GEO 6

GLOBAL ENVIRONMENT OUTLOOK

SUMMARY FOR POLICYMAKERS

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GEO-6 Assessment Process

The sixth Global Environment Outlook (GEO-6), focusing on the theme "healthy planet, healthy people", aims to help policymakers and all of society achieve the environmental dimension of the Sustainable Development Goals, internationally agreed environmental goals and the multilateral environmental agreements. It does so by assessing recent scientific information and data, analyzing current and past environmental policy, and identifying future options for achieving sustainable development by 2050.

The original request to prepare GEO-6 came from Member states at the first session of the United Nations Environment Assembly of the United Nations Environment Programme (UNEP), when, in paragraph 8 of resolution 1/4, the Executive Director of UNEP was requested, within the programme of work and budget, to undertake the preparation of the sixth Global Environment Outlook, supported by UNEP Live, with the scope, objectives and procedures of GEO-6 to be defined by a transparent global, intergovernmental and multi-stakeholder consultation informed by document UNEP/EA.1/INF/14, resulting in a scientifically credible, peer-reviewed GEO-6 and its accompanying summary for policymakers, to be endorsed by the Environment Assembly no later than in 2018.

At its third session, the Environment Assembly, in paragraphs 1 and 2 of its decision 3/1, requested the Executive Director to issue the sixth Global Environment Outlook at least three months before the fourth session of the Assembly; to schedule the negotiations on the Summary for policymakers at least six weeks in advance of the fourth session of the Assembly; and to present the Outlook and the Summary for consideration and possible endorsement by the Assembly at its fourth session.

Scope

GEO-6 builds on previous GEO reports and continues to provide an analysis of the state of the global environment, the global, regional and national policy response as well as the outlook for the foreseeable future. It differs from previous GEO reports in its emphasis on Sustainable Development Goals and in providing possible means of accelerating achievement of these goals. GEO-6 is made up of four distinct but closely linked parts.

- **Part A** assesses the state of the global environment in relation to key internationally agreed goals such as the Sustainable Development Goals.
- **Part B** provides an analysis of the effectiveness of the policy response to these environmental challenges.
- **Part C** reviews the scenarios literature and assesses pathways towards achieving Agenda 2030 as well as achieving a truly sustainable world in 2050.
- **Part D** identifies future data and knowledge necessary to improve our ability to assess environmental impacts.

The GEO-6 also considers key policy questions. These include:

- What are the primary drivers of environmental change?
- What is the current state of the environment and why?
- How successful have we been in achieving our internationally agreed environmental goals?
- Have there been successful environmental policies?
- What are the policy lessons learned and possible solutions?
- Is the current policy response enough?
- What are the business as usual scenarios and what does a sustainable future look like?
- What are the emerging issues and megatrends including their possible impacts?
- What are the possible pathways to achieving Agenda 2030 and other internationally agreed environmental goals?

The development of GEO-6 involved extensive collaboration both within UN Environment and between UN Environment and a network of multidisciplinary experts and research institutions.

The intergovernmental and multi-stakeholder consultation mentioned above (Oct. 2014) requested that experts for content development, including reviewers and advisory groups, be nominated by governments and other main stakeholders based on their expertise and using a transparent nomination process while considering geographic and gender balance.

The following three GEO-6 specialized advisory bodies were convened to support the assessment process:

High-Level Intergovernmental and Stakeholder Advisory Group

The panel included 25–30 high-level government representatives from all six UN Environment regions as well as 8-10 key stakeholders. The High-level Group provided strategic advice and initial guidance on the structure and content of the GEO-6 Summary for Policymakers and further guidance to the experts in finalizing the draft Summary, in preparation for the final intergovernmental negotiation.

Science Advisory Panel

The Panel included 22 distinguished scientists who met face to- face five times. The Panel was responsible for providing advice on the scientific credibility of the assessment process. The Panel provided scientific advice; standards and guidelines for the assessment and review process; and reviewed the findings of the mid-term evaluation of the assessment process.

Assessment Methodologies, Data and Information Working Group

This working group of 12 professionals met face-to-face three times between 2015 and 2018 and provided support and guidance to the assessment process on the use of core datasets and indicators.

This Summary for Policymakers is based on and consistent with the findings of the GEO-6 assessment. The GEO-6 Summary for Policymakers was negotiated and endorsed at an intergovernmental meeting from 21 to 24 January 2019 in Nairobi, Kenya.

This Summary for Policymakers highlights the findings of the sixth Global Environment Outlook (GEO-6) report and is prepared by the UN Environment Secretariat with:

Guidance from members of the GEO-6 High Level Intergovernmental and Stakeholder Advisory Group (HLG)

Nassir S. Al-Amri, Hæge Andenæs, Juan Carlos Arredondo, Sara Baisai Feresu, Benon Bibbu Yassin, Simon Birkett, Gillian Bowser, Joji Carino, Fernando E.L.S. Coimbra, Victoria de Higa Rodriguez, Laksmi Dhewanthi, Noasilalaonomenjahary Ambinintsoa Lucie, Arturo Flores Martinez (alternate), Sascha Gabizon, Prudence Galega, Edgar Gutiérrez Espeleta, Keri Holland (alternate), Pascal Valentin Houénou (Vice-chair), Yi Huang (Co-chair), Ingeborg Mork-Knutsen (alternate), Melinda Kimble, Asdaporn Krairapanond, Yaseen M. Khayyat, Pierluigi Manzione, Veronica Marques (alternate), Jock Martin, John M. Matuszak, Megan Meaney, Naser Moghaddasi, Bedrich Moldan, Roger Roberge, Najib Saab, Mohammed Salahuddin, Jurgis Sapijanskas (alternate), Paolo Soprano (Co-chair), Xavier Sticker, Sibylle Vermont (Vice-chair), Andrea Vincent (alternate), Terry Yosie.

Guidance from the co-chairs and vice-chairs of the GEO-6 Scientific Advisory Panel (SAP)

Nicholas King (Co-chair), Sarah Green (Co-chair), Maria del Mar Viana Rodriguez (Vice-chair), N.H. Ravindranath (Vice-chair)

Technical inputs from the GEO-6 Co-chairs and Authors

Paul Ekins (GEO-6 Co-Chair), Joyeeta Gupta (GEO-6 Co-Chair), Frederick Ato Armah, Giovanna Armiento, Ghassem Asrar, Elaine Baker, Graeme Clark, Irene Dankelman, Jonathan Davies, Nicolai Dronin, Mark Elder, Pedro Fidelman, Sandor Fulop, Erica Gaddis, Ania Maria Grobicki, Steve Hedden, Andres Ernesto Guhl, James Hollway, Fintan Hurley, Klaus Jacob, Mikiko Kainuma, Terry Keating, Peter King, Richard King, Andrei Kirilenko, Peter Lemke, Paul Lucas, Oswaldo Lucon, Diana Mangalagiu, Diego Martino, Shanna McClain, Gavin Mudd, Nibedita Mukherjee, Farhad Mukhtarov, Andrew Onwuemele, Leisa Perch, Laura Pereira, Walter Rast, Jake Rice, Peter Stoett, Michelle Tan, Detlef van Vuuren, Pandi Zdruli,

and

all authors whose contribution in the GEO-6 main assessment report served as a basis for the GEO-6 Summary for Policymakers

It was negotiated and agreed on 24 January 2019 by:

Afghanistan, Angola, Argentina, Armenia, Bangladesh, Belgium, Bhutan, Brazil, Burkina Faso, Canada, Chad, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Cuba, Democratic Republic of the Congo, Djibouti, Dominican Republic, Ecuador, Egypt, Eritrea, Estonia, Ethiopia, Eswatini, European Union, Fiji, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Hungary, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Italy, Japan, Jordan, Kenya, Lao People's Democratic Republic, Lebanon, Madagascar, Malawi, Maldives, Mali, Marshall Islands, Mexico, Mongolia, Montenegro, Myanmar, Nepal, Netherlands, Niger, Norway, Pakistan, Paraguay, Philippines, Qatar, Republic of Korea, Romania, Russian Federation, Saint Lucia, Samoa, Saudi Arabia, Senegal, Serbia, Singapore, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Syrian Arab Republic, United Republic of Tanzania, Thailand, Timor Leste, Togo, Trinidad and Tobago, Turkey, Tuvalu, Uganda, United Kingdom of Great Britain and Northern Ireland, United States of America, Uruguay, Zambia

Palestine attended the meeting as an observer

The UN Environment Secretariat included

Pierre Boileau (GEO-Head), Hilary Allison, Matthew Billot, Jillian Campbell, Charles Chapman, Kilian Christ, Yunting Duan, Valentin Foltescu, Francesco Gaetani, Caroline Kaimuru, Eddah Kaguthi, Angela Kim, Rachel Kosse, Allan Lelei, Jian Liu, David Marquis, Patrick Mmayi, Caroline Mureithi, Franklin Odhiambo, Brigitte Ohanga, Adele Roccato, Edoardo Zandri

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1. What is the Global Environment Outlook?

The Global Environment Outlook (GEO) is the result of a consultative and participatory process to prepare an independent assessment of the state of the environment, the effectiveness of the policy response in addressing environmental challenges and the possible pathways to achieving various internationally agreed environmental goals. The GEO is a series of studies that inform environmental decision-making for Governments and other stakeholders. {1.1}

The sixth Global Environment Outlook (GEO-6), under the theme "Healthy Planet, Healthy People", aims to provide a sound, evidence-based source of environmental information to help policymakers and all of society to achieve the environmental dimension of the 2030 Agenda for Sustainable Development and internationally agreed environmental goals, and to implement the multilateral environmental agreements. It does so by assessing recent scientific information and data, analysing current and past environmental policies and identifying future options to achieve sustainable development by 2050. {1.1}

Since the first edition of the Global Environment Outlook (GEO) in 1997, there have been many examples of environmental improvement, especially where problems have been well-identified, manageable, and where regulatory and technological solutions have been readily available. Much more can be achieved in that regard through more effective implementation of existing policies. {Chapters 12 to 17}

Nevertheless, the overall condition of the global environment has continued to deteriorate since the first edition of GEO, despite environmental policy efforts across all countries and regions. Environmental policy efforts are being hindered by a variety of factors, in particular unsustainable production and consumption-patterns in most countries and climate change. GEO-6 concludes that unsustainable human activities globally have degraded the Earth's ecosystems, endangering the ecological foundations of society. {Chapters 4 to 9}

Urgent action at an unprecedented scale is necessary to arrest and reverse this situation, thereby protecting human and environmental health and maintaining the current and future integrity of global ecosystems. Key actions include reducing land degradation, biodiversity loss, and air, land and water pollution; improving water management and resource management; climate change mitigation and adaptation; resource efficiency; addressing decarbonization, decoupling and detoxification; and the prevention and management of risk and disasters. Those all require more ambitious and effective policies, including sustainable consumption and production, greater resource efficiency and improved resource management, integrated ecosystem management, and integrated waste management and prevention.[1] {Chapter 22}

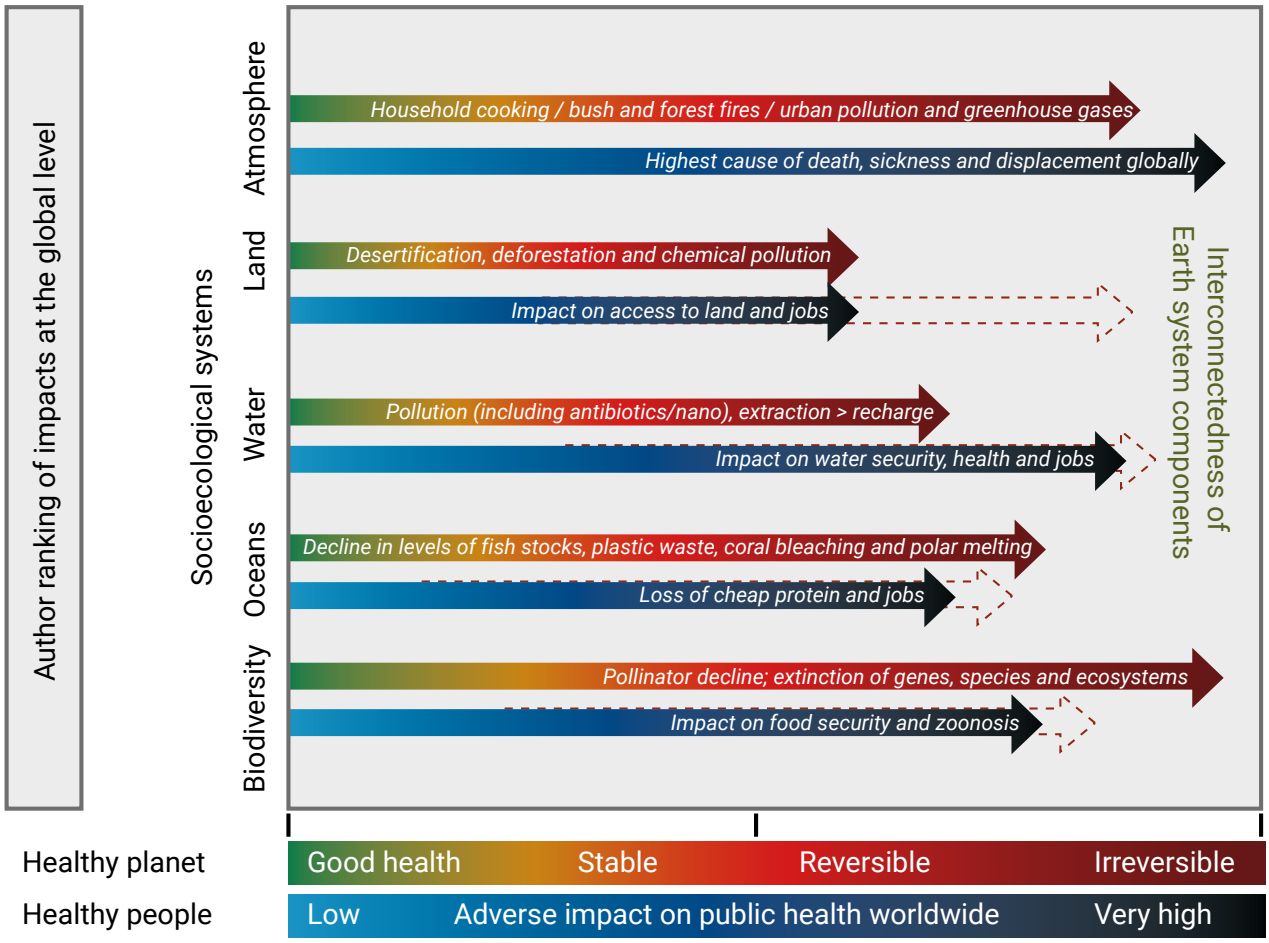
Mainstreaming environmental considerations into social and economic decisions at all levels is of vital importance. In line with the Sustainable Development Goals, GEO-6 shows that environmental issues are best addressed in conjunction with related economic and social issues, taking into account synergies and trade-offs between different goals and targets, including consideration of equity and gender dimensions. Governance can be improved at the local, national, regional and global levels, including broad coordination between policy areas. More ambitious and effectively implemented environmental policies are necessary, but alone they are not sufficient to meet sustainable development objectives. At the same time as ensuring sustainable sources of financing for sustainable development and aligning financing flows with environmental priorities, capacities have to be strengthened and scientific information taken into account for environmental management. Strong commitment from all stakeholders, partnerships and international cooperation would greatly facilitate the realization of environmental goals. {Chapters 22, 23, 24}

GEO-6 shows that a healthy environment is the best foundation for economic prosperity, human health and well-being. As figure SPM.1 illustrates, human behaviour has had various impacts on biodiversity, atmosphere, oceans, water and land. That environmental degradation, which ranges from serious to irreversible, has had a negative impact on human health. Atmospheric pollution has had the most severe negative impact, followed by degradation of water, biodiversity, ocean and land environment. It is therefore important that opportunities for prosperity and well-being that maintain or regain the integrity of ecosystems should be attained through sustainable development pathways that are shared and pursued globally. {24.4}

The following sections highlight the main global drivers of environmental change, the condition of the environment, the scale and effectiveness of policy responses, the potential pathways for achieving the Sustainable Development Goals in an increasingly complex world, and the data and information needs and opportunities that can support decision-making towards achieving those Goals.

1 This summary for policymakers uses confidence statements to better inform policymakers of the extent of evidence on a particular subject and the level of agreement across that evidence. Qualitative confidence statements used include the following: "well established" (much evidence and high agreement), "unresolved" (much evidence but low agreement), "established but incomplete" (limited evidence but good agreement) and "inconclusive" (limited or no evidence and little agreement). In addition, the higher confidence statements are sometimes further refined as follows: "very well established" (very comprehensive evidence base and very low disagreement) or "virtually certain" (very robust evidence base covering multiple temporal and spatial scales and almost no disagreement). Some statements providing quantitative confidence statements are also provided. Those include the following: "likely" (greater than 66 per cent probability) and "very likely" (greater than 90 per cent probability).

Figure SPM.1. Relationship between planetary health and human health



NOTE: Dotted arrows show how things may be experienced differently in various parts of the world

Source: Gupta et al. (2019).

Note: The figure shows the degree of impact of human activity on the health of the planet (ranging from good health to irreversible damage) and the impact of the health of the planet on human health (ranging from low damage to high damage). Some environmental and health impact may be remediable in the short or long term, but "irreversible" environmental impact can only be remedied over the very long term, if at all.

2. What is happening to our environment and how have we responded?

2.1 Drivers of environmental change, megatrends and governance challenges

Human population dynamics or trends, particularly population pressure, and economic development have been acknowledged for many decades as the primary drivers of environmental change (*well established*). More recently, rapid urbanization and accelerating technological innovation have been additional influences. There are wide disparities globally in the consumption and production patterns that lie behind those drivers. {2.1.1, 2.2}

Those driving forces are also strongly intertwined, complex, and spread widely and unevenly across the world (*well established*). They are megatrends, developing at speeds with which responses by established governance structures at all levels – urban and rural, local, national, regional, global and supranational – are thus far insufficient to keep pace. {2.1.1}

The global population in 2018 is some 7.5 billion, with median projections estimating nearly 10 billion by 2050 and nearly 11 billion by 2100 (United Nations figures) (*well established*). Increases in life expectancy and reductions in infant and other mortality mean that population growth rates will continue to remain positive in all regions except Europe and certain parts of Asia. Unequal access to education, and lack of empowerment of women, as well as their lack of access to sexual and reproductive health services, all contribute to high birth rates. Without changes in production and consumption patterns, population growth will continue to increase environmental pressures. {2.3, 2.3.4, 2.1.1}

Urbanization is happening at an unprecedented rate globally and cities have become the foremost drivers of economic development across the world (*well established*). More people, especially in emerging and developing economies, are living in cities and towns, and the world's urban population is expected to rise to 66 per cent by 2050 (*well established*). Approximately 90 per cent of city growth will occur in Africa and Asia. Africa is the most rapidly urbanizing region, and is also the region expected to experience the highest population growth (*well established*). Some 30 per cent of urban residents globally have no access to basic services or social protection, with poor women in low-income urban neighbourhoods being particularly vulnerable. {2.4, 2.4.3}

Almost all coastal cities of any size and small island developing States are increasingly vulnerable to rising sea-levels, floods and storm surges caused by climate change and extreme weather events (*established but incomplete*). In general, those cities in developing countries that are urbanizing most rapidly are in a more vulnerable situation. In contrast, sustainable urbanization can represent an opportunity to increase citizens' well-being while decreasing their environmental impact. Lower-impact urban lifestyles can be facilitated by improved governance, infrastructure, services, sustainable land-use planning and technological opportunities. Investment in rural areas can reduce pressure to migrate. {2.4.4, 17.3}

Economic development has lifted billions of people out of poverty and enhanced access to health and education in most regions of the world (*well established*). Nevertheless, the "Grow now, clean up later" economic approach used in certain regions has not accounted for climate change, pollution or degraded natural systems. That approach has also contributed to increasing inequality within and between countries and will ultimately be more costly. It will not be able to sustainably support 10 billion healthy, fulfilled and productive people in 2050 without profound and urgent changes in consumption and production patterns. {2.5.1}

Decoupling of environmental degradation and resource use from economic growth and associated production and consumption patterns is required for achievement of the Sustainable Development Goals (*well established*). Partial decoupling between environmental pressures and economic growth can already be observed for some impacts and resources in certain countries. Further decoupling requires the scaling-up of existing sustainable practices and more fundamental transitions in the ways in which we produce, consume and dispose of goods and materials across society. Those transitions are likely to be more effective if supported by long-term, comprehensive, science-based targets that provide the objective basis for future directions and actions. {2.5.1}

The growth in technological innovation since the 1990s has been unprecedented, both globally and historically, bringing many benefits to people's lives, but has also had some negative consequences (*established but incomplete*). Some technological and social innovations can reduce the environmental pressures associated with unsustainable consumption and production**.** Enhancing access to existing environmental technologies that are adapted to domestic circumstances could help countries to achieve environmental objectives more quickly. Application of precautionary approaches, according to international agreements (where applicable), to new technological innovations can reduce unintended negative consequences for human and ecosystem health. {2.6.2, 2.6.3, 2.6.4}

Countries that prioritize low-carbon, resource-efficient practices may gain a competitive advantage in the global economy (*established but incomplete*). Well-designed environmental policies and appropriate technologies and products can often be implemented in tandem at limited or no cost to growth and competitiveness and can expand the capacity of countries to develop and diffuse innovative technologies. That may be positive for employment and development, while reducing greenhouse gas emissions and, ultimately, facilitating sustainable development (*established but incomplete*). {2.5.1}

Climate change is a priority issue affecting both human systems, including human health, and natural systems – air, biological diversity, freshwater, oceans and land – and which alters the complex interactions between those systems (*well established*). Historical and ongoing greenhouse gas emissions have committed the world to an extended period of climate change (*well established*), which is leading to global warming of air and ocean; rising sea-levels; melting glaciers, permafrost and Arctic sea ice; changes in carbon, biogeochemical and global water cycles; food security crises; fresh water scarcity; and

more frequent and extreme weather events. Higher atmospheric concentrations of carbon dioxide also lead to ocean acidification and affect the composition, structure and functionality of ecosystems. Time is running out to prevent irreversible and dangerous impacts of climate change. Unless greenhouse gas emissions are radically reduced, the world is on course to exceed the temperature threshold set out in the Paris Agreement under the United Nations Framework Convention on Climate Change. That makes climate change a global driver of environmental, social, health and economic impact and heightened society-wide risks. {2.7.3}

Society-wide risks associated with environmental degradation and climate change effects are generally more profound for people in a disadvantaged situation, particularly women and children in developing countries (*established but incomplete*). Many of the impacts outlined above are serious or irreversible and may lead to loss of livelihood, increased morbidity and mortality, and economic slowdown, and have greater potential for violent conflict, human mass migration and decreasing social resilience. Measures for more effective adaptation are now urgently required, especially for populations and regions which are in a vulnerable situation. {2.7.3}

The increasing scale, global reach and speed of change in those drivers of environmental change pose urgent challenges for managing environmental and climate change problems (*well established*). In many domains, our scientific understanding of adverse, increasingly high impact is becoming more widespread, as is the understanding that the nature of change may sometimes be irreversible. The thematic priorities addressed by GEO-6 have been chosen and analysed with that context in mind and the summaries by theme have been organized to provide decision-makers with the most crucial insights within themes, including links to drivers and optional avenues for action. {2.7.3}

2.2 The state of the environment

2.2.1 Air

Emissions generated by human activity continue to alter the composition of the atmosphere, leading to air pollution, climate change, stratospheric ozone depletion and exposure to persistent, bioaccumulative and toxic chemicals (*well established*). {5.3}

Air pollution is the main environmental contributor to the global burden of disease, leading to between 6 million and 7 million premature deaths (*well established*) and welfare losses estimated at US$5 trillion annually (*established but incomplete*). Air pollution exposure, especially to fine particulate matter, is highest for urban residents in some countries with rapid urbanization trends (*established but incomplete*) and for the approximately 3 billion people who depend on burning fuels such as wood, coal, crop residue, dung and kerosene for cooking, heating and lighting (*well established*). The elderly, very young, ill and poor are more susceptible to the impact of air pollution (*well established*). {5.2.4, 5.4.1}

Globally, decreasing emission trends from local air pollutants in certain sectors and regions have been offset by larger increases in others, including some rapidly developing countries and areas of rapid urbanization (*well established*). Available data indicate that emissions decrease significantly when regulations are put in place. {5.2} International agreements have been successful in addressing specific chemicals. Both improvement of energy efficiency and pollution control techniques may be used to achieve lower air pollutant emissions. As controls have been placed on power plants, large industrial facilities and vehicles, the relative contribution of other sources, including agriculture, domestic fuel use, construction and other portable equipment, and forest or open fires, has grown in importance (*established*). Electricity generated from non-renewable resources and the fossil fuel production and consumption sectors ("energy") is the largest anthropogenic emitting sector of SO_2 and non-methane volatile organic compounds and the main emitting sector of other air pollutants, including greenhouse gases.

Global increases in anthropogenic greenhouse gas emissions and climate impacts have occurred, even while mitigation activities have taken place in many parts of the world. Globally, economic and population growth continue to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. Atmospheric concentrations of long-lived greenhouse gases continue to increase, driven primarily by fossil fuel extraction and use for electricity generation, industry and transport, although they are also affected by land use, land-use change, agriculture and forestry (*well established*). The evidence of current global climate change is unequivocal (*well established*). Since 1880, the global average surface temperature has increased by between approximately 0.8 degrees Celsius and 1.2 degrees Celsius (*very likely*). Eight of the ten warmest years on record have occurred within the past decade (*virtually certain*). If greenhouse gas emissions persist, global average temperatures will continue to increase at the current rate, crossing the temperature target agreed as part of the Paris Agreement between 2030 and 2052 (*very likely*). The Paris Agreement committed countries to holding the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius above pre-industrial levels, recognizing that doing so would significantly reduce the risks and impact of climate change. Current nationally determined contributions, presented in Paris in 2015, constitute only one third of the mitigation required to establish a least-cost pathway for staying well below 2 degrees Celsius (*well established*). {2.2, 2.7, 4.2.1, 5.2, 5.3.4} To maintain a good chance of remaining well below a 2 degrees Celsius temperature increase, emissions need to drop by between 40 and 70 per cent globally between 2010 and 2050, falling to net zero by 2070. {2.7.4}

Achieving the goals set out in the Paris Agreement requires transformational changes leading to deep reductions in greenhouse gas emissions and the balancing of emission sources and sinks (*established but incomplete*). In addition to emissions reductions for CO_2, the main anthropogenic greenhouse gas, decreasing emissions of short-lived climate pollutants (also called forcers), specifically black carbon, methane, tropospheric ozone and hydrofluorocarbons, provide opportunities to limit warming in the short term and are a critical component of an integrated climate change mitigation and air-quality management programme. However, since long-lived greenhouse gases dominate climate forcing in the long term, decreasing emissions of short-lived climate pollutants in the short term needs to be combined with mitigation of long-term greenhouse gases. (*well established*). {4.2.1, 5.3.4} Non-CO_2 emissions in pathways

that limit global warming to 1.5 degrees Celsius show deep reductions that are similar to those in pathways limiting warming to 2 degrees Celsius.[2]

Government capacity and political will to manage air pollution and climate change varies significantly (*well established*). Some regions have well-developed systems of national-to-local policies and compliance and enforcement programmes (*well established*), although ambition levels in terms of both scope and policy may differ. In other regions, international agreements or national legislation may exist, but implementation and compliance and enforcement are often affected by weak national-to-local institutional capacity (*established but incomplete*). Future policy efforts can build upon renewed attention to those issues in international forums and several decades of experience with various governance strategies in different countries. Between 1998 and 2010, there was a five-fold increase in the number of national climate laws (more than 1,500 laws and policies worldwide) and by 2012 those laws covered 67 per cent of all emissions (*well established*). Some city and subnational governments are leading the way with benefits for other parts of their countries (*well established*). {5.4, 5.5, 12}

2.2.2 Biodiversity

A major species extinction event, compromising planetary integrity and Earth's capacity to meet human needs, is unfolding. Biodiversity refers to the diversity of living things at the genetic, species and ecosystem levels. It helps to regulate climate, filters air and water, enables soil formation and mitigates the impact of natural disasters. It also provides timber, fish, crops, pollination, ecotourism, medicines, and physical and mental health benefits (*well established*). {6.1, 6.4.2}

Environmental and human health are intricately intertwined, and many emerging infectious diseases are driven by activities that affect biodiversity (*established but incomplete*). Changes to the landscape (through natural resource extraction and use, for example) can facilitate disease emergence in wildlife, domestic animals, plants and people. Zoonoses are estimated to account for more than 60 per cent of human infectious diseases. {6.1, 13.1; boxes 6.1, 13.1}

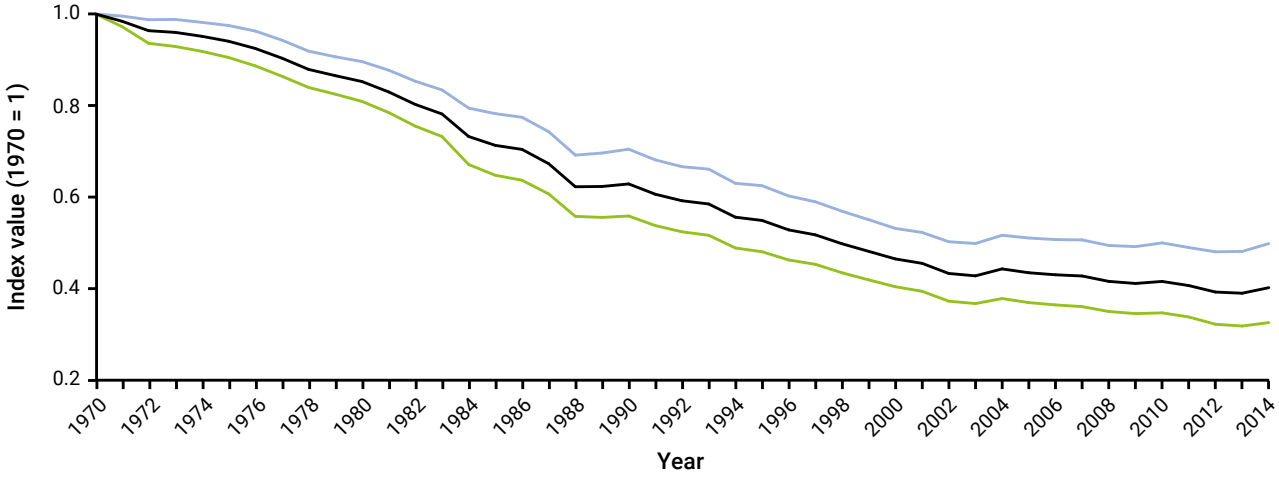
Genetic diversity is declining, threatening food security and the resilience of ecosystems, including agricultural systems and food security (*well established*). {6.5.1}

Populations of species are declining and species extinction rates are increasing. At present, 42 per cent of terrestrial invertebrates, 34 per cent of freshwater invertebrates and 25 per cent of marine invertebrates are considered at risk of extinction. Between 1970 and 2014, global vertebrate species population abundances declined by on average 60 per cent (*well established*). Steep declines in pollinator abundance have also been documented. {6.5.2}

Ecosystem integrity and functions **are declining.** Ten out of every fourteen terrestrial habitats have seen a decrease in vegetation productivity and just under half of all terrestrial ecoregions are classified as having an unfavourable status (*well established*). {6.5.3}

Native and non-native invasive species threaten ecosystems, habitats and other species. The economic costs, both direct and indirect, amount to many billions of dollars annually. {6.4.2}

Figure SPM.2. Global Living Planet Index



Source: World Wide Fund for Nature and Zoological Society of London (2018).

Note: The centre line shows the index values, indicating a 60 per cent decline between 1970 and 2014, and the upper and lower lines represent the 95 per cent confidence limits surrounding the trend. This is the average change in population size of 4,005 vertebrate species, based on data from 16,704 times series from terrestrial, freshwater and marine habitats.

2 United Nations Intergovernmental Panel on Climate Change, 2018: Summary for Policymakers. In: Global warming of 1.5°C. An IPCC 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. World Meteorological Organization, Geneva.

Biodiversity loss is also an equity issue, disproportionately affecting poorer people, women and children. If current rates of decline continue, future generations will be deprived of the health benefits of biodiversity. The livelihoods of 70 per cent of people living in poverty directly depend on natural resources (*well established*). {6.1, 6.6.5; boxes 6.5, 13.2}

The critical pressures on biodiversity are habitat change, loss and degradation; unsustainable agricultural practices; the spread of invasive species; pollution, including microplastics; and overexploitation, including illegal logging and trade in wildlife. Illegal trade in wildlife, fisheries and forest products is worth between US$90 billion and US$270 billion per annum. There is evidence to suggest that climate change will pose the gravest threat in the future, as species, including disease vectors, migrate with temperature shifts (*well established*). {6.5}

Although governance efforts are progressing, greater efforts are required to achieve international objectives, such as the Aichi Biodiversity Targets within the United Nations Convention on Biological Diversity's Strategic Plan for Biodiversity 2011–2020, and the Sustainable Development Goals. Over 190 National Biodiversity Strategies and Action Plans have been submitted to the Convention, although their quality and reliability, as well their subsequent implementation, remains uneven; the Cartagena and Nagoya Protocols to the Convention provide a deeper governance context. There is increasing international collaboration between various law enforcement authorities in combatting illegal wildlife trafficking. {Annex 6-1}

The science-policy interface for biodiversity and the contribution that nature makes to people was strengthened in 2012 through the establishment of the Intergovernmental Platform for Biodiversity and Ecosystem Services. Parties to the Convention on Biological Diversity are negotiating the post-2020 global biodiversity framework. Negotiations under the United Nations Convention on the Law of the Sea continue towards an agreement on the sustainable use and conservation of marine biological diversity beyond national jurisdiction. {6.7.2, 6.7.4, 13.1}

Several multilateral environmental agreements provide additional governance architecture on biodiversity, including the Convention on Wetlands of International Importance especially as Waterfowl Habitat and the Convention on International Trade in Endangered Species of Wild Fauna and Flora. The continual updating of the International Union for Conservation of Nature Red List of Threatened Species and other independent monitoring efforts, such as the Global Biodiversity Information Facility, the consideration of the multiple values of biodiversity and the inclusion of the value of biodiversity in national economic valuation methods, will support and inform the implementation thereof. Furthermore, there is a pressing need to expand ecosystem assessments to better understand the global state of ecosystems and the trends therein. {6.5.3, 6.7.4, annexes 6.1 and 13.1}

Protecting species and ecosystems requires conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from the utilization of genetic resources (*well established*). Species and ecosystems are most effectively safeguarded through the conservation of natural habitats (*well established*) and there is clear evidence that conservation can help to reduce biodiversity loss. Implementation, management and representative coverage of different ecosystems within protected areas remains insufficient. Less than 15 per cent of terrestrial habitats, including inland waters, and less than 16 per cent of coastal and marine areas within national jurisdiction are protected areas. {6.7.3}

Biodiversity is slowly being mainstreamed or integrated into health, gender and other equity concerns through such efforts as the 2015–2020 Gender Plan of Action under the Convention on Biological Diversity and its relationship to the Convention's Strategic Plan for Biodiversity 2011–2020 and the achievement of the Aichi Biodiversity Targets (*well established*). Indigenous peoples and local communities play a key role in biodiversity protection by offering bottom-up, self-driven and innovative solutions, based on traditional knowledge and the ecosystem approach. However, protected areas can adversely affect indigenous communities if access to natural resources within protected areas is denied. {13.1}

***Ex situ* conservation of genetic material provides safeguards for maintaining adaptive potential, in particular of crop and agricultural species. Gene banks and seed collections complement in situ conservation of genetic resources, yet the conservation status of genetic diversity for most wild species remains poorly documented.** Yet accelerating biodiversity loss and the large, escalating costs of inaction, including numerous threats to human health, require an urgent increase in global investment in sustainable use and conservation, and the consistent integration of biodiversity concerns into all facets of economic and social development. {6.5.1, 13.2.4}

Greater focus on strengthening governance systems; improving policy frameworks through research; policy integration; implementation; and encouraging partnerships and participation, are all measures that have the potential to address the greatest pressures on biodiversity. Efforts to combat biodiversity loss must also address poverty eradication, food security challenges, gender inequality, systemic inefficiencies and corruption in governance structures and other social variables. Identification of the countries of origin of genetic resources, in accordance with the Convention on Biological Diversity and the Nagoya Protocol thereto, will help to ensure progress against the objectives of those instruments and the fair and equitable sharing of benefits arising from the commercial utilization of those resources with such countries. {6.8}

2.2.3 Oceans and coasts

The principal drivers of change facing oceans and coasts are ocean warming and acidification, ocean pollution and the increasing use of oceans, coasts, deltas and basins for food production, transportation, settlement, recreation, resource extraction and energy production (*well established*). The main impacts of those drivers are marine ecosystem degradation and loss, including death of coral reefs (*well established*), reduced marine living resources and the resulting disturbance of marine and coastal ecosystem food chains (*well established*), increased nutrient and sediment run-off (*well established*) and marine litter (*established but incomplete*). Those impacts interact in ways that are just beginning to be understood and their interaction may amplify their effect (*inconclusive*). If left unaddressed, there is a major risk that they will combine to produce a destructive cycle of degradation and that the ocean will no longer provide many vital ecosystem services (for example, livelihoods, income, health, employment, and aesthetic, cultural and religious values).

More effective compliance, enforcement and other instruments are needed, as current efforts are not sufficient to achieve the aims of the Sustainable Development Goals, particularly Goal 14. Interventions based on emerging technologies, taking into account a precautionary approach, in accordance with international agreements (where applicable), and strategic management approaches, such as resilience-based management and ecosystem-based management, can contribute to improved conservation of marine ecosystems and marine living resources. {7.1, 14, 14.2.1, 14.2.3, 14.2.4}

A holistic, integrated monitoring and assessment of the marine environment needs to be fostered hand in hand with the implementation of pollution reduction measures to achieve and maintain the targets of "Good Environmental Status" of the marine environment, including harmonization of assessment criteria and methods at all levels. To be effective, such measures should be combined with actions to mitigate and adapt to climate change and reduce the input of pollution and litter to the oceans while promoting their conservation and sustainable use. {7.3.1, 7.3.2, 7.3.3}

The rate of human-induced release of greenhouse gases is driving rising sea levels, changes in ocean temperatures and ocean acidification. Coral reefs are being devastated by those changes (*well established*). Mass coral bleaching, induced by chronic heat, has damaged many tropical reefs beyond recovery (*well established*). The collective value of coral reefs has been estimated at US$29 billion per annum. The loss of coral reefs has an impact on fisheries, tourism, community health, livelihoods and marine habitats (*well established*). Interventions based on emerging technologies and sustainable management approaches (such as resilience-based management, integrated coastal zone management and ecosystem-based management) are key to building resilience and may help to preserve some areas of reef (*unresolved*), but Governments should prepare for a dramatic decline (if not a collapse) (*well established*) of coral reef-based industries and ecosystem services, as well as negative effects on food chains related to the decline and collapse of coral reefs. {7.3.1, 14.2.1}

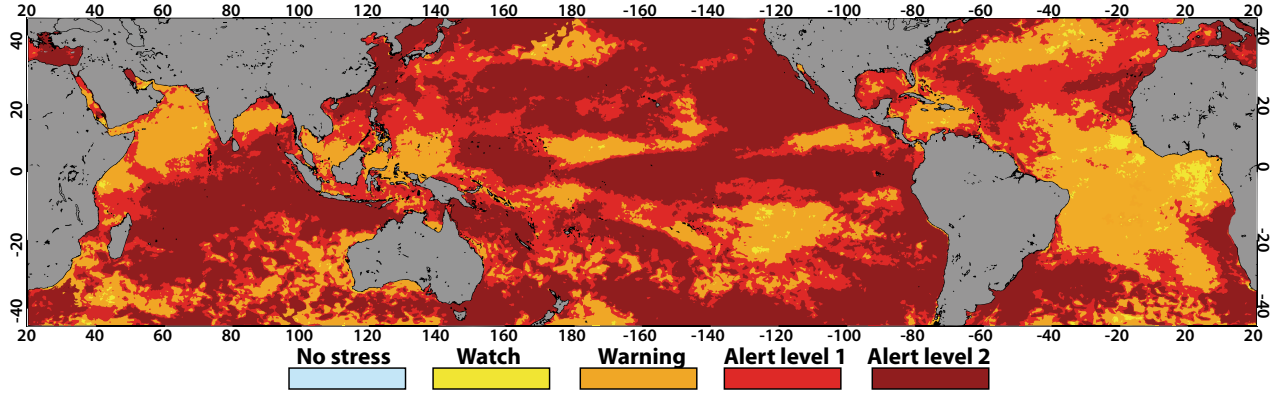
The oceans play an important role in the global economy and are likely to become increasingly important. Fisheries and aquaculture currently generate US$252 billion annually. Small-scale fisheries support the livelihoods of between 58 million and 120 million people (*established but incomplete*). Fish provide 3.1 billion people with over 20 per cent of their dietary protein and contain nutrients important for their health. Ensuring the sustainability of capture fisheries and aquaculture requires significant investment in monitoring, assessment and operations management and, in many cases, strong local community-based approaches. Investment in fisheries monitoring and gear technologies can improve selectivity of target species when harvesting and reduce habitat impact, both in ocean fisheries and aquaculture. {14.2.4}

Measures to minimize the effects of fishing on the ecosystem have had mixed success (*established but incomplete*). Where resource assessments and monitoring, control, and surveillance and enforcement measures are not available, overfishing and illegal, unreported or unregulated fishing continues and may be expanding (*established but incomplete*). {14.2.3, 14.4, 14.5}

Marine litter, including plastics and microplastics, is now found in all oceans, at all depths (*established but incomplete*). The scale and importance of the problem has received increasing attention in recent years, but there are still large gaps in knowledge. Current estimates suggest that input of plastic marine litter linked to domestic waste mismanagement in coastal areas amounts to some 8 million tonnes annually, (*established but incomplete*) 80 per cent of which originates from land-based sources. Marine plastic litter can result in a significant ecological impact from entanglement and ingestion, and can also act as a vector for the transport of invasive species and other pollutants (*established but incomplete*). Abandoned, lost or otherwise discarded fishing gear (ALDFG) is a major source of marine litter. Not only is ALDFG highly harmful, it also reduces numbers of fish stock and constitutes a significant economic threat, given its ability to damage maritime vessels, fisheries and ecosystem services. {7.3.3, 7.4.3}

The growing presence and abundance of microplastics has potential adverse effects on the health of both marine organisms (*established but incomplete*) **and humans** (*unresolved*). Furthermore, marine litter has a significant economic impact on a range of coastal sectors, such as tourism and recreation, shipping

Figure SPM.3. Map showing the maximum heat stress experienced during the 2014–2017 global coral bleaching event



Source: National Oceanic and Atmospheric Administration (2017).

Note: Alert level 2 heat stress indicates widespread coral bleaching and significant mortality; alert level 1 heat stress indicates significant coral bleaching; lower levels of stress may also have caused some bleaching.

and yachting, fisheries, aquaculture, agriculture and human health (*established but incomplete*). The damage to fishing gear in Europe alone is estimated at more than US$72 million per annum and the cost of cleaning beaches is estimated at US$735 million per annum, a figure which is increasing (*established but incomplete*). {7.4.4}

Improving waste management, including recycling and end-of-life management, is the most urgent short-term solution to reducing input of litter to the ocean (*well established*). Longer-term solutions include improved governance at all levels, and behavioural and systemic changes that reduce plastic pollution from the production and use of plastic, and increase recycling and reuse. A holistic and evidence-based approach, taking into account the full life-cycle approach to waste management should be applied. Cleaning up coasts and beaches can provide environmental, social and economic benefits, and trapping surface litter in the ocean may be effective in small areas, but such efforts should not distract from action to stop litter entering the ocean. While many relevant international agreements exist, there is no global agreement that addresses the issue of marine litter and microplastics in a comprehensive and integrated manner. Coordination and cooperation between international bodies could be enhanced to progress international agreement. {14.2.2}

Policy-sensitive indicators used to track progress in addressing key pressures and drivers may not fully capture the multiple dimensions of pressures and drivers (*well established*). Area-based indicators, such as Aichi Biodiversity Target 11 on the coverage of marine protected areas under national jurisdiction, do not alone establish that such areas are effectively managed; nor can they guard against the impact of climate change or pollution (*well established*). Efforts to develop methods to evaluate the effectiveness of protected areas and their contribution to overall ocean health are therefore critical. The lack of standardization and compatibility between the methods used and the results obtained in various bottom-up projects makes an overall assessment of the status of marine litter across large geographic areas difficult (*well established*). {14.3, 14.3.1, 14.3.2, 14.3.3}

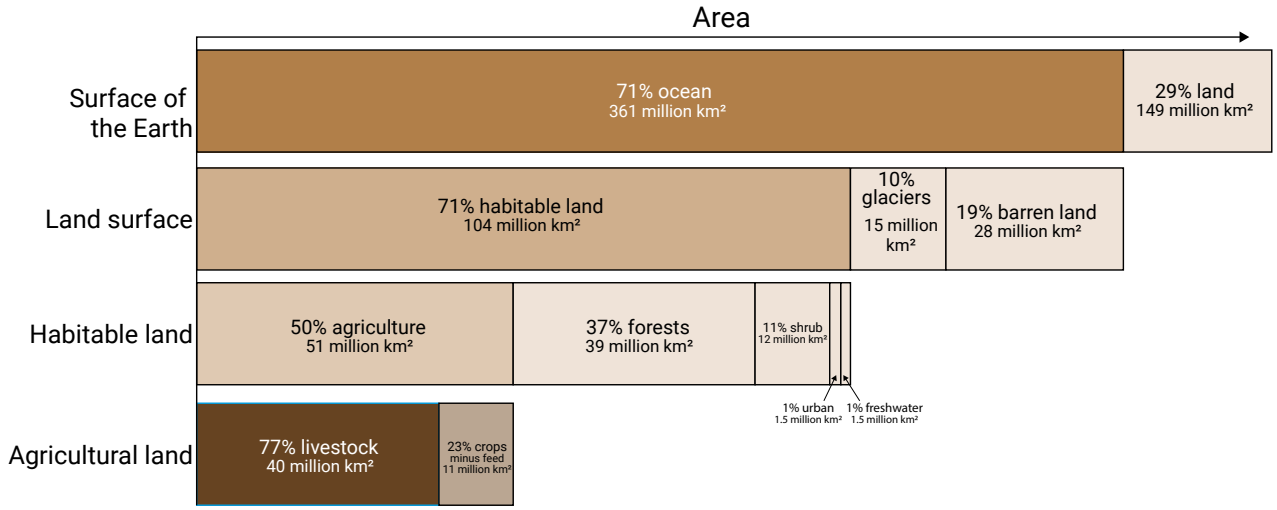
2.2.4 Land and soil

Food production is the largest anthropogenic use of land, using 50 per cent of habitable land (*well established*). Livestock production uses 77 per cent of agricultural land for feed production, pasture and grazing (*well established*) (see figure SPM.4). Furthermore, traditional livestock provides livelihoods for many indigenous and local communities. Sustainable land management can address food security while preventing the loss of the contribution made by nature and promoting gender and social equality (*established but incomplete*). Adequately feeding 10 billion people by 2050 will require an increase of 50 per cent in food production (*well established*), while some 33 per cent of global edible food is lost or wasted, of which approximately 56 per cent occurs in developed countries (*well established*). Increasing productivity has slowed down the expansion of agricultural land, but inefficient or unsustainable farming systems are often associated with environmental and soil degradation and biodiversity loss (*unresolved*), and an increase in crop specialization and distribution can raise the risk of poor harvests. {8.5.1, 8.5.3, 8.4.1}

Securing land rights for local communities can help to turn land assets into development opportunities and secure more sustainable use of land. For most people, land is their most important asset (*well established*). Women represent 43 per cent of those active in agriculture, yet they hold the title to less than 20 per cent of agricultural land. Insecure access to land resources hinders sustainable land management (*well established*). Indigenous and other forms of community-managed land could generate billions of US dollars' worth of ecosystem benefits through, among other things, carbon sequestration, reduced pollution, clean water and erosion control (*established but incomplete*). Those benefits could justify securing land tenure and the right to inheritance for women and indigenous and local communities. Decreasing the gender gap in access to information and technology, and access to and control over production inputs and land, could increase agricultural productivity and reduce hunger and poverty (*established but incomplete*). Policies

Figure SPM.4. Global surface area allocation for food production

The breakdown of the surface of the Earth by functional and allocated uses, down to agricultural land allocation for livestock and food crop production, measured in millions of square kilometres. The area for livestock farming includes land for animals, and arable land used for animal feed production.



Source: Food and Agriculture Organization of the United Nations (2017).

empowering women, indigenous peoples, family farmers and pastoralists to ensure that those groups have secure access to land resources, fertilizers and other inputs, knowledge, extension services, financial services, markets, opportunities for adding value and non-farm employment can facilitate the achievement of the Sustainable Development Goals and reduce environmental impact (*established but incomplete*), increase agricultural productivity and contribute to reducing poverty and hunger (*well established*). {8.6, 8.5.3}

Land degradation and desertification have increased (*established but incomplete*), with land degradation hotspots covering approximately 29 per cent of global land, where some 3.2 billion people reside (*well established*). Investing in avoiding land degradation and restoring degraded land makes sound economic sense and the benefits generally far exceed the costs. {8.4.2}

Whilst the pace of deforestation has slowed, it continues globally. Furthermore, although many countries are now taking steps to increase their forest cover, it is primarily being done through plantations and reforestation (*well established*), which may not provide the same range of ecosystem services as natural forests. {8.4.1}

Urban clusters – meaning urban centres and their suburbs – have grown by a factor of approximately 2.5 since 1975 (*well established*), and in 2015 accounted for 7.6 per cent of global land, affecting, among other things, the hydrological cycle and soil functions, causing urban heat islands. {8.4.1}

Achieving the land-related Sustainable Development Goals requires adequate land and water resource management (*well established*). Innovative technologies, sustainable land management strategies, nature-based solutions and land-resource stewardship (such as sustainable forest management, agro-silvo-pastoral production systems, conservation agriculture, integrated crop production and agroforestry) can contribute to making agriculture sustainable. Payment for ecosystem services, land restoration and land titling need to be more effectively promoted and adopted. When compatible with local culture, such strategies contribute to better management and conservation of land resources (*well established*) and are integral for the reduction of hunger (Sustainable Development Goal 2). Economic incentives for agriculture, including distortive agricultural production subsidies, contribute to land degradation, and their reduction and removal will be important for the achievement of sustainable agriculture. {8.5.1}

Sustainable land-use planning and management can protect high-quality, fertile agricultural soil from competing interests, thus maintaining land-based ecosystem services such as food production, and preventing land from flooding and disaster. Frameworks targeting land degradation, such as the Land Degradation Neutrality initiative under the United Nations Convention to Combat Desertification, may also contribute to climate change mitigation and resilience (*well established*). Yet the policy framework on land management remains complex and incomplete. {8.4.1, 8.5.3, 8.5.4}

2.2.5 Fresh water

Population growth, urbanization, water pollution and unsustainable development are all increasing pressure on water resources across the world, and that pressure is further exacerbated by climate change. In most regions, slow-onset disasters, such as water scarcity, drought and famine, lead to increased migration (*well established*). Increasing numbers of people are also being affected by severe storms and floods. Increasing glacial and snowpack melt as a result of global warming will affect regional and seasonal water availability, especially in Asian and Latin American rivers, which provide water for some 20 per cent of the global population (*well established*). Changes to the global water cycle, including extreme events, are contributing to water quantity and quality problems, with impact distributed unequally across the world. {9.1, 9.1.2, 9.2}

In most regions, water quality has worsened significantly since 1990, owing to organic and chemical pollution, such as pathogens, nutrients, pesticides, sediments, heavy metals, plastic and microplastic waste, persistent organic pollutants and salinity. Some 2.3 billion people (approximately 1 in 3 of the global population) still lack access to safe sanitation (*likely*). Approximately 1.4 million people die annually from preventable diseases, such as diarrhoea and intestinal parasites, that are associated with pathogen-polluted drinking water and inadequate sanitation (*well-established*). {9.5, 9.5.7, 9.5.2}

Without effective counter-measures, human illnesses due to antimicrobial-resistant infections may become a major cause of death from infectious diseases worldwide by 2050 (*established but incomplete*). Water plays a key role in this, as antimicrobial-resistant bacteria are now found in sources of treated drinking water worldwide (*well-established*), stemming from antibiotics entering the water cycle through domestic sewage and industrial wastewater disposal, agriculture, intensive livestock rearing and aquaculture. In addition, various endocrine-disrupting chemicals are now widely distributed through the freshwater system on all continents (*well established*), with long-term impact on foetal underdevelopment and male infertility (*established but incomplete*). {9.5.1, 9.5.7}

On the positive side, 1.5 billion people gained access to basic drinking water services over the 15-year period from 2000 to 2015. However, women and girls still carry most of the physical burden of transporting water in many developing countries, reducing the time available for them to participate in productive activities and education. The positive impact of women being able to spend time on other activities should be widely acknowledged, since economic surveys indicate that they typically reinvest up to 90 per cent of their income in their families, improving family health and nutrition, and increasing access to schooling for their children. {9.7.1}

Worldwide, agriculture uses an average of 70 per cent of all fresh water withdrawals, rising to 90 per cent in many poorer countries. The competition for more water from cities and industry creates an imperative to improve the efficiency of agricultural water use while at the same time producing more food and using fewer and less harmful inputs (*well established*).

Figure SPM.5. Summary of global progress in providing basic drinking water services and the disproportionate impact on women in sub-Saharan countries who still lack access to basic drinking water services

Source: UNICEF and WHO (2012); WHO and UNICEF (2017).

Many aquifers are depleting rapidly due to overabstraction for irrigation, drinking water, industrial and mining uses (*established but incomplete*). More sustainable management and better monitoring of surface and groundwater is urgently needed. {9.4.2, 9.9.5}

Promoting water-use efficiency, water recycling, rainwater harvesting and desalination is becoming increasingly important to ensure greater water security and more equitable water allocation for different users and uses. The agricultural sector needs substantial improvements in water-use efficiency and productivity. The industrial and mining sectors also have strong potential for increasing water-use efficiency, recycling and reuse, as well as for limiting water pollution. Broader adoption of water-sensitive urban design, including infrastructure to manage storm water, grey water, wastewater and managed aquifer recharge, would improve water management and urban water outcomes. {9.9, 9.9.3, 9.9.5}

Freshwater ecosystems are among the world's most biodiverse habitats and valuable natural infrastructures. Wetlands buffer against impact from climate change (both drought and floods) and improve water quality, but 40 per cent of all wetlands have been lost since 1970 through agricultural development, urbanization, infrastructure development and overexploitation of water resources. Severe consequences include the loss of inland fisheries, which affects the livelihoods of millions of people (*likely*). The total annual economic cost of wetland losses over the 15-year period from 1996 to 2011 has been estimated at US$2.7 trillion (*likely*). Greater investment, both public and private, would facilitate more sustainable wetland management and restoration. {9.6}

The decomposition, due to human intervention, of peatlands, a type of wetland that stores more carbon than all the world's forests combined, currently contributes approximately 5 per cent of annual global carbon emissions (*established but incomplete*). The thawing permafrost in boreal peatlands, agricultural conversion of some tropical peatlands and the transformation and loss of other peatlands are causing increased carbon emissions, infrastructure damage and wildfires. Protection and restoration of peatlands, including rewetting of drained peatlands, is an important climate change mitigation strategy. {9.6.2}

Innovative and integrated policy mixes are essential to manage interactions between water, food, energy, transport, climate change, human health and ecosystems. Good governance includes integrated water resource management, as illustrated by integrated flood risk management (*established but incomplete*), ecosystem-based approaches in subnational and transboundary basins (*well established*), circular economy and other approaches that promote sustainable consumption and production as one approach towards achieving sustainable development (*established but incomplete*) and substantive progress on decoupling water use from economic growth through increasing water efficiency (*established but incomplete*). Such approaches support improved land-use planning and cross-sectoral policy coordination between government departments (*well established*). {9.8, 9.9.4}

Social equity and gender equality remain key aspects for achieving Sustainable Development Goal 6 on fresh water (*well established*). Enhanced participatory processes will enable greater knowledge input from local and indigenous communities into decision-making (*well established*). Goal 6 can only be achieved by engaging the public, private and non-governmental sectors, civil society and local actors, and by taking into account other interlinked Sustainable Development Goals. {20.3, 9.10, 16.4}

Multilateral environmental agreements governing water resources and water-related ecosystem management and climate change can support the embedding of integrated water resource management in the rule of law through national and local legislation. Increased investment in the scope and rigour of standardized water data is essential to improve policy and governance for sound water management. {9.10}

2.2.6 Cross-cutting issues

Several issues cut across all environmental themes. Some, such as human health, gender, urbanization and education, relate to people and livelihoods; others, such as climate change, polar regions, mountains and environmental disasters, are concerned with changing environments; and yet others, such as the use of resources, solid waste disposal, energy, chemicals and the food system, reflect the use of resources and materials. Those topics all have interdependent dynamics across environmental themes.

People and livelihoods

Environmental and social conditions interact to both support and damage human health (*well established*). Poor environmental conditions which can be changed ("modifiable conditions") cause approximately 25 per cent of global disease and mortality (*established but incomplete*). In 2015, environmental pollution caused some 9 million deaths (*established but incomplete*), in particular from outdoor and household air pollution, but also from contaminated water (*well established*). Environmental health effects take a particular toll on vulnerable or disadvantaged groups related to age (children and old people), ill-health, poverty (within and between countries) and race (*established but incomplete*). The risks are systemic and solutions need to be wide-ranging, tackling not only sources of pollution, but also aiming for co-benefits (*established but incomplete*). Major changes may be needed, with "Healthy Planet, Healthy People" potentially being central to our understanding of genuine progress. {4.2.1}

The scale and magnitude of global consumption, especially in urban areas, is affecting global resource flows and planetary cycles. Cities and their surrounding areas will continue to grow in both population and size and to act as generators of economic growth (*established but incomplete*). The process and prospect of that urbanization represent an enormous challenge for existing subnational governance structures, but also provide an opportunity to improve human well-being, with potentially decreasing environmental impact per capita and per unit of production (*inconclusive*). Given the current pace of urbanization, seizing this opportunity for future benefits depends on planning decisions made today (*well established*). {4.2.5}

Gender equality has a multiplier effect in advancing sustainable development, environmental protection and social justice (*well established*). All aspects of the environment, including drivers, pressures, impacts, perceptions, policies and responses, are shaped by gender relations and mutually constituted considerations of gender norms and responsibilities, and they shape one another. Bringing gender perspectives to bear on environmental policies and governance, especially by supporting participation, leadership and decision-making by women, ensures that new and different questions and viewpoints, as well as gender-disaggregated data, are integrated into environmental assessments (*well established*), and public resources are more likely to be directed towards human development priorities and investments. Decreasing the gender gap in access to information and technology can strengthen women's control over land and other resources. {4.2.3}

Education for sustainable development is essential for achieving the Sustainable Development Goals, promoting a more sustainable society and accommodating unavoidable environmental changes (*well established*). Significant progress has been made around the world in implementing education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for sustainable development in all educational sectors (*well established*). However, scaling it up is essential so that it can be included as a core element of education system structures globally (*well established*). Policies that eliminate economic and gender barriers will improve access to education. Education for sustainable development can be scaled up by informal and non-formal education, including by the media. Community engagement and local (place-based) learning also have an important role to play. {4.2.4}

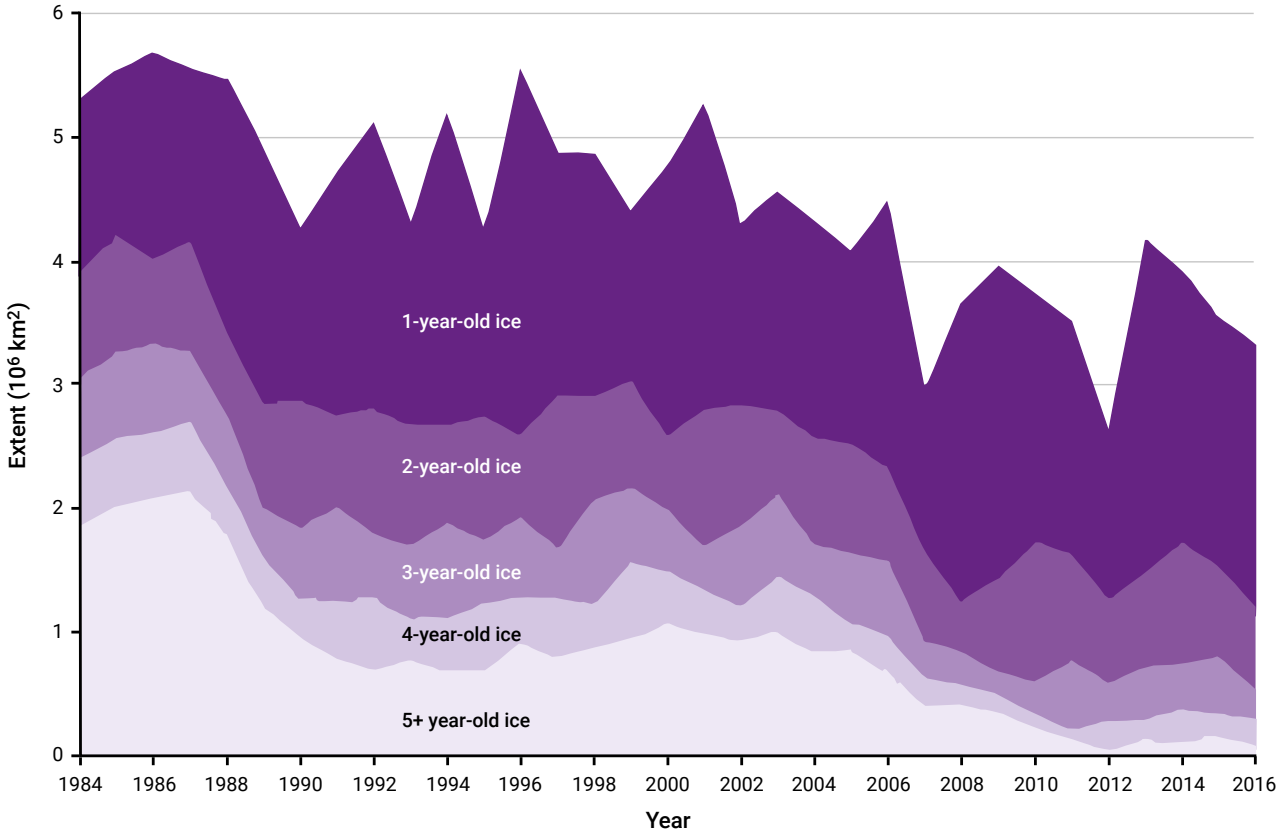
Changing environments

Climate change alters weather patterns, which in turn has a broad and deep impact on the environment, economics and society, threatening the livelihoods, health, water, food and energy security of populations (*well established*). In turn, that increases poverty (*well established*), migration, forced displacement and conflict (*established but incomplete*), with particular impact on populations in a vulnerable situation (*well established*). Negative effects are expected, even if the current warming is halted; for example, if the goal of limiting warming to 1.5 degrees Celsius is achieved, sea levels will still continue to rise. Those risks will be amplified under conditions of warming above the 1.5 degrees Celsius target established by the Paris Agreement (*established*). {4.3.1}

Increases in polar surface temperature are more than two times greater than the mean global temperature rise (*well established*). This amplified warming has cascading effects on other components of the polar climate system, with sea ice in the Arctic retreating, permafrost thawing, snow cover extent decreasing, and ice sheets, ice shelves and mountain glaciers continuing to lose mass (*well established*). {4.3.2} In turn, those effects have global repercussions, such as accelerated global sea level rises and the disturbance of climate and weather patterns.

The number of people affected by both slow and sudden-onset environmental disasters is increasing due to compounding effects of multiple and interacting drivers. Those drivers include climate change and environmental degradation, poverty and social inequality, demographic change and settlement patterns, increasing population density in urban areas, unplanned urbanization, unsustainable use of natural resources, weak institutional arrangements, and policies which do not take risks fully into account. Disasters undermine human security and well-being, resulting in loss and damage to ecosystems, property, infrastructure, livelihoods, economies and places of cultural significance, forcing millions of people to flee their homes each year. Disasters disproportionately affect some of the more vulnerable populations, including women. {4.2.2}

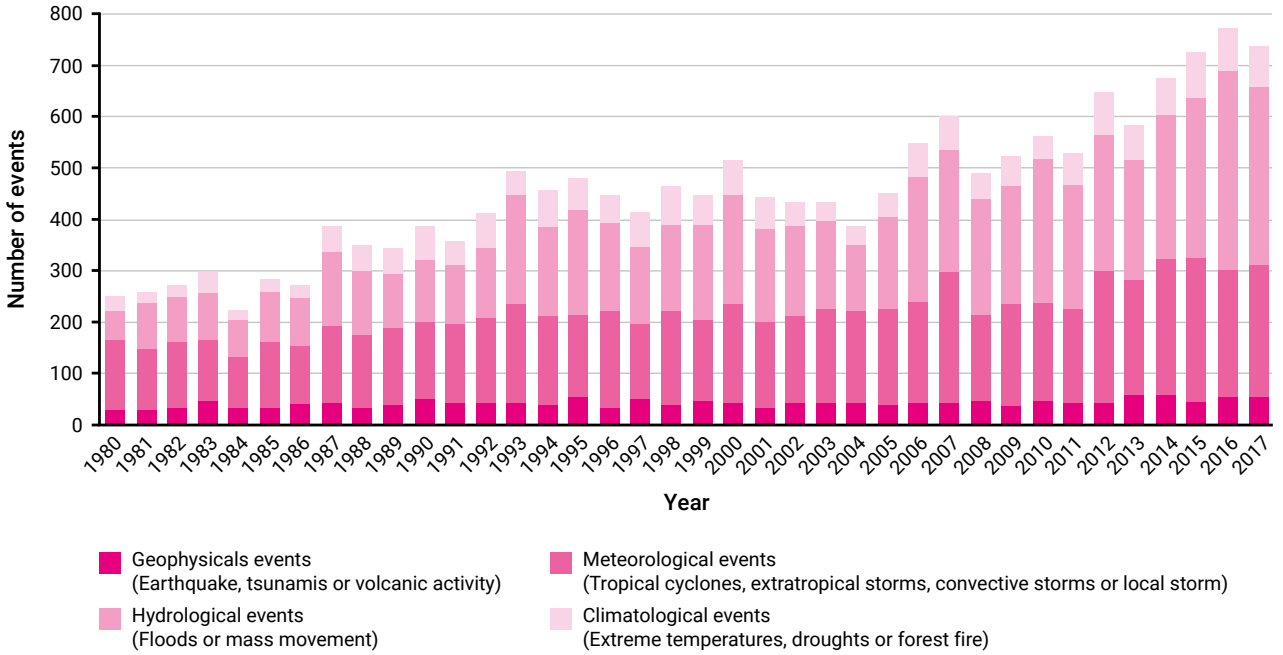
Figure SPM.6. Reduction in the extent of Arctic sea ice by age



Source: United States National Snow and Ice Data Center (2017).

Note: A few decades ago, a large proportion of Arctic sea ice survived the summer melt. In 1984, more than a third of sea ice was older than five years. Figure SPM.6 shows the sharp reduction in sea ice of that age since then.

Figure SPM.7. Trends in numbers of loss-related natural events



Source: Munich Re (2017).

Resources and materials

Consumption rates and linear activities (extract-make-use-dispose) have increased resource exploitation beyond the recovery ability of ecological systems, with harmful consequences at all levels from the local to the global (*established but incomplete*). Globally, two out of every five people lack access to controlled waste disposal facilities. Inadequate and sometimes illegal practices include those related to food waste, e-waste, marine litter, waste trafficking and crime. Developed countries have policies in place to promote reduced waste and resource efficiency, while developing countries still face basic management challenges, such as uncontrolled dumping, open burning and inadequate access to services (*well established*). Sound policies for resource accounting and waste management in the context of broader sustainable consumption and production include a circular economy as one of the approaches to achieving sustainable development through reducing, reusing, remanufacturing and refurbishing products (*established but incomplete*). {4.4.1}

Global energy consumption is expected to rise significantly during the period from 2014 to 2040 (by as much as 63 per cent, according to one estimate), much of which is attributed to expected consumption in countries that currently depend on fossil energy sources (*very likely*). Equity and gender issues, such as universal access to improved final energy services, are still a problem that is far from being resolved. Despite the fast deployment and cost reduction of renewables and improvements in efficiency, without further and effective, ambitious measures, energy-related greenhouse gas emissions will result in the Paris Agreement temperature targets being missed (*very likely*). {4.4.2}

Despite the many benefits brought to humanity, in this, the most chemical-intensive era in history, the pollution that is associated with chemicals poses a global problem, because toxic substances can spread to the most remote environments, including to receiving water systems worldwide (*well established*). Products in everyday use contain toxic compounds that interfere with the health of humans, other species and the environment (*well established*). {4.3.3}

Multilateral environmental agreements and concerted national initiatives have made progress in addressing several of the most concerning chemicals. However, significant gaps in assessing and regulating harmful chemicals continue to exist, due, inter alia, to insufficient national legislation or enforcement to address associated risks and to missed innovation opportunities. Failure to address the risks posed by such chemicals can result in adverse impact on human health and the environment, with estimated costs amounting to hundreds of billions of US dollars (*established but incomplete*). Emerging issues requiring more science-based information, precaution, in accordance with international agreements (where applicable), and risk assessment and management include endocrine disruption, widespread antibiotic resistance and the use of nanotechnology. Global chemical safety requires best management practice in all countries, including the provision of access to information and public awareness (well established). Regulations, assessment and monitoring, and industry and consumer responsibility in informing and substituting the use of chemicals of global concern with safer alternatives when technically and economically feasible are needed {4.3.3}.

The food system, in response to growing and changing consumer demand, is increasing pressure on local ecosystems and the global climate (*well established*). Agriculture is the largest consumer of water and, when not sustainably managed, food production is a major driver of biodiversity loss and polluter of air, fresh water and oceans, as well as a leading source of soil degradation and greenhouse gas emissions. Changing environmental conditions and consumption patterns are both increasing such pressures and presenting new food security challenges, reflecting malnourishment, including in the form of overnourishment, as well as undernourishment. Providing nourishing and sustainable food for all, as envisaged in Sustainable Development Goal 2, remains challenged by climate change, natural resource constraints, demographic trends and national capacities, and necessitates significant changes in food production, distribution, storage, processing and consumption patterns (*well established*). {4.4.3}

3 Effectiveness of environmental policies

Most countries have introduced environmental policies and established a governance structure for such policies, and there are now hundreds of multilateral environmental agreements in existence. Part B of GEO-6 addresses the question: "How effective have these policy innovations and governance approaches been in addressing the problems and achieving the agreed targets?" The analysis combines an evaluation of case studies on implemented policies with an indicator-based approach covering a diversity of policy approaches from various levels in the thematic areas of the report, including the following: {10.5, 10.7}

- Provision of information: for example, access to data on air quality or coral reefs;
- Voluntary agreements: for example, voluntary reporting on the use of water, voluntary guidelines for sustainable soil management or standard-setting for best management practice and sustainability reporting;
- Economic incentives and market-based instruments: for example, free water allowances, individual transferable quotas for fishers, or payments for ecosystem services;
- Planning for the environment: for example, adaptive water management and urban biodiversity management;
- Promotion of innovation: for example, innovation for sustainable agriculture or financing for clean cookstoves;
- Regulatory approaches: for example, car exhaust emission standards or regulating wildlife trade through the Convention on International Trade in Endangered Species of Wild Fauna and Flora;
- Governance approaches that include communities, and private sector and civil society actors: for example, city actions to limit food waste or to promote community-based conservation.

Indicators for the evaluation include, for example for air, annual mean $PM_{2.5}$ concentrations (population-weighted), ozone-depleting substance emissions and long-lived greenhouse gas emissions. The indicators address a wide range of multilateral environmental agreements and Sustainable Development Goals.

There has been innovation in environmental policies and instruments to reduce emissions and resource depletion (*well established*). There is no single superior approach that addresses the wide variety of barriers to sustainable development and that is applicable in all contexts. A diversity of approaches and innovation in policymaking is justified. {10.3}

Policy design is at least as important as the choice of policy instrument for policy effectiveness (*well established*). Common elements of good policy design include the following: (i) setting a long-term vision through inclusive, participatory design processes; (ii) establishing a baseline of environmental conditions, quantified science-based targets and milestones; (iii) effectively integrating environmental, social and economic concerns; (iv) conducting ex ante and ex post cost-benefit or cost-effectiveness analysis to ensure that public and private funds are being used with optimal efficiency and effectiveness and that social aspects are being considered in sufficient detail; (v) building-in monitoring regimes during implementation that support adaptive policies, ideally involving affected stakeholders; and (vi) conducting post-intervention evaluation of policy outcomes and impacts to close the loop for future policy design improvement. {11.2.3}

In many cases, environmental policymaking does not meet the suggested criteria for effective policies, meaning that it does not reach its full potential (*established but incomplete*). For example, in many cases neither ex ante nor ex post cost-effectiveness analysis of policy outcomes has been attempted, making success or failure difficult to evaluate, or clear and measurable targets are missing. {Chapter 18}

Policy innovation increasingly takes place in developing countries (*established but incomplete*). This includes market-based and regulatory approaches that provide environmental improvements while also meeting access rights for the poor. Examples exist of environmental policy instruments that provide access to natural resources and income for the poor, such as the provision of free water in South Africa and sustainable fisheries policies in Chile. {Chapters 12 to 17}

Environmental policymaking can become more dynamic through scaling-up over time (*established but incomplete*). Policies are revised and improved, based on experience; for example, by increasing the level of ambition or choosing more effective instruments. However, such ratcheting-up is not applied on a systematic basis. There are few policies which have policy feedback mechanisms built in; hence the potential of temporal dynamics is not fully exploited. In many cases, no baseline of existing environmental conditions, which would be necessary for ex post or ex ante evaluation, is established. {11.2.2}

Policy diffusion between countries is increasingly taking place (*well established*). Successful policies serve as role models for adoption in other countries when national circumstances, priorities, capabilities and legislation allow for it. Multilateral agreements and policy networks at the subnational level serve as catalysts for policy learning between countries. However, there are indications that policy diffusion takes place more often in the field of voluntary and innovation promotion, while market-based instruments or redistributive policies, such as the removal of environmentally harmful subsidies or regulatory approaches, are less often subject to policy diffusion. {11.2.1}

Multilevel governance is a source for policy innovation (*well established*) **at the international level and multilateral environmental agreements support environmental policymaking at the national level to pursue related policies.** Stakeholder participation in all phases of the policy cycle from design to implementation to monitoring and evaluation is crucial. At the subnational level, communities, cities and the private sector are all establishing their own policy approaches, which is also supportive for advancing policies at other levels. {11.4}

An integrated approach is key for effective policies (*well established*). The integration of environmental concerns into

the various sectors of policymaking at all levels, including agriculture, fisheries, tourism, forestry, industry, manufacturing and processing, energy and mining, transport, infrastructure and health, is key for effective protection of the environment. Social and economic aspects require particular consideration when environmental policy is being developed. Similarly, a gender-integrative approach could support more effective and transformative environmental policies and interventions. {11.3}

There is no consistent consideration of environmental aspects in other sectors. Environmental aspects find consideration in other sectors when demonstrating economic and social co-benefits (*established but incomplete*). Tools for ex ante assessment can reveal potential co-benefits. For example, "green investment" of just 2 per cent of global gross domestic product would deliver long-term growth over the period from 2011 to 2050 that could be at least as high as an optimistic business-as-usual scenario, while minimizing the adverse impact of climate change, water scarcity and the loss of ecosystem services. Although analyses such as strategic environmental assessments, environmental impact assessments and assessments of natural resources are increasingly being carried out, their potential has not yet been fully exploited. Environmental integration is insufficient if there are no benefits to other sectors or if costs are imposed on influential groups while benefits are widely dispersed in society (*well established*). Departments of the environment are often too weak to enforce environmental policy integration. Effective legal, procedural and institutional mechanisms for environmental policy integration are not widely applied or implemented (*well established*). {11.3, 11.3.3}

An analysis of policy-related indicators shows that despite considerable innovation and effort in advancing environmental policies, the efforts and effects to date remain insufficient (*well established*). Existing policies have proven insufficient to address the backlog of environmental problems, and policy gaps remain in the agenda areas of pollution control, efficiency improvement and planning for the environment. Besides more ambitious and better-designed policies, urgent action is needed, as resource depletion and growing emissions have a partially irreversible impact on ecosystems, human health and economic costs. {Chapters 12 to 17}

To pursue the 2030 Agenda for Sustainable Development and the Sustainable Development Goals and to achieve the internationally agreed environmental goals on pollution control, clean-up and efficiency improvements will not be sufficient (*established but incomplete*). Instead, transformative change, in the sense of reconfiguration of basic social and production systems and structures, including their institutional framework, social practices, cultural norms and values, is necessary. Transformative change enables and combines visionary, strategic and integrated policymaking with the enabling of bottom-up social, technological and institutional innovation and the systematic use of experience drawn from such experimentation. {Chapter 18}

Successful models of environmental governance should be built upon well-designed policies and their implementation, compliance and enforcement. Such models should pay close attention to early signals from science and society and ensure adequate oversight capacity and investment in knowledge systems, such as data, indicators, assessments, policy evaluation and sharing platforms. Greater investment is needed in environmental accounting systems to ensure that external costs are addressed and that processes are incorporated that will identify possible future risks, opportunities and conflicts. {Chapter 18}

Greater application of the precautionary approach, in accordance with international agreements (where applicable), can reduce environmental risk. Coalitions between government institutions, businesses and civil society to agree on pathways for tackling societal risks can achieve progress, even in conditions of great uncertainty. Multilevel coordination between local and national policy levels will be instrumental in accelerating the transition towards sustainable development models. {Chapter 18}

4 Changing the path we are on

4.1 The need for urgent, sustained and inclusive action

Without additional policies, trends in environmental degradation are projected to continue at a rapid rate and the related Sustainable Development Goal targets and internationally agreed environmental goals are not expected to be achieved, including on climate change, biodiversity loss, water scarcity, excess nutrient run-off, land degradation and ocean acidification (*well established*). Current patterns of consumption, production and inequality are not sustainable, adding to other severe environmental pressures. Many environmental indicators are projected to move in the wrong direction. Projected population growth, urbanization trends and economic development will significantly increase demand for natural resources, such as food, energy and water, towards 2050. Under a business-as-usual scenario, resource efficiency in production and consumption, agricultural yields and nutrient use, water and energy efficiency are projected to increase, thereby partially offsetting demand for key environmental resources. However, such improvements will be inadequate to reduce the pressure on already-stressed environmental systems. {21.3.1–21.3.5}

Indicators related to human development are projected to improve, but trends are insufficient to meet related targets (*established but incomplete*). Improvements are projected on global hunger, and access to safe drinking water, adequate sanitation and modern energy services, but significant inequality of access remains, and those improvements are not expected to take effect quickly enough for many countries to achieve the related Sustainable Development Goal targets. Preventable environment-related health risk factors are projected to remain prominent in 2030. Related global child mortality is projected to decrease, but not sufficiently for many developing countries to achieve the related Development Goal target, in particular in sub-Saharan Africa. Furthermore, air pollution is expected to continue to contribute to millions of premature deaths in the coming decades. {21.3.2, 21.3.3, 21.3.4, 21.3.6}

Overall, the world is not on track to achieve the environmental dimension of the 2030 Agenda for Sustainable Development and internationally agreed environmental goals by 2050. Urgent action is now needed to reverse those trends and restore both environmental and human health to the planet (*established but incomplete*). Future projections show that development is either

Figure SPM.8. Projected global trends in target achievement for selected Sustainable Development Goals and internationally agreed environmental goals

Human development indicators			Environmental indicators		
Related Sustainable Development Goals	Target	Projection	Related Sustainable Development Goals	Target	Projection
2 ZERO HUNGER	2.1 End hunger		6 CLEAN WATER AND SANITATION	6.3 Improve water quality 6.4 Reduce water scarcity	
3 GOOD HEALTH AND WELL-BEING	3.2 End preventable deaths of children under 5		11 SUSTAINABLE CITIES AND COMMUNITIES	11.6 Improve air quality in cities	
6 CLEAN WATER AND SANITATION	6.1 Achieve universal access to safe drinking water 6.2 Universal access to adequate sanitation		13 CLIMATE ACTION	13 Limit global warming	
7 AFFORDABLE AND CLEAN ENERGY	7.1 Achieve universal access to modern energy services		14 LIFE BELOW WATER	14.1 Reduce marine nutrient pollution 14.3 Minimize ocean acidification 14.4 Sustainably manage ocean resources	
			15 LIFE ON LAND	15.2 Achieve land degradation neutrality 15.5 Halt biodiversity loss	

Legend

On track to achieve target (under bbusiness-as-usual scenarios target is projected to be achieved)

Progress towards target, but at an insufficient rate (unless effort is increased, target is projected not to be achieved)

Moving away from target (the trend is projected to be worse, rather than better)

Note: Many Sustainable Development Goal targets and internationally agreed environmental goals are broader in scope than shown in the above figure, which only assesses selected targets or elements of targets. The icons shown indicate the related Sustainable Development Goal. Trends are based on an assessment of business-as-usual projections in the scenario literature. For several target elements, trends are confirmed by multiple studies {SDG targets 2.1, 3.2, 7.1, 6.4, 11.6, 14.3 and 15.5, and SDG 13}, while for others, only limited scenario literature was available. (SDG targets 6.1, 6.2, 6.3, 14.1, 14.4 and 15.2) {Table 21.2}

too slow to achieve the targets or even that it moves in the wrong direction (see figure SPM.8). Continuing failure to take urgent action is leading to ongoing and further potentially irreversible adverse impact, including on critical environmental resources and human health. {Section 2.2} Current patterns of consumption and production may be more expensive in the long term for many countries, as it often costs more to clean up later than it does to prevent damage now, added to which cleaning up later may not always be possible. For example, a further delay in climate action increases the cost of achieving the goals of the Paris Agreement, and at some point will make it impossible to achieve them. {21.3.3, 21.4, 24.4}

4.2 Transformative change and an integrated approach are needed

Pathways exist that show that the healthy planet needed for sustainable development can be achieved (*established but incomplete*). The literature includes many scenarios that provide information on the ways in which the Sustainable Development Goals, multilateral environmental agreements and related internationally agreed environmental goals can be achieved. Those pathways emphasize a number of key transitions in moving towards a healthy planet. They are associated with achieving sustainable consumption and production patterns for energy, food and water in order to provide universal access to those resources, while preventing climate change, air pollution, land degradation, loss of biodiversity, water scarcity, and overexploitation and pollution of oceans. They include changes in lifestyle, consumption preferences and consumer behaviour on the one hand, and cleaner production processes, resource efficiency and decoupling, corporate responsibility and compliance on the other hand. {22.3}

Transformative changes are needed to meet the Sustainable Development Goals, multilateral environmental agreements and related internationally agreed environmental goals. They go beyond what can be achieved by environmental policies alone (*established but incomplete*). The rate of change in the pathways indicates that incremental environmental policies alone will not suffice. A mix of social and technological improvements and innovations is required, facilitated by effective policy measures and cooperation on a scale from the local to the international. {22.4.1}

Meeting the targets related to climate change, reducing air pollution and providing sustainable energy for all is possible. Measures can be combined in different ways but need to be implemented rapidly and at an unprecedented scale (*well established*). It involves investment in energy access, enhancing the development and implementation of energy-efficiency improvements, lifestyle changes, a more rapid introduction of low greenhouse gas-emission technologies (including sustainable and equitably-produced bioenergy, hydropower, solar, wind and carbon-capture-and-storage), air pollution control and reducing emissions and increasing removals from land use and land-use change and forestry of anthropogenic greenhouse gas emissions (including non-CO_2 greenhouse gas emissions from agriculture). Pathways consistent with the Paris Agreement are characterized by a reduction of carbon intensity in the global economy of 4 to 6 per cent per annum between now and 2050 (compared with 1 to 2 per cent per annum historically), which would reduce energy system greenhouse gas emissions to almost zero by 2050. {22.3.2}

Eliminating hunger, preventing biodiversity loss and halting land degradation is possible by combining measures related to consumption, production, waste and redistribution of food, and nature conservation policies (*established but incomplete*). Scenarios achieving those social and environmental targets are typically characterized by a 50 per cent faster improvement in agricultural yields than a business-as-usual scenario, but depend heavily on changes on the consumption side and improvements in food distribution. Halting biodiversity loss would also require measures related to landscape management and protected areas. Ecological infrastructure can buffer farmers and rural and urban communities against climate shocks such as droughts and floods, mitigate water pollution and increase water supply, while at the same time protecting biodiversity. Sustainable agriculture also requires a reduction in the nitrogen and phosphorus imbalance to reduce pollution of freshwater systems, groundwater and coastal zones in oceans. Reducing water scarcity requires more efficient water use, increasing water storage and investing in desalination. Ambitious scenarios in the literature typically show higher water-use efficiency rates than in business-as-usual scenarios, but still fail to reach full water security. {22.3.1, 22.3.3, 22.3.4}

Synergies exist between specific measures and a broad range of sustainability targets, including measures related to education, promoting sustainable consumption, specifically a healthy diet and reducing air pollution (*well established*). Improved education, especially for women and girls, has a particularly strong connection with health outcomes, economic growth, reduced poverty and better environmental management. Meat products require more land than crops (see figure SPM.4). Therefore, promoting sustainable and healthy diets, reducing food waste in both developing and developed countries, and adopting sustainable agricultural practices would contribute towards meeting the nutritional needs of the 9–10 billion people projected to be on the planet in 2050. In doing so, synergies could be realized between improving health and nutrition, while reducing biodiversity loss, advancing habitat restoration and preventing land degradation and water scarcity. Phasing out the use of fossil fuels and moving towards lower-carbon-emission fuels, including sustainable bioenergy, would lead to important co-benefits, achieving both climate and air-quality targets, the latter also having synergies with improving human health, increasing agricultural production and reducing biodiversity loss. {22.4.2}

There are also potential trade-offs between achieving different sustainability targets. Land-based climate change mitigation, namely bioenergy crop production, and agricultural intensification are key measures for achieving climate and food targets respectively, but could have significant detrimental effects on other environmental targets if not managed carefully (*well established*). While nearly all scenarios consistent with the Paris Agreement rely on land-based mitigation measures, their use increases demand for land and could thus have a potentially massive influence on land-use patterns and eventually lead to higher food prices, which would in turn affect food security. Increasing agricultural yields would improve overall food availability and reduce pressure on natural land. Applying unsustainable agriculture practices could lead to land degradation, hypoxia, harmful algal blooms, biodiversity loss and an increase in greenhouse gas emissions. {22.4.2}

Understanding the interlinkage between measures and targets is crucial for synergistic implementation and policy coherence (*well established*). Integrated approaches would enable synergies to be grasped and potential trade-offs to be dealt with so that environmental targets could be achieved simultaneously. {22.4.2}

4.3 Innovation for systemic transformation to achieve environmental goals

Coordinated and ambitious policy, coupled with social and technological innovation, could enable the achievement of the Sustainable Development Goals, related multilateral environmental agreements and internationally agreed environmental goals (*established, but incomplete*). Transformative pathways to sustainable development require the following: (i) vision to guide systemic innovation towards sustainability; (ii) social and policy innovation; (iii) phasing-out of unsustainable practices; (iv) policy experimentation; and (v) engaging and enabling diverse actors, including local and indigenous people. Integrated approaches can help to deal with the synergies and potential trade-offs between the various policies and measures. A vision for sustainable development and leadership can energize popular support. Examples of integrated policies for achieving sustainability goals include providing economic incentives, including the removal of environmentally harmful subsidies, improving price structures and introducing taxes to internalize social and environmental costs. {24.3}

Transformative projects and innovative solutions exist that could collectively help in achieving the Sustainable Development Goals, the aims of multilateral environmental agreements and internationally agreed environmental goals (*unresolved*). Social, policy and technological innovation is needed. At the local level, many transformative projects and innovative solutions already exist that could be scaled appropriately. Reviewing bottom-up initiatives reveals ideas, actions and programmes that seek to achieve the Sustainable Development Goals and involve a wide range of public and private stakeholders, including the following: (i) nature-based solutions, including those that draw on indigenous knowledge, such as ecological infrastructure and ecological restoration; (ii) monitoring and reporting innovations, including Earth observation systems, for better information on environmental conditions, citizen science initiatives that involve citizens in environmental monitoring and which involve decentralization of technologies to educate and engage citizens (for example, web applications that allow citizens to monitor water quality and report problems to relevant government agencies), and natural capital accounting that integrates economic, social and environmental components; (iii) circular and sharing economy innovations that involve the increased efficiency of resource use, specifically through new business models that better engage with waste products of other production processes and innovations related to the peer-to-peer sharing of goods and services; (iv) innovations and policies that help to reduce toxic substances and solid waste, including plastic waste; (v) improving public awareness and building relevant skills through sustainability and environmental education; (vi) an emphasis on gender equality, the empowerment of women and solutions that promote the fair treatment of all, from the local level to the global arena; and (vii) smart, sustainable cities that, for example, use modern digital technologies to engage and connect with citizens in addressing key sustainability challenges for cities, such as transportation, consumption patterns, energy, nutrition, water and waste management. {17.7, 23.11.1}

Financial investment and engagement of individuals, businesses and other non-governmental stakeholders are critical to the achievement of this agenda (*established, but incomplete*). Unsustainable products and industrial processes could be phased out by introducing the following: (i) new regulatory mechanisms setting standards (for example, securing land tenure rights); (ii) financial mechanisms to boost sustainability investment (for example, on rural electrification), improve chemical use efficiency and minimize harmful chemicals, and to account for both market and non-market risks and impact; (iii) environmental education and education for sustainable development to enhance awareness and competencies for sustainability-driven consumer choices, entrepreneurship, greater corporate social responsibility and promoting viable business models; (iv) exploration and promotion of pathways that provide opportunities for all stakeholders to participate in a well-being economy; (v) overcoming the inertia of existing unsustainable technologies and vested interests and (vi) economic instruments that set a price on pollution. {23.11, 24.3}

Transformative change requires adaptive policy, the creation of an enabling environment for niche innovations and the removal of barriers to change (*established, but incomplete*). Political, institutional and lifestyle changes can enable a sustainable and inclusive transition to environmental sustainability. Local-scale policy experiments provide space for policy tailoring and innovation that is closely monitored, and also allow for the inclusion of systems of local and indigenous knowledge for improved environmental management. Redress for environmental degradation through legal mechanisms such as access to courts and justice also provide an important mechanism for ensuring inclusive access to a clean and healthy environment for all. {23.11, 24.2}

Participatory approaches can help decision-makers and non-State actors to identify and pursue innovative solutions towards sustainability (*established but incomplete*). Participatory and grassroots approaches could provide a useful set of initiatives and aspirational visions, pathways and solutions from stakeholders to achieve the Sustainable Development Goals and multilateral environmental agreements. That includes inclusive innovation, in which power and decision-making is relatively decentralized and externalities are internalized. Furthermore, such approaches can highlight gaps and blind spots in distributional equity, responsibility and capacity to address global environmental problems and their solutions. Participatory approaches can help to deliver context-relevant solutions. For example, decentralized renewable energy and microgrids fit neatly into many bottom-up sustainable visions that challenge traditionally modelled large-scale, centralized energy transitions. Accounting for regional differences, gender and other demographics are important for assessing and addressing problems, including the need for disaggregated data. Sustainable Development Goal policy design and implementation requires alignment of the collective well-being of actors from the local to other levels, taking into account in particular the needs of the vulnerable and most marginalized in society. Information and communications technology can drive change, if risks such as privacy are minimized. {23.9.2, 23.14, 24.3.5}

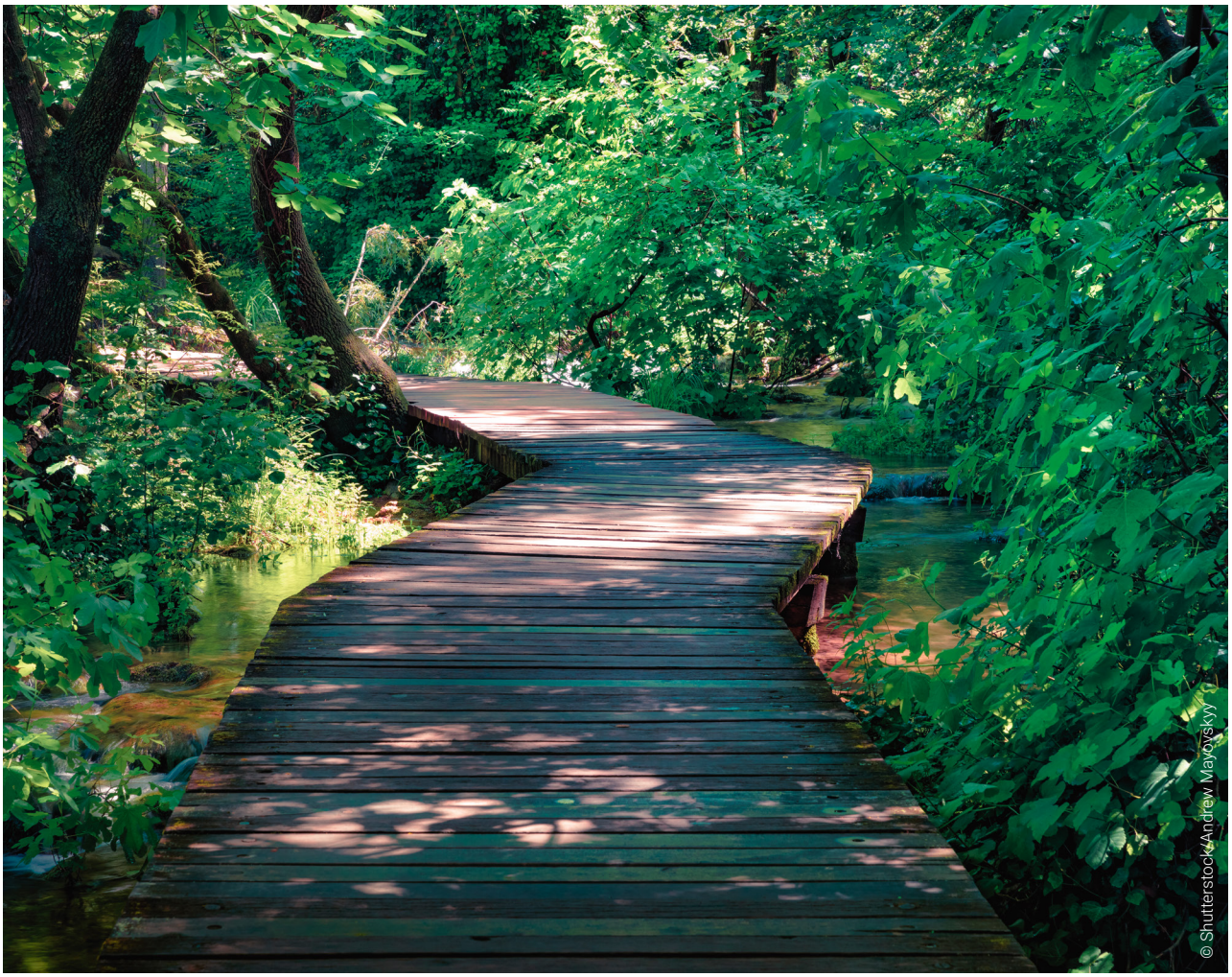
Strengthened international cooperation, including support to least developed countries, is needed to tackle this agenda (*well established*). International cooperation and support, coupled with financial commitment and international funding,

are critical if this agenda is to be achieved. Effective governance solutions to improve multilevel and multi-country cooperation and harmonization across scales include improved management of interdependencies to reduce interregional inequalities. Bilateral, plurilateral and multilateral environmental treaties are important governance mechanisms for achieving inclusive and sustainable development across knowledge systems. {11.4, 19.1, 23, 14}

4.4 The benefits that will result from following more sustainable future pathways

Investments in policies that address environmental issues promote human health and well-being, prosperity and resilient societies (*well established*). Mobilizing financial resources for sustainable development is necessary to resolve environmental problems and ensure environmental protection, especially in developing countries. Sustainable future pathways are intended to create a "healthy planet, healthy people". A healthy planet will result in people who live longer, healthier lives: nearly one quarter of all deaths globally in 2012 could be attributed to modifiable environmental risks, with a greater portion occurring in populations in a vulnerable situation and in developing countries. Achieving the Sustainable Development Goal targets on hunger, access to safe drinking water and sanitation and modern energy services could reduce deaths in children under 5 related to malnutrition, diarrhoea and lower respiratory infections by more than 400,000 per year by 2030. Furthermore, air pollution is the largest environmental health risk and is projected to continue to have significant negative effects on health, with scenario studies estimating between 4.5 million and 7 million premature deaths by mid-century under a business-as-usual scenario. Combined climate and air pollution policies could reduce those numbers significantly. {5.4.1, 21.3.3, 21.3.6, 22.3.2, 22.3.5, 23.12, 24.4}

Improved health outcomes have significant economic benefits (through a larger and healthier labour force), as well as demographic implications (*established but incomplete*). The health co-benefits of reducing greenhouse gas emissions and air pollutants can outweigh the costs of mitigation. For example, global health savings for reaching a 2 degrees Celsius target are estimated to be approximately US$54 trillion, compared with global policy costs of approximately US$22 trillion. Decreased child and maternal mortality, especially when combined with female education and access to sexual and reproductive health services, including modern contraception, is likely to lead to lower fertility rates in the longer term, curbing population growth, one of the major drivers of environmental degradation, thus highlighting the fact that healthy people can also support a healthy planet. {2.3, 22.3.5, 24.4}



5. Knowledge for action

5.1 Improved data and greater knowledge enable better and more effective actions and solutions in more places

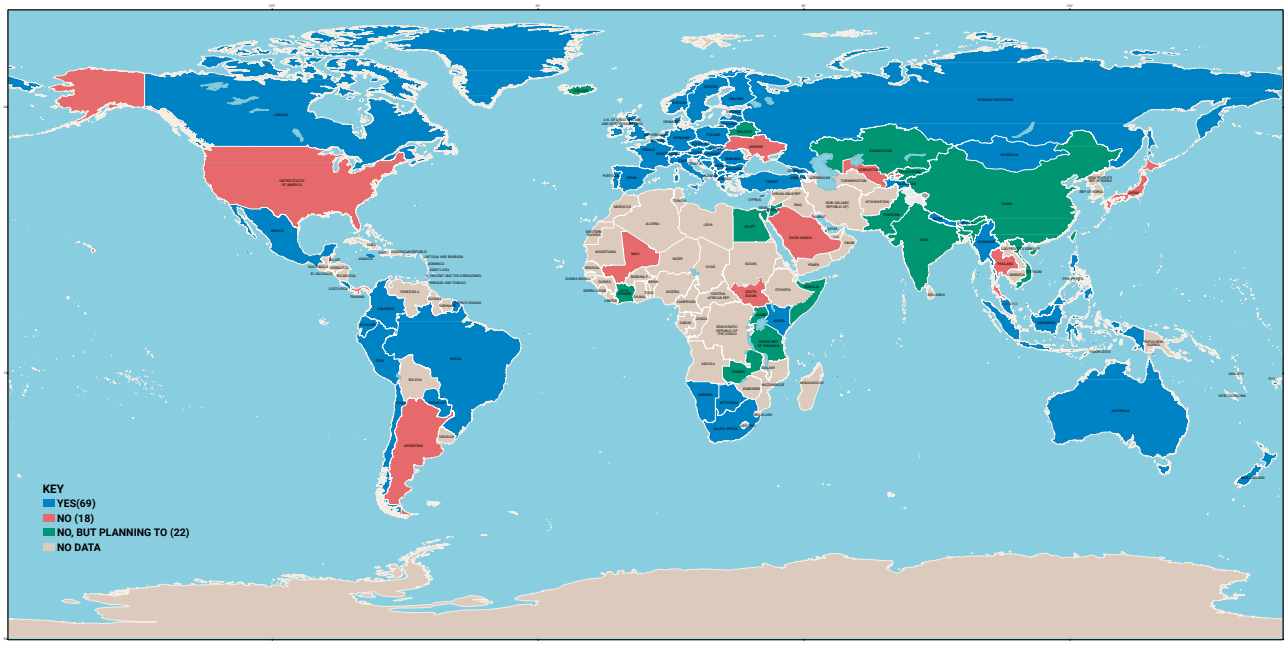
Though actions must be undertaken on the basis of the knowledge already at hand, the world needs openly accessible data, information, analysis, knowledge and science to better inform and guide what needs to be done to achieve sustainability across all environmental dimensions (*established but incomplete*). Achieving the Sustainable Development Goals, multilateral environmental agreements, internationally agreed environmental goals and science-based targets will require an integrated approach that considers linkage across different environmental and non-environmental components, building upon disaggregated data generation and incorporating traditional knowledge and citizen science. Achievement of the Sustainable Development Goals and targets needs to be followed up upon and reviewed, using the global indicators, complemented by indicators at the national and regional levels, and work is needed to develop the baselines for those targets for which national and global baseline data do not yet exist. Integrated data and analysis can prioritize needs, shape effective policies and strengthen monitoring and evaluation outcomes. {3.1, 25.1}

Advances in collecting official statistics and other evidence that feed into geographic information systems for environmental monitoring and accounting have expanded knowledge, while highlighting data gaps in every environmental domain (*well established*). Such gaps limit our capacity to formulate and implement policy solutions. More data will assist in linking people with the environment. Time series data is vitally important in that regard, as it forms the basis for monitoring change. Regular standardized data collection can be translated into statistics and indicators that highlight vulnerabilities within and between communities. Disaggregated data that captures information by gender, ethnicity, race, income, age and geographic region identify critical differences and promote effective policy design. {3.5, 3.7}

In addition to filling knowledge gaps with new data, enormous gains can be made from consolidating, curating, harmonizing and increasing open access to existing data which are widely dispersed and cannot be easily combined or compared (*well established*). Common frameworks, initiatives and political will are needed to merge data sources and make better use of what is available. In that context, the Framework for the Development of Environment Statistics, the System of Environmental-Economic Accounting and the System of National Accounts are robust consensus statistical frameworks and methodological approaches that could be broadly adopted (see figure SPM.9). Rationalizing both existing and newly collected data is essential for the development of indicators. {3.3}

Whether an indicator can be measured by Earth observation is a major factor in data availability (*well established*). A revolution in the quality and cost-effectiveness of Earth observation data means that indicators that can be measured remotely have far greater spatial coverage than those that cannot. For example, satellites can estimate deforestation and land use change with increasing accuracy, but cannot monitor all aspects of subsurface ocean environments. Data are particularly sparse for biodiversity, which is measured mostly by in situ observation and genetic analysis. Some freshwater components, such as groundwater and water use, are also data-deficient due to measurement challenges. The dichotomy in the volume of remotely sensed data versus in

Figure SPM.9. Extent of adoption of the System of Environmental-Economic Accounting



Source: United Nations (2018).

situ data will inevitably grow as Earth observation technologies improve. {3.4}

More inclusive and open access to data will assist in achieving equity, transparency and best use of data for sustainability and development (*established but incomplete*). The "open data" movement has gained significant traction in recent years, working towards data being freely available to all. Education is a key component of access and countries should be forward-thinking in building capacity to analyse and interpret environmental data. For many measures, there is a strong imbalance in data access between developed and developing countries. That contributes to global differences in the ability of nations to understand the environment, its implications for human health and the use of environmental data for socioeconomic gain. {25.2.2}

5.2 Opportunities from emerging data sources and the Earth-human systems modelling revolution

Emerging data sources, such as Earth observation and Earth-human systems models, when combined with socioeconomic data and contextual analysis, can enable better policy decisions towards achieving the Sustainable Development Goals and multilateral environmental agreements (*established but incomplete*). "Big data", generated through new approaches and technologies, is emerging as a valuable resource which can inform environmental assessment processes. Evolving artificial intelligence and technological analytics, including algorithms, programming and mechanical methods, can advance evidence-based information for decision-making, forming part of what some refer to as the "fourth industrial revolution". There is enormous potential for advancing environmental knowledge if big data can be effectively harnessed and interrogated. Stronger collaboration between the public and private sectors, especially large corporations involved in big data collection, are critical for promoting economically viable and equitable solutions. Protocols for big data use are continually being developed and refined, but the extreme pace at which big data is evolving creates the potential for misinterpretation and misuse, raising issues of ethics, privacy and protection, for which urgent policy attention is required. {25.1.2}

Future sensor technology should allow detailed data disaggregation of spatial and demographic information (*established but incomplete*). A combination of satellites and airborne and ground-based networks can help to monitor developments and impact at the local, regional and global levels in near-real time. The resulting data and information, together with rapidly emerging digital infrastructure, can enable rapid response to changing circumstances. Realizing those benefits, however, depends on appropriate governance and national circumstances for data collection, processing, curation and use, along with combining environmental data with context-relevant socioeconomic information. {25.1.2}

While Earth observation is the primary contributor to remotely-sensed big data, citizen science enables timely, cost-effective collation of in situ data from dispersed sources (*well established*). When coupled with emerging technologies, such as smart sensors, mobile devices and web applications, citizen science enables the collection and analysis of large volumes of geographically-referenced data to inform and support decision-making, educate the public about environmental issues and enhance public participation. There are, however, significant challenges in ensuring that citizen science data are of appropriate quality, representative, can be soundly analysed and that results are effectively disseminated. {25.1.1}

Traditional knowledge is a globally underutilized resource which can complement science-based knowledge (*well established*). In 2007, the United Nations Declaration on the Rights of Indigenous Peoples helped indigenous peoples to document, revive and strengthen their knowledge, but capacity-building is needed to develop practices for managing the collection of information and the integration of traditional knowledge with other knowledge systems. Collaborative work between traditional knowledge holders, academia and Governments has led to innovative processes, procedures and tools for data generation, and knowledge production and enrichment, which can help in understanding and caring for the environment. {25.1.3}

Importantly, data gaps will be an ongoing reality for the foreseeable future and should not delay urgent action (*well established*). Decision-makers at all levels cannot wait for new data before acting, but should implement evidence-based management from current knowledge, then be adaptive and responsive as new knowledge becomes available. Governments and society need to embrace the evolving data landscape, facilitate the development of new information technology skills and adopt a holistic approach in utilizing both existing and emerging data and knowledge tools. {25.2.4}

International cooperation and sharing of data and information resulting from observational networks on Earth and in space are key to success (*well established*). Continued investment in education and training of the next generation of experts and decision-makers is essential for maintaining the pace of progress on the multigenerational challenges associated with the "Healthy Planet, Healthy People" theme of GEO-6. {25.3}

5.3 The way forward

The sixth Global Environmental Outlook has set out many of the challenges and opportunities faced by the world today, moving forward from today to 2030 and beyond that to 2050. The ongoing revolution in data and knowledge of all types at the local, national and multinational levels offers an opportunity to increase our capacity to address environmental and governance challenges and accelerate progress. Most important is the need to take bold, urgent, sustainable and inclusive action that integrates environmental, economic and social activity on pathways to achieve the Sustainable Development Goals, multilateral environmental agreements, internationally agreed environmental goals and other science-based targets.

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Figure SPM.8. Projected global trends in target achievement for selected Sustainable Development Goals and internationally agreed environmental goals

Integrative diagram by the authors.

Figure SPM.9. Extent of adoption of the System of Environmental-Economic Accounting

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