemes.[30] Agricultural losses can also be reduced by developing real-time plant disease diagnostics, supported by a global surveillance system, to monitor and contain crop disease outbreaks Limiting post-harvest losses requires investments in rural roads, electricity infrastructure, storage and cooling systems.

Small-scale farmers, in particular women farmers, need to be empowered to embrace sustainable practices. Small-scale agricultural producers are at the heart of the challenge of food security. They therefore need access to information and technology, gender-sensitive and participatory research and extension services, financial and legal services, markets, added-value opportunities, access to and control over land and production inputs (including high-yielding, water-efficient, and pest- and disease resistant crops, and fertilizers), and groundwater and irrigation services. Reliable and affordable insurance for small-scale farmers to withstand and recover from environmental shocks is also needed.

Measures are needed and available to protect pollinators. Given the worldwide decline in the populations and diversity of wild pollinators and the seasonal colony loss of western honey bees in some regions, it is important to maintain healthy pollinator communities. This can be achieved through agroecological farming practices, strengthening existing diversified farming systems, and investing in ecological infrastructure by protecting, restoring and connecting patches of natural and semi-natural habitats in agricultural landscapes. These measures need to be complemented by reducing the effects of pesticides, particularly insecticides such as neonicotinoids, on pollinators through integrated pest management. Honeybees also need to be protected from a broad range of parasites, including Varroa mites, by placing greater emphasis on hygiene and control of pathogens.[31]

Policy instruments to achieve water system sustainability include water reallocation at the basin scale and education and incentives to increase water use efficiency in agriculture. Integrated water resource management has moderate mitigation potential, with no adverse impacts on challenges related to climate change mitigation and adaptation, desertification and food security.[32] Drought resilience policies, including drought preparedness planning, early warning and monitoring, and improving water use efficiency, synergistically improve agricultural producer livelihoods and reduce water stress.[33] Environmental farm programs and agri-environment schemes, water efficiency requirements, and water pricing and incentive programs, such as water accounts and payment for ecosystem services programs, can also help relieve water stress.[34,35]

Sustainable food production from freshwaters and the oceans requires improved management, planning and policy action. Fisheries management, spatial planning (including the implementation and expansion of marine protected areas) and policy action are needed to address drivers of decline in aquatic ecosystems such as climate change and pollution. Pathways to sustainable fisheries entail conserving, restoring and sustainably using marine ecosystems; rebuilding overfished stocks (including through targeted limits on catches or moratoria); reducing pollution; managing destructive extractive activities; eliminating harmful subsidies and illegal, unreported and unregulated fishing; adapting fisheries management to climate change impacts and reducing the environmental impact of aquaculture. For example, ending overfishing and rebuilding depleted resources may result in an increase of as much as 20 per cent in potential yield, provided that the transitional costs of rebuilding depleted stocks can be addressed.[36] Marine protected areas (including no-take zones) have demonstrated success in biodiversity conservation when managed effectively and can be further expanded through larger or more interconnected protected areas or new protected areas in currently underrepresented regions and key biodiversity areas. Integrated marine and coastal planning are important. Additional tools could include both non-market and market-based economic instruments for financing sustainable use and conservation, including for example payment for ecosystem services, biodiversity offset schemes, blue carbon sequestration, cap-and-trade programmes, green bonds and trust funds, new legal instruments, such as the proposed international, legally binding instrument on the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction under the United Nations Convention on the Law of the Sea, and halting harmful subsidies, especially those aimed at maintaining capacity.

Inequalities, especially regarding income and food subsistence for local communities and small-scale artisanal fisheries, need to be addressed to advance sustainability. For local communities, reduced, declining and unequal access to marine resources may, in a complex interaction with other factors, be a source of conflict. Adding to the risk from overfishing, tropical regions face critical challenges due to interactions with climate change (with fish stocks projected to move poleward), and intense coastal development. Equitable sharing of fish resources is a ubiquitous challenge worldwide that often translates into competition between industrial fisheries and small-scale artisanal fisheries. It is therefore critical to foster well-managed small-scale fisheries using selective and non-destructive gear to promote employment, lower fossil fuel consumption and reduce fisheries' footprint on the oceans.

7.2.2 Using consumer habits, corporate standards and government action to reshape food and water systems

Changing consumer behaviour is critical to transforming food and water systems. Changing the dietary habits of consumers in developed countries by reducing the demand for animal products would improve human health and reduce the pressure on land, water, biodiversity and the climate system. Changes in consumer behaviour must be based on increasing consumer and retail awareness of the environmental and human health consequences of different purchasing patterns and may require legislation that helps reconcile supply by retailers and food manufacturers with demand. For water, it will be critical to change incentives, for instance through water pricing to discourage non-essential use and through infrastructure to encourage behaviour change, and to increase awareness and knowledge among consumers.[37]

Regulatory changes, incentives, changes to subsidies and corporate action are all part of reshaping the interlinked food and water systems. Key policy tools for transforming water and food systems include government regulation, economic incentives, standards (including voluntary standards, certification and labelling schemes, and supply chain agreements), the removal of distorting agricultural subsidies and integrated landscape planning. Regulatory mechanisms are needed to address the risks of co-option and lobbying, where commercial or sectoral interests work to maintain high levels of demand, monopolies and continued use of pesticides and chemical inputs. Agricultural commodity chains can be regulated by involving all private stakeholders along the chain to establish sustainability standards that transform the entire sector. Other measures include multisectoral cooperation on coastal management, corporate social responsibility measures, construction standards and eco-labelling. For water, policy instruments include: setting and enforcing environmental laws, regulations and standards; collaborative initiatives with communities and with the corporate sector and use of economic instruments such as appropriate water pricing, improved investment and financing, and new market instruments such as wetland mitigation banking and payments for ecosystem services.[38] Achieving sustainable food and water systems will require data gathering and monitoring, including in co-operation with indigenous peoples and local communities. Promoting community-based and multiple-use integrated water resource management and encouraging transboundary water governance will also be necessary.[39] A viable policy framework is needed to ensure environmental flows to deltas in order to prevent seawater intrusion.[40]

7.3 Transforming to low-carbon energy systems with access to clean energy for all is possible

Universal access to clean energy requires a rapid transition to low-carbon systems in both the production and use of energy. Improving access to affordable and modern energy (SDG 7), preferably clean energy, coupled with innovation and efficiency gains, is vital to achieving equitable and sustainable economic growth while limiting global warming. Clean energy will also reduce poverty and indoor and outdoor air pollution and provide critical services such as communications, lighting and water pumping. Achieving this goal while combating climate change involves a rapid transition to low-carbon energy systems encompassing both production and consumption. Investments in the energy transition need to grow five- or sixfold between now and 2050 to limit warning to 1.5 °C as aspired to in the Paris Agreement.[41] Renewable energy technologies such as wind and solar, along with improved energy efficiency in buildings and elsewhere, will be key.

Since 2000, progress with respect to access to modern energy services has been made in all regions, but billions of people still lack such access. Progress on access to modern energy has been made especially in Asia, while in sub-Saharan Africa, population growth largely outpaced the advances made, with these trends projected to continue towards 2030.[42] More than 800 million people still do not have access to electricity,[43] and some 3.8 billion are exposed to household air pollution from burning of solid fuels such as traditional biomass, kerosene and coal[44] – fuels that also contribute to climate change. Striking global inequality in access to energy services is reflected in adverse impacts on development and health. In 2019, air pollution is estimated to have contributed to about 6.5 million deaths worldwide, and one third of these deaths are attributed household air pollution.[45]

To achieve universal access to clean fuels and technologies, the affordability, availability and safety of fuels and practices for cooking, heating and lightning need to be improved.[46] Achieving universal access to electricity requires expanded generation capacity and distribution networks, as well as access to more efficient and affordable appliances, with a focus on poor, remote communities. Clean cooking and universal access to electricity improve health and reduces greenhouse gas emissions if traditional fuels are replaced by electricity (especially if it is generated renewably) or natural gas.

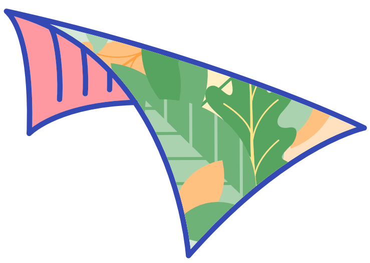
It is possible to transform the energy system to provide clean and affordable energy for all. Analyses show that energy efficiency and sufficiency, increasing the share of renewable energy, and electrification all play a key role in providing access to modern energy services.[47] Today's reliable, affordable and resilient energy options are driving a new paradigm of heterogeneity. Distributed solutions today offer increasingly compelling economics for those without access to traditional energy carriers, suggesting a fundamental reconsideration of infrastructure policies, energy access solutions and economics that does not rely on uniform – or old and outdated – assumptions about energy systems and embraces a portfolio of solutions versus singular approaches.

Transforming the energy system is key to reducing greenhouse gas emissions. Key components of a strategy to transform the energy system include mitigating energy demand, decarbonization of the power system, further electrification of energy supply and phasing out fossil fuel use in other sectors. Mitigating energy demand (either by efficiency improvements or changes in human activity) is essential. It not only leads to direct emission reductions, but it also limits the volume of energy supply, which reduces the environmental impacts associated with energy supply beyond those of climate change.

Falling costs for the generation of renewable energy and energy storage are bringing higher mitigation targets within reach. In the last decades, the cost of photovoltaic solar cells, wind turbines and batteries has fallen significantly. As a result, in some cases renewable electricity is as cheap to generate as fossil-fuel based alternatives. This development has resulted in rapid growth of renewable energy capacity, a trend that can help create a net-zero power system, although further developments to overcome system integration issues are needed.[48]

Smaller-scale renewable-based energy systems are becoming increasingly economically attractive. Small-scale systems offer rapid scalability and applicability to serve growing energy demands. They can power critical services such as communications, lighting, and water pumping and purification, enabling healthier, productive lives, better education and reduced child labour. Utility-scale variable renewable systems offer the potential to substantially reduce local air pollution, drastically cut greenhouse gas emissions, and provide reliable energy at low cost. Application of the appropriate mix of these heterogeneous energy systems offers developing countries another opportunity for leapfrogging. Much as cell phones and wireless communications have transformed communications in developing countries, distributed, affordable, and clean energy systems offer a compelling opportunity to leapfrog traditional energy paradigms.[49]

Achieving a sustainable energy system will require transformative change in the underlying drivers that determine investment decisions and behaviour. The technological changes discussed above will only be implemented if the underlying drivers of day-to-day decisions are changed. This can involve policies like carbon pricing and legislation, but also social and behaviour change, for instance in terms of mobility patterns. Governments must develop laws and policies that enable greater public and private investments in generation and distribution, while also encouraging more responsible energy consumption. Government policy and incentives can speed the phase-out of fossil fuels in power generation and transportation, including by supporting the development of renewable energy storage and electric vehicles. Large-scale renewable energy installations on land, watercourses and in the ocean require careful planning to avoid or minimize adverse effects.



1 TWI2050 2020
2 IPBES 2019a, GA SPM, 40
3 IPBES 2019b, GA, 5
4 IPBES 2019a, GA SPM, C2, 23
5 Ouyang *et al.* 2020
6 Brundtland Commission 1987
7 Arrow *et al.* 2012
8 UN University and UNEP 2012, Inclusive Wealth Report 2012
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11 IPBES 2019a, GA SPM, B5
12 IPBES 2019b, GA, 6
13 GSDR 2019, 4.2
14 IPBES 2019b, GA, 5.4.1.1
15 TWI 2050 2020
16 UNEP 2019a, GEO-6, 17
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18 IPCC 2018a, SR 1.5, 2.5.2.2
19 CBD 2020b, GBO-5, Target 3
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21 Mudaliar and Dithrich 2019
22 Brundtland Commission 1987
23 IPCC 2019b, SRCCL SPM, Figure SPM.3
24 IPBES 2019b, GA, 3.3.2.1
25 IPCC 2019c, SRCCL, 3.3, 3.6.1
26 IPCC 2019c, SRCCL, 3.4.2, 3.6.1, 3.7.2
27 IPCC 2019c, SRCCL, 6.1, 6.2, 6.3, 6.4
28 IPBES 2019b, GA, 5.3.2.4
29 IPBES 2019b, GA, 5.3.2.4
30 IPBES 2019b, GA, 5.3.2.1, 5.4.2.1
31 IPBES 2016a, Pollinators Assessment, SPM, C
32 IPCC 2019c, SRCCL, 6.3.6
33 IPCC 2019c, SRCCL, 7.4.3, 7.4.6, 7.5.6, 7.4.8, 7.5.6, 7.6.3
34 IPCC 2019c, SRCCL, 3.8.5
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36 UN 2016, World Ocean Assessment I, Summary Part V.C
37 IPBES 2019b, GA, 5.4.1
38 IPBES 2019b, GA, 5.3.2.4, 6.3.4
39 IPBES 2019b, GA, 6.3.4
40 IPCC 2019c, SRCCL, 4.9.7
41 IPCC 2018b, SR 1.5 SPM, C.2.6
42 UNEP 2019a, GEO-6, 21.3.3
43 IEA 2020
44 HEI 2020
45 HEI 2020
46 UNEP 2019a, GEO-6, 23.3.2
47 TWI 2050 2020, Box 1
48 IEA 2020, World Energy Outlook
49 TWI 2050 2020, 2.3

8

Keeping the planet healthy is key to providing health and well-being for all

People's health and well-being are strongly influenced by environmental factors. This section identifies actions that can be taken to reverse environmental declines that threaten human health. It also examines the role of environmental factors and natural resources in promoting peaceful societies before addressing how making cities more sustainable can promote human well-being.

8.1 Reversing environmental decline reduces threats to human health and well-being

The ensemble of environmental issues that threaten human health and exacerbate inequalities within and between countries must be addressed. Policies and technologies are needed to limit the impacts on human health from climate change (e.g. vector- and water-borne diseases, heat stress mortality, extreme weather events, less nutritious foods), air pollution (e.g. cardio-vascular and respiratory diseases), loss of biodiversity and illegal wildlife trade (e.g. zoonotic and vector-borne diseases), water pollution (e.g. diarrhoea and cholera), and exposure to chemicals (e.g. poisoning from mercury, lead and pesticides). The policies and technologies required are addressed in more detail below.

Substantial improvements in global human health and well-being (SDG 3) can be achieved through transformative changes. They include a shift to sustainable land management and environmental stewardship. A transformation of energy and transport systems to create a low-carbon economy promises large benefits for human health, including through reduced pollution (SDG 7). Transformative changes focus action on high-level determinants of the health of people and the environment as well as the drivers of environmental change. A shift to sustainable land management is essential to safeguard human health and nutrition as well as livelihoods and other components of well-being. Reduced environmental impacts, which can be achieved through innovative technology, policy or institutional and cultural changes, are required to maintain the valuable ecosystem services upon which human lives depend (SDG 12).[1,2] Eliminating the use of fossil fuels can significantly reduce outdoor air pollution, which is projected to contribute annually to 4.5 million premature deaths by 2040 and 7 million premature deaths by 2050,[3] while also reducing the adverse health impacts from human-induced climate change (SDG 13). Access to clean and modern energy can reduce mortality and morbidity among the about 3.8 billion people who still rely on solid fuels for heating and cooking (see Section 7.3).

New forms of governance and cooperation that are inclusive and participatory can generate sustainable improvements in the health of people and nature. Improved coordination and collaboration between governments, individuals, civil society, the private sector and scientists can break cycles of intergenerational poverty and inequality by emphasizing the value of investing in the well-being of people (SDGs 11, 16 and 17). Such new forms of governance and cooperation are needed to provide better education, health care, nutrition, water and sanitation, and energy access, which are all critical to maintaining healthy individuals.[4] An example is cooperation between herders, health officials, human and veterinary doctors, ecologists and anthropologists in the management of zoonotic diseases.[5] Addressing inequalities and poverty can also help to achieve long-term environmental sustainability with benefits for health.[6]

Preventing environmental degradation saves lives. Environmental stewardship is key to a preventative approach to health care, which is in turn key for long-term health outcomes. A preventative approach can be achieved through intersectoral approaches, local community-based interventions, judicious legal and policy frameworks, rapid detection programmes, adequate financial resource allocation and ready-to-use rapid-response intervention plans. Large-scale approaches based on multidisciplinary efforts, such as One Health, encompass the opportunities and challenges pertaining to the interconnections of the human-animal-environment interface.[7] The primary aim is optimal health outcomes for all three sectors: human health, animal health and environment health. Through the surveillance of "hot-spots" for emerging diseases by considering behaviours, practices, and biological and ecological factors, successful detection, management and control of emerging infectious diseases, such as zoonoses, is possible. This must happen at a local level for best results.[8] By protecting the environment and increasing understanding of risks of emerging infectious diseases, countries will be better equipped to prevent, prepare for, and respond to (the threat of) an outbreak (see Box 8.1).[9]

Box 8.1 Avoiding pandemics and the transition to a sustainable world

The COVID-19 pandemic, which was still unfolding at the time of the completion of this report, illustrates why the transformation to a sustainable future needs to be accelerated. Science plays a pivotal role in informing policies that can drive this transformation, and a key area that needs to be better understood is the interaction between society and nature.

The emergence of new infectious diseases in humans, animals and plants can be exacerbated by human activities. Activities that contribute to ecological degradation can increase the risk of zoonotic-origin disease from wildlife through increased human contact with pathogens and changes in pathogen ecology. These activities include climate change, land-use change and fragmentation, agricultural intensification, deforestation, and legal and illegal commercial wildlife trade. In particular, the creation of new habitat edges at the interfaces between humans and wildlife increases the risk of pathogens spilling over from their wildlife hosts into human populations and their livestock.[10]

The risk of zoonotic-origin epidemics and pandemics can be reduced by managing such human activities and by applying a holistic One Health approach.[11,12,13]

A One Health approach recognizes how human, animal, plant and environmental health are intrinsically connected and profoundly influenced by human activities. COVID-19 has delivered a shock to humanity that could spark a paradigm shift towards a healthier and more sustainable future. Governments around the world are investing trillions of US dollars to catalyse economic recovery. This is an opportunity to build back better by ensuring that the social and economic measures put in place by countries to emerge from the crisis aim at moving away from unsustainable practices and accelerating the transformation towards the implementation of all the SDGs.

SDG 17 calls for "Partnerships for the Goals," to ensure that all SDGs are implemented with science-based decision-making, sound governance and a sense of responsibility of individuals. To achieve transformation, society must overcome sectoral silos, entrenched power, and economic interests, eliminate harmful drivers and perverse incentives, while promoting resilience and adaptation. There is a need for cooperative, multilateral and engaged democratic action at all levels of society, in every country, and at the international level. As part of this effort, promoting and operationalizing the One Health approach is paramount to secure human health in this changed world, including by preventing and improving the response to future pandemics. COVID-19 has shown the exorbitant cost of inaction and provides a critical learning opportunity. Transformative change towards preventing pandemics needs to occur now. Preparedness, including via policies for reducing risks of disease emergence such as from land use and wildlife trade, closing of critical knowledge gaps, and engaging all sectors of society, is essential.[14]

8.2 Promoting peaceful societies is key to reducing environmental degradation

Conflicts represent a major impediment to the transformation to sustainability. Conflicts can destabilize social systems with adverse environmental impacts, which in turn may cause or affect other conflicts. Those conflicts undermine governance, in turn generating further shifts in threats to ecosystems in a harmful socio-ecological feedback loop. For instance, urban development challenges, particularly in the Global South, that are difficult even in peacetime, are much more complex and problematic in conflict or post-conflict settings.[15,16]

Resolving conflict over natural resources requires understanding of the values of local stakeholders. At the local and regional levels, when there are conflicts over natural resources, it is important to adopt approaches and methods to understand the underlying values of different stakeholders and the social-cultural contexts in which they operate. To understand conflicting values, it is important to work in local contexts because cultural, ecological, economic and social values are intertwined, and priorities may vary greatly in different geographical regions. This puts emphasis on cultural significance rather than cultural values and emphasizes how people establish significant meaning around components of nature.[17]

8.1. Pathogen spillover events

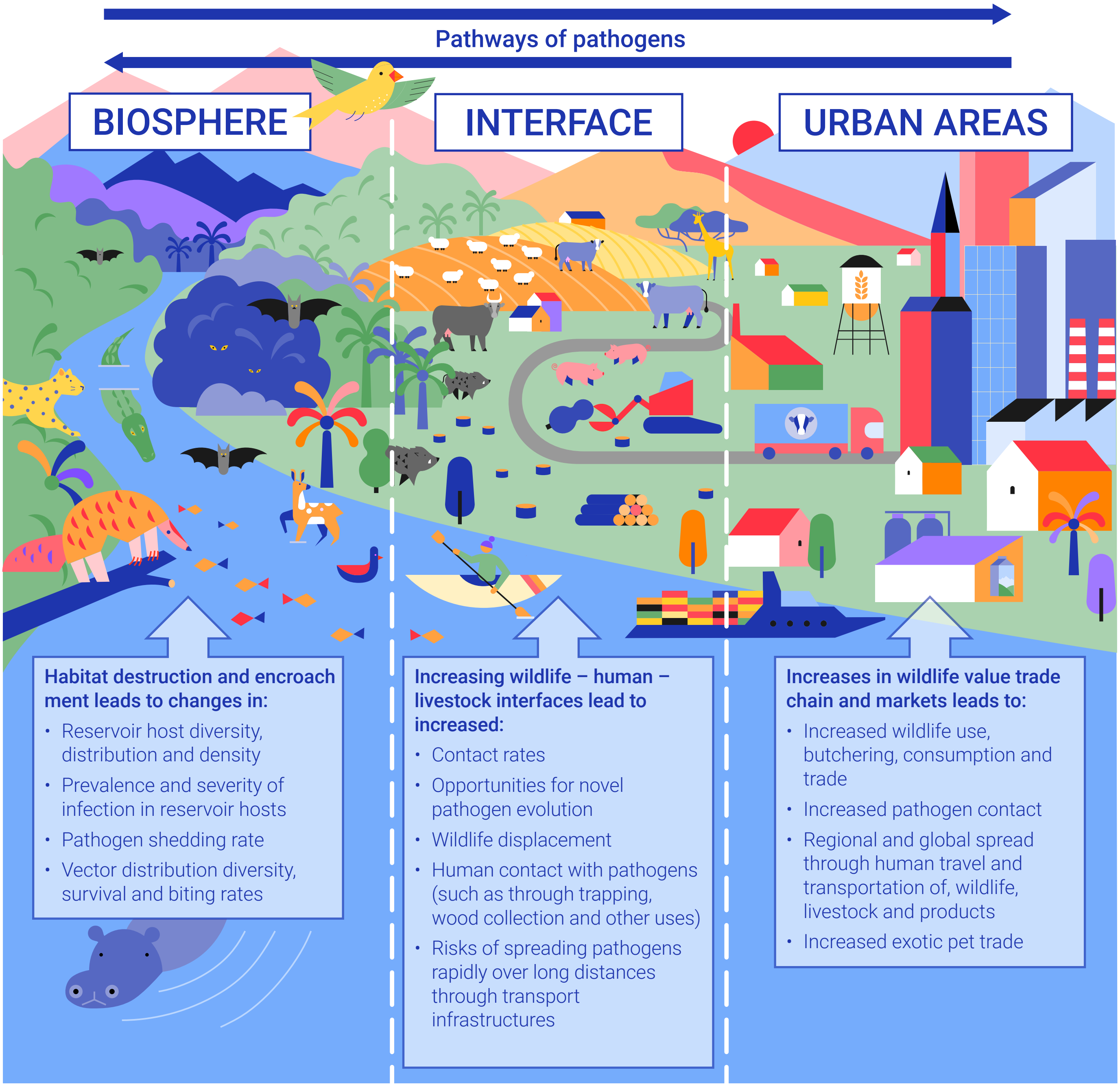

Figure 8.1: Possible pathogen spillover events in the wildlife – human – livestock interfaces.

Stakeholder involvement is central to lessening conflicts over climate change adaptation. Stakeholder involvement in decision-making, including community-based approaches, can reduce the risk of conflict over how to adapt to the impact of climate change. For instance, stakeholder involvement reduces informational and normative uncertainty; helps to build consensus on criteria for monitoring and evaluation; can empower stakeholders to influence adaptation and take appropriate actions themselves by sharing knowledge and responsibility in participatory processes; can reduce conflicts and identify synergies between adaptation activities of various stakeholders, thus improving overall chances of success; and can improve the likely fairness, social justice, and legitimacy of adaptation decisions and actions by addressing the concerns of all relevant stakeholders.[18,19]

Participatory approaches to spatial planning can lessen conflicts over resources. At the regional level, participatory approaches to spatial planning and zoning, including land-use planning, water use planning, ecosystem modelling, marine spatial planning, integrated coastal zone management, and integrated watershed management can lessen the conflicts between economic actors competing for resources.[20] Measures to prevent and reduce conflict include supporting co-management regimes for collaborative water management, fostering equity between water users (while maintaining minimum flows for aquatic ecosystems) and promoting transparency and access to information.[21]

Multilateral agreements addressing transboundary issues are key to protecting the global commons. At the international level, multilateral agreements addressing transboundary issues are key to the protection of the global commons, and adaptive governance involving a wide range of institutions and stakeholders can help ensure their sustainable management. Building upon and enhancing existing international agreements can further strengthen the protection of global commons and help establish partnerships for solving conflicts and for the sustainable management of commons.[22]

8.3 Making cities and communities sustainable is critical

Rapid urbanization makes the design of environmentally and socially sustainable cities critical. The share of people living in urban areas is projected to increase from 54 per cent in 2015 to 78 per cent in 2050. Around 90 per cent of population growth in cities is projected to take place in low-income countries, mainly in small and medium-sized cities in Sub-Saharan Africa and South Asia (see Section 2.3.1). The expansion of the world's urban areas in the next two to three decades poses challenges and represents opportunities to plan and design sustainable cities.[23,24,25] In rapidly growing and urbanizing regions, climate mitigation strategies based on urban design, spatial planning and efficient infrastructure can avoid the lock-in of high emission patterns.[26,27] In industrialized countries with cities characterized by urban sprawl, it is crucial to promote more intensive and smarter use of space and regeneration of city centres.[28] Urban systems transitions require deep and far-reaching solutions, significant upscaling of investments[29] and institutional capacity development.[30] Integrated city-specific and landscape-level planning, nature-based solutions and responsible production and consumption are key solutions.[31]

There are many actions and pathways available for building sustainable cities. Numerous approaches and technologies that address critical human needs while conserving and restoring nature and ecosystem services have been developed. These include: engaging in sustainable urban planning; encouraging densification for compact communities, especially in sprawling cities; regional planning to mainstream biodiversity, nature and ecological restoration; promoting sustainable production and consumption; promoting nature-based solutions; promoting, developing, safeguarding or retrofitting with soft infrastructure for water management while improving hard infrastructure to address biodiversity outcomes;[32,33] promoting ecosystem-based adaptation within communities; maintaining and designing for ecological connectivity within urban spaces; increasing urban green spaces and improving access to them; increasing access to urban services for low-income communities; and promoting urban agriculture to increase local food supply.[34,35]

Effective governance, policy alignment, strong capacities and financing are key for urban climate adaptation. Effective multilevel governance, the alignment of policies and incentives, strengthened local government and community adaptation capacity, synergies with the private sector and appropriate financing and institutional development are vital to cities' ability to adapt to climate change. Enhancing the capacity of low-income groups and vulnerable communities and their partnerships with local governments can be an effective urban climate adaptation strategy. Examples of adaptation mechanisms include large-scale public-private risk reduction initiatives, economic diversification and government insurance for the non-diversifiable portion of risk. In some locations, especially at the upper end of projected climate changes, responses could also require transformative changes such as managed retreat.[36,37]

Stakeholder engagement, participatory and integrative planning, alternative business models and incentives for urban conservation are key to creating sustainable cities and communities. Key means for implementing sustainable cities and communities include stakeholder engagement and participatory and integrative planning, which can enable rapid, systemic transitions and resilience in communities.[38,39] Encouraging alternative business models and incentives for urban conservation are also important.[40] Sustainable solutions at urban and city scale are most effective when aligned with wider economic and sustainable development, and when local and regional governments and decision makers are supported by national governments and effective multilevel governance.[41,42] Shifts toward sustainability in urban areas are expected to be most effective when policy instruments are bundled; successful strategies involve packages of mutually reinforcing policies.[43,44]

1 GSDR 2019, Box 1-8
2 UNEP 2019a, GEO-6, 8
3 UNEP 2019a, GEO-6, 21
4 GSDR 2019, 2.5.2
5 GSDR 2019, 3.3.1
6 IPBES 2019b, GA, 5
7 UNEP 2019a, GEO-6, Box 6.1
8 UNEP 2016, Frontiers
9 FAO, WHO, OiE 2019, 5
10 IPBES 2020, ES
11 CBD 2018
12 UNEP 2020c, IV
13 IPBES 2020, 5
14 IPBES 2020, 5
15 GSDR 2019, 1.2.1
16 IPCC 2019c, SRCCL, 7.6
17 IPBES 2019b, GA, 4.4.1.1.2
18 IPCC 2018a, SR1.5, 4.4.1, Cross-Chapter Box 9, Box 4.3
19 IPCC 2019c, SRCCL, 6, 6.1.2.1, 6.4.4.3, 6.3.2.2, 6.3.5.1, 6.4.5
20 WRI 2019, 23, 303
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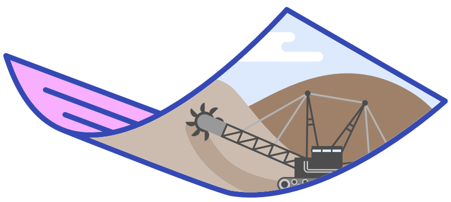
22 GSDR 2019, 2.10
23 IPCC 2014f, AR5 WGIII SPM, 12.2, 12.3, 12.4, 12.8
24 IRP 2018, 3.1
25 UNEP 2019a, GEO-6, 2.4.4
26 IPCC 2014c, SYR, 4.5
27 IPBES 2019b, GA, 5.3.2
28 IRP 2018, 3.3.4, 6.2
29 IPCC 2018a, SR1.5, 2.3, 2.4, 2.5, 4.2, 4.3, 4.4, 4.5
30 IPCC 2014f, AR5 WGIII SPM, 4.2.5
31 IPBES 2019a, GA, SPM, 39
32 IPBES 2019a, GA SPM, Table 1
33 IPCC 2019c, SRCCL, A6.5
34 IPBES 2019a, GA SPM, Table 1
35 IPCC 2019c, SRCCL, Table TS.1, Cross Chapter box 4, 5.6.5
36 IPCC 2014d, AR5 WGII SPM, B-2, 8.3–8.4, 24.4, 24.5, 26.8, Box 25-9
37 IPCC 2014c, AR5 SYR, 4.5
38 IPCC 2014a, AR5 SYR SPM, 6.3.5.3, 4.5
39 IPCC 2018a, SR1.5, 3.5, 4.4, 4.5
40 IPBES 2019a, GA SPM, Table 1, 6.3.2.1
41 IPCC 2018a, SR1.5, 4.3.2, 4.3.3, 4.4.1, 4.4.2
42 IPCC 2014c, AR5 SYR, 4.5
43 IPCC 2014f, AR5 WGIII SPM, 8.4, 12.3, 12.4, 12.5, 12.6
44 IPCC 2019c, SRCCL, TS.7, 7.3.1, 7.4.7, 7.4.8, 7.5.6, Cross-Chapter Box 10



9

All actors have a part to play in transforming humankind's relationship with nature

All actors have a role to play in the transformations needed to achieve a sustainable world. This section identifies the actions that different actors can take, individually and collectively.

At the heart of the transformative changes needed for a sustainable future are informed, fair and participatory governance systems, where all relevant stakeholders have a voice. Polycentric systems of governance allow for information flow as well as collaborative planning, participation and coordination. Because governance systems are not merely the product of governments but rather of all societal actors, realizing governance systems suited for sustainability will require coordination amongst many different actors, including those who frequently don't cooperate. This will mean a move towards a new norm of transcending boundaries of responsibility and authority (between individuals as well as between and within organizations, agencies and sectors) in pursuit of the common objective of transformative change for vibrant, sustainable futures.[1,2] The post COVID-19 era may provide an opportunity for stimulating such collaboration.

All actors have individual, complementary and nested roles to play in bringing about cross-sectoral and economy-wide transformative change with immediate and long-term impact (table 9.1). Governments initiate and lead in intergovernmental cooperation, policies and legislation that transform society and the economy. Such transformations enable the private sector, financial institutions, non-governmental organizations, scientific and educational institutions and media, as well as individuals, households and civil society groups, to initiate and lead transformations in their domains. Table 9.1 lists potential actions sector by sector for a range of actors that can bring about transformative change toward sustainability. This structure has been chosen so that each actor can see the actions they should take, recognizing that actions within one sector can have synergistic effects on other sectors, and that some actions are relevant to more than one sector.

Knowledge-based cooperation that harnesses human, societal and technological ingenuity will unveil new possibilities and opportunities in the transformation to a sustainable future. Multiple actors will need to cooperate within each transformation, for example in further developing the framework for using inclusive wealth in decision-making, or in developing policies and strategies to integrate biodiversity conservation and restoration into the many uses of terrestrial, freshwater and marine ecosystems (see Sections 6 and 7). There are also a number of actions that are not specific to a single sector, so that many of the actors (in particular governments and the private sector) need to consider them, in addition to the sector-specific actions listed in table 9.1 for each actor. These general actions include: transforming decision-making to be pre-emptive, inclusive, integrated, robust to uncertainty and executable; and eliminating the negative environmental effects of production, resource extraction, construction and other activities by transforming supply chains and development processes (see Sections 5, 6 and 7). The media and social networks play a critical role in informing the public about the interconnected nature of pressing issues and the role that environmental degradation plays in exacerbating societal issues, thus stimulating public awareness and political support for meaningful solutions. The media can also hold governments and businesses to account, comparing promises with actions taken. Social networks can be designed and managed to showcase reasonable dissent and prosocial norms and expose false claims. Cooperation and innovation on this scale by all actors can generate new possibilities and opportunities for social and economic development in the transformation to a sustainable future.

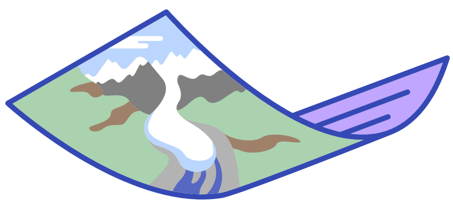


Table ES.1 Actors and actions to transform humankind's relationship with nature

Actors	Examples of key actions to be taken
Governments – legislature, judicial and executive branches at national, subnational and local level	**1. Address Earth's environmental emergencies and human well-being together** a) **Synergies** Establish mechanisms and approaches for cross-sectoral coordination of assessments, policies, legislation, enforcement and financing, including through integrated approaches such as a One Health policy for human and animal health and the environment. b) **Climate change** Adopt plans and goals consistent with the Paris Agreement for transitioning to net-zero carbon dioxide emissions by 2050, cutting emissions by 45 per cent by 2030 compared with 2010. Put a price on carbon, phase out fossil fuel finance and end fossil fuel subsidies, stop building new coal power plants and advance adaptation and resilience to climate change. c) **Biodiversity loss and ecosystem degradation** Develop policies and strategies to integrate biodiversity conservation and restoration into the many uses of terrestrial, freshwater and marine ecosystems, as well as expanding and improving protected areas. Drastically reduce deforestation and systematically restore forests and other ecosystems as the single largest nature-based opportunity for climate mitigation. d) **Health and well-being** Recognize a healthy environment as a basic human right and provide health and well-being for all. Comply with obligations under the chemicals conventions. Implement and enforce chemicals and waste policies, adopt reuse and recycling standards and develop strategies to meet WHO guidelines for air pollutants. Invest in community-based family planning and assist women to access financing and education. e) **Cities and settlements** Design and develop socially and environmentally sustainable cities and settlements by embracing nature-based solutions, promoting enhanced access to services such as clean water and energy and public transport, and making infrastructure and buildings sustainable. **2. Transform economic and financial systems so they lead and power the shift toward sustainability** a) **Accounting for nature** Reform national economic, financial, planning and tax systems to include natural capital (using inclusive wealth as a measure of sustainable economic performance) and environmental costs (by internalizing externalities) in decision-making. Integrate the goals of carbon neutrality, land degradation neutrality and conservation of biodiversity into all economic and fiscal policies and decisions. b) **Subsidies and markets** Reform subsidies to eliminate harmful environmental and social effects including by ending fossil fuel subsidies. Establish carbon taxes, carbon pricing, markets for carbon trading, and schemes for offsetting of nature and payments for ecosystem services. Regulate to establish a level playing field in national and international markets. c) **Investments** Invest in economic activities, research and development – nationally and through international development assistance and transfer of technology – that enhance the stock of natural assets and advance the shift towards sustainability and a low-carbon economy. Provide funding for developing countries to meet their obligations under the multilateral environmental agreements and SDGs.

Governments – legislature, judicial and executive branches at national, subnational and local level (continued)	**3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner** a) **Access** Develop and implement policies to provide sustainable access to affordable and nutritious food, clean energy and safe water for all. b) **Food and water** Integrate sustainable production and management of food and water within terrestrial, freshwater and marine ecosystems. Make agriculture, forestry, fisheries, aquaculture and resource extraction biodiversity-positive. Promote sustainable agricultural intensification, agroecological practices and conservation of genetic resources. Stop overfishing. Promote healthy diets and reductions in food and water waste. Restrict groundwater extraction and advance appropriate water pricing and the use of agricultural, forestry and fisheries certification standards. c) **Energy** Develop energy efficiency regulations, renewable energy targets, sustainable bioenergy strategies and infrastructure for electric vehicles.
Intergovernmental organizations	**1. Address Earth's environmental emergencies and human well-being together** a) **Synergies** Facilitate international cooperation in science-policy interfaces and advance UN system-wide efforts including by promoting synergies among scientific assessments and multilateral environmental agreements through norms, implementation, financing, capacity-building and technological cooperation. b) **Climate change** Build a global coalition for carbon neutrality consistent with the Paris Agreement for transitioning to net-zero carbon dioxide emissions by 2050 and cutting emissions by 45 per cent by 2030 compared with 2010. Advance adaptation, especially in least developed countries. c) **Biodiversity loss and ecosystem degradation** Advance international cooperation on addressing the biodiversity emergency, including through relevant multilateral environmental agreements. Promote ambitious post-2020 targets and actions for biodiversity and land neutrality. Support the UN Decade on Ecosystem Restoration focused on preventing, halting and reversing the degradation of forests, land and other ecosystems worldwide. Make own international activities and operations sustainable. d) **Health and well-being** Facilitate international cooperation on protecting the health of the planet in order to provide health and well-being for all. Advance a One Health approach and strategies to meet WHO guidelines for air pollutants. Continue to promote the coordination and implementation of existing chemicals conventions and strengthen the science-policy interface for chemicals and waste. Implement monitoring and surveillance and early warning systems. e) **Cities and settlements** Promote sustainable urban planning, nature-based solutions for climate and biodiversity in urban areas, retrofitting of blue and green infrastructure, and access to urban services including clean energy and water. **2. Transform economic and financial systems so they lead and power the shift toward sustainability** a) **Accounting for nature** Facilitate international cooperation on frameworks for natural capital accounting, reform of measures and models of economic growth including through the use of natural capital and inclusive wealth in decision-making, and reform of trade systems to make them more fair and environmentally sustainable.

Intergovernmental organizations (continued)

b) **Subsidies and markets** Promote a circular economy, elimination of environmentally damaging fossil fuel and agricultural subsidies, harmonization of environmental taxes such as carbon taxes, cooperation on carbon trading, schemes for offsetting nature and payments for ecosystem services. Support private sector initiatives to create sustainable global supply chains.

c) **Investments** Facilitate cooperation on international development assistance, capacity-building and transfer of technology that help enhance the stock of natural assets in recipient countries and advance their shift towards sustainability and a low-carbon economy.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Facilitate international research and cooperation on improving access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Promote and facilitate sustainable policies, technologies and management within agriculture-fisheries-forestry-water-energy systems, including through sustainable fisheries, agricultural intensification, agroecological practices and multifunctional landscapes. Advance the use of agricultural, forestry, aquaculture and fisheries certification standards and labelling. Encourage healthy diets, and reductions in food and water waste. Support cooperation on water management including through freshwater treaties and assist the development of agreements for the protection of genetic resources for agriculture and the fair and equitable sharing of benefits arising from their use.

c) **Energy** Support the transition to a low-carbon economy, both in the production and use of energy.

Financial organizations

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Finance international and cross-sectoral cooperation, capacity-building and technological cooperation that address environmental challenges and human well-being. Disclose climate-related financial risk, and the use of natural resources and the impact of these activities on the environment. Align operations with the net-zero carbon emissions objective and sustainability principles.

b) **Climate change** Multilateral, regional and national development institutions as well as private banks should commit to align their lending to the global net-zero carbon emissions objective. Asset owners and managers should decarbonize their portfolios and join initiatives including the Global Investors for Sustainable Development Alliance and the Net-Zero Asset Owners Alliance. Multilateral and national development banks should commit to increase the share of adaptation and resilience finance to at least 50 per cent of their climate finance to support activities such as early warning systems, and climate-resilient infrastructure and agriculture.

c) **Biodiversity loss and ecosystem degradation** Develop and promote innovative financing mechanisms for the conservation and restoration of biodiversity, including through payments for ecosystem services. Support the expansion and better management of protected areas and other effective area-based conservation measures and activities aligned with the UN Decade on Ecosystem Restoration.

d) **Health and well-being** Support One Health and disease prevention initiatives and strategies to meet WHO guidelines for air pollutants. Support health research, especially in developing countries. Provide financing for improved waste management.

e) **Cities and settlements** Develop and promote innovative financing for sustainable infrastructure. Support sustainable urban planning and investments in low-carbon infrastructure, including mass transportation, congestion charges, nature-based solutions and green and blue spaces.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Promote and use natural capital accounting and inclusive wealth in decision-making, including lending and grant-making policies. Promote the internalization of externalities in prices and a circular economy.

b) **Subsidies and markets** Promote the elimination of environmentally harmful subsidies. Facilitate carbon trading, schemes for offsetting nature and payments for ecosystem services. Develop environmental and social risk registers for all financial transactions.

c) **Investments** Facilitate a major shift away from investments in environmentally unsustainable activities and toward economic activities that enhance the stock of natural assets. Fund the transition to a circular, green and low-carbon economy. Funding should flow to resilience, adaptation and just transition programmes. Fund research and development nationally and through international development assistance.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Fund programmes that improve access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Finance sustainable intensification and ecological intensification of agriculture, and sustainable fisheries, and stop supporting unsustainable activities such as deforestation. Advance the use of agricultural, forestry, aquaculture and fisheries certification standards and labelling and encourage healthy diets, and reductions in food, water and energy waste. Support the development and use of certification standards for agriculture, fishing, aquaculture, forestry and water use.

c) **Energy** Finance low-carbon energy production and use, and stop supporting unsustainable activities, such as fossil fuel energy.

Private sector

1. **Address Earth's environmental emergencies and human well-being together**

a) **Synergies** Help develop and comply with strong environmental legislation that levels the playing field so that firms cannot gain competitive advantage by externalizing costs that are then borne by society. Implement certified and traceable sustainable practices along the complete supply chain. Disclose climate-related financial risk, use of natural resources and the impact of activities on the environment. Practise corporate social responsibility.

b) **Climate change** Adjust business models and align them with the global net-zero carbon emissions objective and sustainability practices in all sectors, including in shipping and aviation. Investors should demand information from companies on the resilience of those models.

c) **Biodiversity loss and ecosystem degradation** Develop and promote innovative public-private partnerships for financing and engaging in the conservation and restoration of biodiversity, including through the use of payments for ecosystem services. Implement sustainable land management practices for agriculture and forestry. Engage in transformative landscape governance networks. Develop sustainable global supply chains for deforestation-free agricultural commodities.

d) **Health and well-being** Comply with environmental standards to protect human health. Move industries to a sustainable and circular business model by reducing waste and resource use and encouraging sharing, reuse and recycling. Promote and support plastic free/environmentally friendly packaging. Conduct transparent risk assessments of the impact of chemicals on the environment and human health. Increase the use of green chemistry, invest in waste recycling and set high standards for waste disposal.

e) **Cities and settlements** Engage with and support government in sustainable urban planning, public transport, energy-efficient buildings and partnerships to enhance access to urban services.

2. **Transform economic and financial systems so they lead and power the shift toward sustainability**

a) **Accounting for nature** Use natural capital in decision-making and develop environmental and social risk registers for all projects and investments.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting nature, and payments for ecosystem services. Promote behaviour change in customers. Further develop and implement social and environmental standards for corporate operations.

c) **Investments** Shift investments and operations away from unsustainable industries, such as fossil fuels. Invest in innovation, environmentally sound technologies and move towards a circular economy.

3. **Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner**

a) **Access** Develop and invest in systems to produce, store and distribute affordable and clean power and water and healthy food to all.

b) **Food and water** Provide modern food storage and distribution services that minimize waste. Promote the development and use of food certification standards and product labelling. Invest in sustainable intensification in agriculture, fisheries and aquaculture. Develop climate-resilient crops and livestock breeds as well as alternatives to harmful agricultural inputs, including to fertilizers and pesticides.

c) **Energy** Develop, invest in and use low-carbon energy technologies and distribution networks.

Non-governmental organizations

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Support education, promote youth movements and engage communities in citizen science. Participate in community-led initiatives to promote sustainable consumption and production. Help hold societal actors accountable for their environmental promises, commitments and responsibilities. Support the training of the next generation of leaders.

b) **Climate change** Promote and align activities and operations with the net-zero carbon emissions objective. Implement mitigation, adaptation and resilience programmes and projects, including through nature-based solutions.

c) **Biodiversity loss and ecosystem degradation** Support and implement efforts for the conservation, restoration and sustainable use of biodiversity. Develop local-regional-national conservation programmes. Participate in community-led initiatives to conserve nature. Engage in transformative landscape governance networks. Support the development and management of protected areas and other effective area-based conservation measures.

d) **Health and well-being** Raise awareness on chemical safety and take a greater role in the SAICM chemicals management processes. Work with communities and local municipalities for the safe disposal of waste.

e) **Cities and settlements** Campaign for and support sustainable urban planning and improved access to urban services and community initiatives, especially for the urban poor.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Promote the use of natural capital accounting, and initiatives for the transformation to a sustainable and circular economy.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting of nature and payment for ecosystem services Promote behavioural change in consumption and production, including among their own members and wider society.

c) **Investments** Advocate for policies and regulations that promote investment in sustainable development.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Advocate for and implement programmes and projects for improved access to affordable and nutritious food, clean energy and safe water for all.

b) **Food and water** Develop and implement initiatives for the ecological intensification and sustainable use of multifunctional landscapes. Promote dietary transitions and reductions in food, water and energy waste. Assist in improving certification standards.

c) **Energy** Participate in community-led initiatives to shift toward cleaner fuels, increase energy-efficiency, conserve energy and develop sustainable bioenergy strategies.

Individuals, households, civil society and youth groups, and indigenous peoples and local communities

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Foster social norms and behaviours that embody sustainability principles by exercising voting and civic rights and holding governments and the private sector accountable for their actions. Review and comment on local and national policies. Engage in initiatives that promote sustainable consumption. Engage in education and citizen-science initiatives.

b) **Climate change** Make climate-friendly everyday choices on travel and consumption that contribute to the net-zero carbon emissions objective. Engage in local adaptation and resilience initiatives, including through nature-based solutions.

c) **Biodiversity loss and ecosystem degradation** Engage in local and national conservation and restoration efforts, transformative landscape governance networks and awareness campaigns to influence consumer behaviour.

d) **Health and well-being** Understand and promote the links between environment and human health. Participate in community-led clean-ups of waste in public spaces. Ensure materials are recycled and waste is properly disposed of.

e) **Cities and settlements** Engage in participatory processes to advance sustainable urban planning and initiatives to increase access to urban services, and promote nature-based solutions and green and blue infrastructure.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Foster economic and financial transformations by supporting initiatives to include environmental costs in the prices of goods and services.

b) **Subsidies and markets** Engage in carbon trading, schemes for offsetting nature, and payments for ecosystem services. Support fair trade and companies with sustainable production models that provide services and products that foster societal well-being.

c) **Investments** Support shifts in investment towards those needed to achieve the SDGs, and away from unsustainable industries, such as fossil fuels.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Support and engage in local production and distribution systems for healthy food, safe water and clean energy.

b) **Food and water** Consider what constitutes a healthy diet and also reduces environmental damage. Adopt sustainable practices in community-based and small-scale food production. Purchase sustainably produced food and reduce waste. Reduce wasting water, and collect rainwater and use grey water.

c) **Energy** Support community-based energy production. Reduce energy consumption and chose clean energy when possible.

Scientific and educational organizations

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Develop analytical tools, including plausible futures models, using exploratory, target-seeking and policy-screening scenarios that account for the complex interlinkages between environment and development. Further develop observational programs. Engage in national and international scientific assessments. Develop environmental education programs for all age groups. Raise public awareness through public engagements, editorials, social media.

b) **Climate change** Assess the impact of climate change on socio-economic sectors, nature and human health at all scales. Assess the efficacy and cost-effectiveness of different mitigation and adaptation policies and technologies.

c) **Biodiversity loss and ecosystem degradation** Assess the impact of multiple drivers on biodiversity and ecosystem degradation, and the efficacy and cost-effectiveness of conservation and restoration activities, including nature-based solutions.

d) **Health and well-being** Promote education, information and awareness of One Health approaches. Assess interactions among environmental issues and their impacts on socio-economic sectors and human health. Assess the implications of chemicals for human health and the environment, and develop health surveillance and monitoring systems, and approaches to prevent disease outbreaks, including pandemics. Assess the mental health implications of green and blue infrastructure in urban environments.

e) **Cities and settlements** Support sustainable urban planning and development, including the use of nature-based solutions. Promote education, information and awareness on sustainable cities and settlements and their importance for human health.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Further develop the framework for natural capital accounting and the relevant databases. Assess the costs and benefits of mitigating and adapting to climate change, loss of biodiversity and ecosystem degradation, land degradation, and air and water pollution at a range of spatial scales. Assess the implications of reforming measures and models of economic growth. Promote education, information and awareness on sustainable economic and financial systems.

b) **Subsidies and markets** Assess the environmental and distributional social impacts of reductions in harmful subsidies, and the reallocation of these resources to support sustainable consumption and production.

c) **Investments** Assess the environmental and social impacts of switching investments from unsustainable activities such as fossil fuels to sustainable activities.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

a) **Access** Help develop and monitor systems and networks to produce and distribute clean water and energy and nutritional food. Support the development of certification processes.

b) **Food and water** Promote education, information and awareness on sustainability within agriculture-fisheries-forestry-water-energy systems. Assess the implications of environmental degradation on agriculture and water resources. Develop temperature, drought, pest and salinity resistant crops. Assess how to reduce the environmental footprint of agriculture. Facilitate the conservation and sustainable use of genetic resources. Develop water purification and desalination technologies.

c) **Energy** Develop low-carbon production and use technologies, and assess how to overcome the barriers to market penetration of these technologies.

Media and social networks

1. Address Earth's environmental emergencies and human well-being together

a) **Synergies** Inform all actors about the relationships between environment and development issues. Help hold societal actors accountable for their environmental promises, commitments and responsibilities. Support campaigns for meaningful actions to address environmental degradation. Counter disinformation and promote environmentally responsible social norms.

b) **Climate change** Highlight the implications of climate change for people and nature, and the opportunities for adaptation and mitigation.

c) **Biodiversity loss and ecosystem degradation** Highlight the importance of biodiversity for human prosperity and well-being and the options for its conservation and restoration.

d) **Health and well-being** Spread understanding and awareness of One Health approaches. Support campaigns for meaningful transformations in the health sector.

e) **Cities and settlements** Document the impact on people and nature of unsustainable systems in urban areas and support campaigns for transformations in how cities and settlements are planned and designed, including the supply of essential services.

2. Transform economic and financial systems so they lead and power the shift toward sustainability

a) **Accounting for nature** Raise awareness of how current economic models and performance measures as well as the price of some goods and services fail to fully account for natural capital and environmental costs, and how this skews investment toward unsustainable activities. Support campaigns for meaningful transformations in economic and financial systems.

b) **Subsidies and markets** Inform the public and other actors of the adverse consequences of fossil fuel and agricultural subsidies that lead to environmental damage, and explore the impact of redirecting the financing of subsidies to sustainable activities.

c) **Investments** Highlight government spending and private sector investments that are unsustainable and those which are sustainable.

3. Transform food, water and energy systems to meet growing human needs in an equitable, resilient and environmentally friendly manner

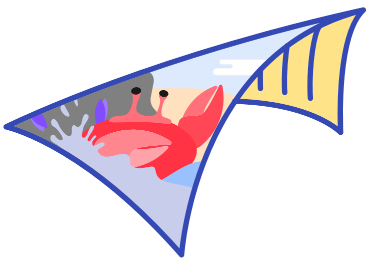
a) **Access** Highlight the inequitable access to safe and affordable food, clean water and clean energy, and ways to improve access.

b) **Food and water** Provide information and raise awareness of the need for more sustainable practices in the agriculture-fisheries-forestry-water-energy systems. Support campaigns for meaningful transformations in the agricultural, water and energy sectors. Provide information on the health and environmental effects of different diets.

c) **Energy** Raise awareness of the benefits from and pathways for meaningful transformations in the energy sector.

1 IPBES 2019a, GA SPM, D

2 GSDR 2019, 6.2



Annex I:
Global environmental assessments used in this report

This report is an expert synthesis based on evidence from global environmental assessments. The analysis rests primarily on key findings from a range of intergovernmental global environmental assessment reports, complemented with findings from assessment reports from Multilateral Environmental Agreements (MEAs) and UN bodies, as well as other reports and, to a limited degree, additional high-impact peer-reviewed literature and grey literature.

Intergovernmental global environmental assessments are developed through processes involving Member States and experts from around the world in the scoping, review and consideration of each assessment, including line-by-line consideration and approval of their Summaries for Policymakers (SPMs). The assessment reports that provided a core evidence base for this report include:

The Intergovernmental Panel on Climate Change (IPCC) assessment reports:[I]

- Special Report, Managing the Risks of Extreme Events and Disaster to Advance Climate Change adaptation (2012)
- Synthesis Report, AR5 Synthesis Report: Climate Change 2014 (2014)
- Special Report, Global Warming of 1.5°C (2018)
- Special Report, Climate Change and Land (2019)
- Special Report, The Ocean and Cryosphere in a Changing Climate (2019)

I https://www.ipcc.ch/reports/

- *The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) assessment reports:*[II]
- Assessment Report on Pollinators, Pollination and Food Production (2016)
- Regional Assessment Report on Biodiversity and Ecosystem Services for Africa (2018)
- Regional Assessment Report on Biodiversity and Ecosystem Services for the Americas (2018)
- Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific (2018)
- Regional Assessment Report on Biodiversity and Ecosystem Services for Europe and Central Asia (2018)
- Assessment Report on Land Degradation and Restoration (2018)
- Global Assessment Report on Biodiversity and Ecosystem Services (2019)

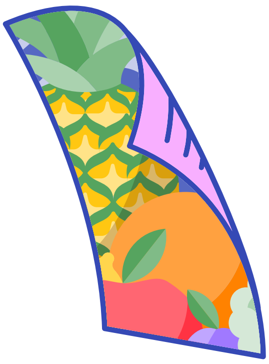
The Global Environment Outlook (GEO) assessment reports:[III]

- Global Environment Outlook-6 (GEO-6) (2019)

II https://www.ipbes.net/assessing-knowledge

III https://www.unenvironment.org/global-environment-outlook/why-global-environment-outlook-matters/global

Assessment reports prepared under the auspices of Multilateral Environmental Agreements, United Nations System entities and others are developed through a variety of processes involving inputs from a range of contributors. Depending on the circumstances, these processes may include contributions by expert authors, advisors, reviewers, staff and Member States. The broad range of assessment reports referred to is presented in footnotes and in the list of references. Key reports include those prepared under the auspices of the Convention on Biological Diversity (CBD);[IV] Montreal Protocol (WMO/UNEP);[V] Ramsar Convention on Wetlands;[VI] United Nations Convention to Combat Desertification (UNCCD);[VII] United Nations Environment Programme (UNEP)[VIII] (including the International Resource Panel[IX] and Global Chemicals Outlook[X]); United Nations General Assembly (including its Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects[XI]); United Nations Department of Economic and Social Affairs (UNDESA) (including its Global Sustainable Development Report[XII]); Food and Agriculture Organization of the United Nations (FAO); International Energy Agency (IEA); International Monetary Fund (IMF); United Nations Development Programme (UNDP); World Bank; World Health Organization (WHO) and other United Nations System entities, regional bodies and non-governmental organizations.



IV https://www.cbd.int/gbo/

V https://ozone.unep.org/science/assessment/sap

VI https://www.global-wetland-outlook.ramsar.org/

VII https://www.unccd.int/actions/global-land-outlook-glo

VIII https://www.unep.org/explore-topics/environment-under-review

IX https://www.resourcepanel.org/

X https://www.unenvironment.org/explore-topics/chemicals-waste/what-we-do/policy-and-governance/global-chemicals-outlook

XI https://www.un.org/regularprocess/

XII https://sustainabledevelopment.un.org/globalsdreport/

Glossary

Adaptation
Adjustment in natural or human systems to a new or changing environment, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.; In human systems, the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Aerosol particles
A collection of airborne solid or liquid particles suspended in air, with a typical size between a few nanometers to tens of micrometres (μm). Aerosol particles can reside in the atmosphere up to weeks. Aerosols may be of either natural or anthropogenic origin.

Billion
10^9 (1 000 000 000).

Bioenergy
Renewable energy produced by living organisms.; Energy derived from any form of biomass such as recently living organisms or their metabolic by- products.

Biomass
Organic material above and below ground and in water, both living and dead, such as trees, crops, grasses, tree litter and roots. In Section 2, used as the unit to measure ratios of mammals on Earth in gigatons of carbon.

Bottom-up
Accumulating from the lowest level of a hierarchy or process to the highest level.

Carbon dioxide removal (CDR)
Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage but excludes natural CO_2 uptake not directly caused by human activities.

Carbon sequestration
The process of increasing the carbon content of a reservoir other than the atmosphere.

Carbon stock
The quantity of carbon contained in a "pool", meaning a reservoir or system which has the capacity to accumulate or release carbon.

Carbon tax
A levy on the carbon content of fossil fuels. Because virtually all of the carbon in fossil fuels is ultimately emitted as CO_2, a carbon tax is equivalent to an emission tax on CO_2 emissions.

Chikungunya
Chikungunya is a viral disease transmitted to humans by infected mosquitoes. It causes fever and severe joint pain. Other symptoms include muscle pain, headache, nausea, fatigue and rash.

Chlorofluorocarbons (CFCs)
A group of chemicals containing chlorine, fluorine and carbon atoms, highly volatile and of low toxicity, widely used in the past as refrigerants, solvents, propellants and foaming agents. Chlorofluorocarbons have both ozone depletion and global warming potential.

Circular economy
A circular economy is a systems-based approach to industrial processes and economic activities that enables the resources used to maintain their highest value for as long as possible. Key considerations in implementing a circular economy are reducing use, extending longevity, renewability, reusability, reparability, replaceability, upgradability of resources and products.

Climate change
The UN Framework Convention on Climate Change definition is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Co-benefits
The positive effects that a policy or measure aimed at one objective might have on other objectives, without yet evaluating the net effect on overall social welfare. Co-benefits, also referred to as ancillary benefits, depend on, among other things, local circumstances and implementation practices.

Conservation
The protection, care, management and maintenance of ecosystems, habitats, wildlife species and populations, within or outside of their natural environments, to safeguard the natural conditions for their long-term permanence.

Coronavirus disease 2019 (COVID-19)
Illness caused by the 'severe acute respiratory syndrome coronavirus 2' (SARS-CoV-2), which was first identified amid an outbreak of respiratory illness cases in East Asia, and first reported to WHO on 31 December 2019. On 30 January 2020, WHO declared the COVID-19 outbreak a global health emergency and March 2020 a global pandemic.

Decarbonization
The process by which countries, individuals or other entities aim to achieve zero fossil carbon existence. Typically refers to a reduction of the carbon emissions associated with electricity, industry and transport.

Dengue
An infectious diseases caused by any one of four related viruses transmitted by mosquitoes. The dengue virus is a leading cause of illness and death in the tropic and subtropics. As many as 400 million people are infected yearly.

Desertification
Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities. It involves crossing thresholds beyond which the underpinning ecosystem cannot restore itself but requires ever-greater external resources for recovery.; When individual land degradation processes, acting locally, combine to affect large areas of drylands.

Driver
The overarching socio-economic forces that exert pressures on the state of the environment.

Earth system
A complex social-environmental system consisting of interacting physical, chemical, biological and social components and processes. It determines the state and evolution of the planet and life on it and the Earth´s interacting physical, chemical and biological processes. The system consists of the land, oceans, atmosphere, frozen water bodies, poles and living organisms including humans and their domestic species. It includes the planet's natural cycles and deep Earth processes (the carbon, water, nitrogen, phosphorus, sulphur and other cycles, and the energy balances).

Ecosystem
A dynamic complex of plant, animal and micro-organism communities and their non-living environment, interacting as a functional unit. Ecosystems may be small and simple, like an isolated pond, or large and complex, like a specific tropical rainforest or a coral reef in tropical seas. Ecosystems are typically embedded in larger ecosystems.

Ecosystem degradation
A long-term reduction in an ecosystem's structure, functionality, or capacity to provide benefits to people.

Ecosystem function (-ality)
The conditions and processes whereby an ecosystem persists, maintains its integrity, and transforms materials and energy. Ecosystem functions include such processes as decomposition, primary and secondary production, nutrient cycling and biogeochemistry, demography, migration and evolution.

Ecosystem restoration
The return of the structure, composition and function of an ecosystem to some desired level, from a degraded state. The desired level may be its inferred original or natural state.

Emerging infectious disease
Infections that have recently appeared within a population or those whose incidence or geographic range is rapidly increasing or threatens to increase in the near future.

Emission pathway
The trajectory of greenhouse gas emissions over time; typically used to describe scenarios of future emissions during the 21st century.

Environmental/material footprint
The effect that a person, entity of activity has on the environment. It can be measured, for example, as the quantity of natural resources that they use, the amount of harmful gases that they produce or the equivalent land area required to provide those resources. In Figure 2.4, material footprint attributes all resources mobilized globally to the final consumer according to country income.

Epipelagic
The uppermost part of the ocean that receives enough sunlight to allow photosynthesis, less than 200 meters.

Equity
Fairness of rights, distribution and access. Depending on context, this can refer to access to resources, services or power.

Exposure
The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure or economic, social or cultural assets in places and settings that could be adversely affected by a given stressor.

Feedback
A process in a system whereby a change in one part propagates through the system and ends up affecting the originating part, either by dampening the original change (negative feedbacks) or amplifying or reinforcing it (positive feedbacks). Feedbacks are responsible for system behaviors such as non-linearity of change, equilibrium (or lack thereof) and tipping points.

Food security
Physical and economic access to food that meets people's dietary needs as well as their food preferences.

Food system
A set of activities and actors ranging from the production to the consumption of food, including agriculture, food transformation, storage, distribution and waste disposal. It encompasses food security and its components – availability, access and utilization – and including the social and environmental outcomes of these activities.

Fossil fuel
Coal, natural gas and petroleum products (such as oil) formed from the decayed bodies of animals and plants that died millions of years ago.

Gender
Gender refers to the roles, behaviors, activities and attributes that a given society at a given time considers appropriate for men and women. In addition to the social attributes and opportunities associated with being male and female and the relationships between women and men and girls and boys, gender also refers to the relations between women and those between men. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. They are context and time-specific and changeable. Gender determines what is expected, allowed and valued in a woman or a man in a given context. Gender is part of the broader socio-cultural context, as are other important criteria for socio-cultural analysis including class, race, poverty level, ethnic group, sexual orientation, age, etc.

Global commons
Natural assets that are not owned by any particular person or entity, but are potentially used by all, such as the atmosphere, he high seas, outer space and the Antarctic.

Global warming
Increase in the global mean near-surface air temperature, primarily caused by increasing concentrations of greenhouse gases in the atmosphere.

Governance
The act, process, or power of governing for the organization of society/ies. For example, there is governance through the state, the market, or through civil society groups and local organizations. Governance is exercised through institutions: laws, property-rights systems and forms of social organization.

Gross domestic product (GDP)
The value of all final goods and services produced in a country in one year. GDP can be measured by adding up all of an economy's incomes (wages, interest, profits; and rents) or expenditures (consumption, investment, government purchases) and net exports (exports minus imports).

Groundwater
Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper surface of the saturated zone is called the water table.

Habitat
The natural home or environment of an animal, plant or other organism. It can also be used to refer terrestrial or aquatic areas distinguished by particular geographic, living and non-living features, entirely natural or semi-natural, in which some organism exists.

Hazard
The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate- related physical events or trends or their physical impacts.

Human health
Health is a state of complete physical, mental and social well-being. It is not merely the absence of disease or infirmity.

Human well-being
The extent to which individuals have the ability to live the kinds of lives they have reason to value; the opportunities people have to pursue their aspirations. Basic components of human well-being include: security, meeting material needs, health and social relations.

Institutions
Regularized patterns of interaction by which society organizes itself: the rules, practices and conventions that structure human interaction. The term is wide and encompassing, and could be taken to include law, social relationships, property rights and tenurial systems, norms, beliefs, customs and codes of conduct as much as multilateral environmental agreements, international conventions and financing mechanisms. Institutions could be formal (explicit, written, often having the sanction of the state) or informal (unwritten, implied, tacit, mutually agreed and accepted).

Invasive species
Introduced species that have spread beyond their area of introduction, and which are frequently associated with negative impacts on the environment, human economy or human health. Rarely, it can include native species that have recently expanded their populations.

Land degradation neutrality
A state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems.

Land degradation
A long-term loss of ecosystem function and services, caused by disturbances from which the system cannot recover unaided.

Land use
The exploitation of land for various human purposes or economic activities. Examples of land use categories include agriculture, industrial use, transport and protected areas. At a given moment, a given parcel of land has only one land cover (see definition), but can have many land uses.

Livelihood
The way someone gains the resources people needed to provide for their needs, such as feed themselves and their family, obtaining clothing and a place to shelter, obtain, etc. It includes activities that earn the money that can be used for these purposes, and has cultural dimensions ("a way of life").

Livestock
Domesticated terrestrial mammals that are raised to provide a diverse array of goods and services.

Mangrove
A tree or shrub that grows in chiefly tropical coastal swamps that are flooded at high tide. Mangroves typically have numerous tangled roots above ground and form dense thickets.

Megacities
Urban areas with more than 10 million inhabitants.

Mitigation
In the context of climate change, a human intervention to reduce the sources, or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings and expanding forests and other 'sinks' to remove greater amounts of CO_2 from the atmosphere.

Nature-based solutions
Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits

Natural resources
Materials or substances such as minerals, forests, water and fertile land that occur in nature and can be used for economic gain.

Nutrients
The approximately 20 chemical elements known to be essential for the growth of living organisms, such as nitrogen, sulphur, phosphorus and carbon. There are small differences between different groups of organisms regarding which elements they need, and in what proportions.

Ocean acidification
Changes in the chemistry of the ocean that result in a reduction of pH. It occurs when atmospheric CO_2 is absorbed by the ocean and reacts with seawater to produce acid. Although CO_2 gas is naturally exchanged between the atmosphere and the oceans, the increased amounts of CO_2 gas into the atmosphere as a result of human activities in modern times (e.g. burning fossil fuels) has results in seawater that is increasingly acidic.

One Health
An approach to health that recognizes the interconnections between people, animals, plants and their shared environments. It is a collaborative, multisectoral and trans- disciplinary approach, working at local, regional, national and global level, to achieve optimal health and well-being outcomes.

Organic agriculture
A production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of synthetic inputs.

Organizations
Bodies of individuals with a specified common objective. Organizations could be, amongst others, political groups; governments; economic organizations, federations of industry; social organizations (non-governmental organizations (NGOs) and self-help groups) or religious organizations (church and religious trusts). It is not synonymous with institutions (see definition).

Ozone layer
A region of the atmosphere situated at an altitude of 10–50 km above the Earth's surface (called the stratosphere) which contains most of the ozone in the atmospheric column, albeit in dilute concentrations.

Pandemic
The worldwide spread of a disease. A pandemic occurs when a new highly-infective agent emerges and spreads around the world, since most people do not yet have immunity.

Particulate matter (PM)
Another name for aerosol particles. Very small (typically less than 10 mm diameter) solid particles or liquid droplets suspended in the air; see also areosols.

Pathogen/Pathogen shedding rate
A bacterium, virus or other microorganism that can cause disease. Shedding rate refers to emission of pathogens throughout the course of infection.

Peatland
A type of wetland with a very high organic carbon content (typically>20%) in the sediment. Peatlands currently cover about 3% of the global land surface. The term refers to both the peat soil and the wetland habitat growing on its surface.

Permafrost
Soil, silt and rock that remains frozen year-round for two or more years, occurring chiefly in polar or high altitude regions.

Persistent organic pollutants (POPs)
Chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment.

Pollutant/ Pollution
Any substance that causes harm when released into the atmosphere. The presence of minerals, chemicals or physical properties at levels that exceed the values deemed to define a boundary between good or acceptable and poor or unacceptable quality, which is a function of the specific pollutant.

Premature deaths
Deaths occurring earlier due to the presence of a risk factor than would occur in the absence of that risk factor. Often these risk factors are related to the environment, particularly pollution.

Primary energy
Energy embodied in natural resources (such as coal, crude oil, sunlight or uranium) that has not undergone any anthropogenic conversion or transformation.

Private sector
The private sector is part of a country's economy which consists of industries and commercial companies that are not owned or controlled by the government.

Projection
The act of attempting to produce a description of the future subject to assumptions about certain preconditions, or the description itself, such as "population projections used in existing assessments vary between 8.5 billion and 10.0 billion people by 2050 and between 6.9 billion and 12.6 billion people by 2100 (Section 2.1)."

Protected area
A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

Scenario
Scenarios are plausible descriptions of how future developments might evolve, based on a coherent and internally consistent set of assumptions about the key relationships and driving forces (box 2.1).

Short-lived climate forcers (SLCF)
Short-lived climate forcers refers to a set of compounds that are primarily composed of those with short lifetimes in the atmosphere compared to well-mixed greenhouse gases, and are also referred to as near-term climate forcers. This set of compounds includes methane (CH4), which is also a well-mixed greenhouse gas, as well as ozone (O3) and aerosols, or their precursors, and some halogenated species that are not well-mixed greenhouse gases. These compounds do not accumulate in the atmosphere at decadal to centennial time scales, and so their effect on climate is predominantly in the first decade after their emission, although their changes can still induce long-term climate effects such as sea level change. Their effect can be cooling or warming. A subset of exclusively warming short-lived climate forcers is referred to as short-lived climate pollutants.

Source
Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere.

Sustainability
A characteristic or state whereby the needs of the present population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Sustainable agriculture
Sustainable Agriculture emphasizes methods and processes that improve soil productivity while minimizing harmful effects on the climate, soil, water, air, biodiversity and human health. It aims to minimize the use of inputs from nonrenewable sources and petroleum-based products and replace them with those from renewable resources; and focuses on local people and their needs, knowledge, skills, socio-cultural values and institutional structures. It aims to ensures that the basic nutritional requirements of current and future generations are met in both quantity and quality terms, and to provide long-term employment, adequate income and dignified and equal working and living conditions for everybody involved in agricultural value chains. It further sets out to reduces the agricultural sector's vulnerability to risks such as adverse natural conditions (e.g. climate) and socioeconomic factors (e.g. strong price fluctuations).

Sustainable development
Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Synergies
These arise when two or more processes, organizations, substances or other agents interact in such a way that the outcome is greater than the sum of their individual effects considered independently.

System
A system is a collection of component parts that interact with one another within some boundary.

Technology
Physical artefacts or the bodies of knowledge of which they are an expression. Examples are water extraction structures, such as tube wells, renewable energy technologies and traditional knowledge. Technology and institutions are related. Any technology has a set of practices, rules and regulations surrounding its use, access, distribution and management.

Transformation
State of being transformed, or a fundamental change in the technological, economic and social organization of society, including world views, norms, values and governance. Transformation can also refer to a series of actions that explores opportunities to stop doing the things that pull the Earth System in the wrong direction and at the same time provide resources, capacity and an enabling environment for all that is consistent with the sustainable-world vision.

Transitions
Non-linear, systematic and fundamental changes of the composition and functioning of a societal system with changes in structures, cultures and practices.

Trillion
10^{12} (1 000 000 000 000).

Uncertainty
A cognitive state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many of sources, including imprecision in the data, ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can be represented by quantitative measures (for example, a probability of being correct) or by qualitative statements (for example, reflecting the judgement of a team of experts).

Urbanization
An increase in the proportion of the population living in urban areas.

Vector
In disease biology, the organism or vehicle that transmits the disease-causing organism from the reservoir to the host. Many vectors are bloodsucking insects and ticks, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal). Vectors can also be an animal, such as a bat, or an inanimate object.

Vector-borne disease
Illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice.

Vulnerability
An intrinsic feature of people at risk. It is a function of exposure, sensitivity to impacts of the specific unit exposed (such as a watershed, island, household, village, city or country), and the ability or inability to cope or adapt. It is multi-dimensional, multi-disciplinary, multi-sectoral and dynamic. The exposure is to hazards such as drought, conflict or extreme price fluctuations, and also to underlying socio-economic, institutional and environmental conditions.

Water-borne disease
Illnesses that are transmitted through contact with, or consumption of, contaminated water.

Water quality
The chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water scarcity
Occurs when annual water supplies drop below 1 000 m^3 per person, or when more than 40 percent of available water is used.

Water security
The sustainable use and protection of water systems, protection against water related hazards (floods and droughts), sustainable development of water resources and the safeguarding of (access to) water functions and services for humans and the environment.

Water stress
Occurs when low water supplies limit food production and economic development, and affect human health. An area is experiencing water stress when annual water supplies drop below 1 700 m^3 per person.

Wetland
Area of marsh, fen, peatland, bog or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water to a depth that does not exceed 6 m at low tide.

Wildlife
Wild animals collectively; the native fauna (and sometimes flora) of a region.

Zika virus
A flavivirus first identified in Uganda in 1947 in monkeys, transmitted primarily by Aedes mosquitoes, biting during the day. Outbreaks of Zika virus disease have been reported in Africa, Asia and the Americas. Most infected people develop mild symptoms for 2–7 days, or no symptoms, but infection during pregnancy can cause infants to be born malformations.

Zoonoses, Zoonotic diseases
Diseases that can spread between animals and people, moving from wild and domesticated animals to humans and from humans to animals. The current COVID-19 pandemic is a zoonotic disease.

Acronyms list

AR	Assessment Report
CBD	Convention on Biological Diversity
CFC	Chlorofluorocarbons
CH4	Methane
CLRTAP	Commission for Europe's Convention on Long-range Transboundary Air Pollution
CO2	Carbon Dioxide
CONABIO	Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
DTU	Technical University of Denmark
EEA	European Environment Agency
EEAP	Environmental Effects Assessment Panel
EGR	Emissions Gap Report
ES	Executive Summary
FAA	Federal Aviation Administration
FAO	Food and Agriculture Organization
GA	Global Assessment
GBD	Global Burden of Diseases
GBO	Global Biodiversity Outlook
GCO	Global Chemicals Outlook
GDP	Gross domestic product
GEO	Global Environment Outlook
GEP	Gross Ecosystem Product
GLO	Global Land Outlook
GMST	Global Mean Surface Temperature
GMST	Global Mean Surface Temperature
GRO	Global Resources Outlook
GSDR	Global Sustainable Development Report
Gt	Gigatonne/gigaton, consistent with the source material
GtCO2e	Gigatonnes of global annual CO2 equivalent emissions
HEI	Health Effects Institute
HFCs	Hydrochlorofluorocarbons
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organization
IMF	International Monetary Fund
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPCC-TEAP	IPCC-Technology and Economic Assessment Panel
IRP	International Resource Panel
IUCN	International Union for Conservation of Nature
KM	Key Messages
LDRA	Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems
MEA	Multilateral Environmental Agreement
N2O	Nitrous Oxide
NASA	National Aeronautics and Space Administration
NDC	National Determined Contribution

NOAA	National Oceanic and Atmospheric Administration
ODS	Ozone-depleting Substances
OECD	Organisation for Economic Co-operation and Development
OiE	World Organisation for Animal Health
OPHI	Oxford Poverty and Human Development Initiative
PM	Particular Matter
SAICM	Strategic Approach to International Chemicals Management
SDG	Sustainable Development Goal
SEEA	System of Environmental-Economic Accounting
SIDS	Small Island Developming States
SLCF	Short-lived climate forcers
SPM	Summary for Policymakers
SR	Special Report
SR 1.5	Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty
SRCCL	Special Report on Climate Change and Land
SREX	Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Adaptation
SROCC	Special Report on the Ocean and Cryosphere in a Changing Climate.
SSP	shared Socioeconomic Pathways
SST	Sea Surface Temperature
SYR	Synthesis Report
TAR	Third Assessment Report
TEAP	Technology and Economy Assessment Panel
TWI 2050	The World in 2050
UEA	University of East Anglia
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
WCMC	World Conservation Monitoring Centre
WFP	World Food Programme
WG	Working Group
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

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