

# Technical Summary





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**GLOBAL ENVIRONMENT OUTLOOK**  
**GEO-6**  
**TECHNICAL SUMMARY**

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## Co-Chairs' Message

The sixth Global Environment Outlook (GEO-6): Healthy Planet, Healthy People, was launched in March 2019 at the fourth UN Environment Assembly. This voluminous report focuses on the multiple pathways through which a healthy planet supports healthy people and conversely on the risks for human health posed by the fast deteriorating health of the planet. Among the long list of ongoing damage to life and health from air pollution, water pollution and land degradation, the report warned that zoonosis is already 60 per cent of all infectious disease and that a pandemic could occur.



Since late 2019, the spread of COVID 19 worldwide demonstrates the enormous challenges such a pandemic can cause for both the health care system and the economy, and the difficult choices facing policy makers between these priorities. Even if such choices are for the short-term, which is by no means clear, these are hard, painful and very expensive choices. We hope that, in investing in the recovery process, states and other stakeholders will consider how such painful challenges could be avoided in the future.

In this Technical Summary of GEO-6 we have distilled the science and data in that report and synthesized the information to make it more accessible to policymakers, students and scientists, and, we hope, more useful both for teaching and learning at the university level, and for policy makers considering how to address environmental problems as they seek to engender economic recovery.

In producing the Technical Summary we have sought to weave the many and disparate themes of GEO-6 – the knowledge about and interactions across the multitude of processes that take place in air, freshwater, land and soil, oceans and coasts, and biodiversity – into a coherent narrative about the cumulative damage to the global environment and the need to address the underlying drivers and pressures. The message that emerges, as in GEO-6, is the need for urgent and sustained action leading to transformational change, if nature's contributions to people are to be sustained.

We have used confidence terms throughout the text, to provide some context for decision makers, along with references back to sections in the main report (in curly brackets) for readers who wish to find more detailed information about an issue as set out in Section 1.1 in Chapter 1. In a few places we have referenced scientific publications and findings that have emerged after publication of the main GEO-6 Report, some of which arose out of the report itself.

We hope that the Technical Summary is useful for academics and their students in universities – and others – who would like to have more specific knowledge about sustainable approaches to health and environmental problems related to air, freshwater, land and soil, oceans and coasts, and biodiversity, as described in GEO-6. References to the main report are included, so that the greater detail on these findings within GEO-6 can be easily accessed, if desired.

We also hope that this publication will help generate greater awareness and understanding of the important findings of GEO-6.

  
Joyeeta Gupta

  
Paul Ekins

# GEO-6 Technical Summary Foreword

In 2019, UNEP released the sixth edition of the Global Environment Outlook at the Fourth UN Environment Assembly. The Report underscored the fact that a healthy planet is necessary for healthy people and called for the urgent transformation of economies, energy and food systems to better protect air, freshwater, land and soil, oceans and coastlines, and nature itself. The global pandemic COVID-19 has demonstrated the interconnected nature of the planet's life support systems and that we cannot return to business as usual. And the good news is that in building back better, we can ensure both a healthy environment and healthy people.

This comprehensive environmental assessment, which was awarded the 2020 Award for Environmental Science from the Association of American Publishers demonstrates that the solutions to meet internationally agreed environmental goals require a systems approach, rather than a continuation of our current approach which looks at each of these issues as separate and distinct.

As we confront the climate and nature emergency and seek to end unprecedented and rapid environmental degradation, it is evident that current policies to achieve internationally agreed environmental goals will be insufficient. More urgent and sustained action is required to address the environmental dimension of the Sustainable Development Goals.

Importantly, our analysis has identified a variety of pathways to this transformation whether it is by transitioning to meat-light or no-meat diets or electrifying the vehicle fleet. Current projections show that about 50 per cent more food will be needed to feed a population of up to 10 billion by 2050. At the same time, the environmental impact of food production needs to decrease significantly to mitigate land degradation, chemical pollution, climate impacts and biodiversity loss associated with the food sector. Our agreed health and environmental goals must be achieved not only through social and technological change, but also with a significant reduction of food wastage and losses.

I hope policymakers, academic institutions and researchers will find that this Technical Summary, as a complement to the Summary for Policymakers, published in 2019, provides useful insights for governments looking to develop rapid, far-reaching and just policies to address the environmental challenges that are so powerfully outlined in the sixth Global Environment Outlook.



A handwritten signature in black ink, which appears to read 'Inger Andersen'.

**Inger Andersen**  
**UN Under-Secretary-General and Executive Director**  
**United Nations Environment Programme**



# 1

## A Healthy Planet Supports Healthy People

**Note:** The numbers in brackets { } throughout this Technical Summary refer to the sections of the main *Global Environment Outlook (GEO-6) report (UNEP 2019a)* and its *Summary for Policy Makers (SPM) (UNEP 2019b)* where more detail on the points made here, including references to the scientific literature, may be found. Further scientific references have been limited to work published in 2018, which had not appeared by the time GEO-6 was finalised, and more recently.

The sixth Global Environment Outlook (GEO-6) assesses the state of the environment, the effectiveness of policy and other responses in addressing environmental challenges, and the possible pathways for achieving various internationally agreed environmental goals. It differs from and complements other global assessments (see Annex 1) in its scope and integrated nature. GEO-6 is more holistic in its analysis, whereas other assessments tend to focus more narrowly on, for example, biodiversity and ecosystem services (the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES]), climate change (the Intergovernmental Panel on Climate Change [IPCC]) or the marine environment (the World Ocean Assessment).

The GEO-6, entitled *Healthy Planet, Healthy People* (United Nations Environment Programme [UNEP] 2019a) and its *Summary for Policymakers* (UNEP 2019b), provides evidence-based environmental information to help policymakers and other decision makers to achieve the environmental mandates of the 2030 Agenda for Sustainable Development (Agenda 2030) and its Sustainable Development Goals (SDGs), together with other internationally agreed environmental goals, as well as to implement multilateral, regional and global environmental agreements. The theme *Healthy Planet, Healthy People* links the environmental dimension of the SDGs to their human and social dimensions. GEO-6 assesses recent scientific knowledge and data, analyses current and past environmental policies (including their objectives and consequences), and identifies options to achieve sustainable development by 2050. {Chapter 1; Summary for Policymakers [SPM]}. This explains why there have been changes in the context, focus and methods of GEO-6 compared with previous GEOs.

This Technical Summary synthesizes the key evidence and messages of GEO-6. Chapter 1 sets out the context

and methodological approach of the GEO-6 assessment. It is followed by chapters that:

- ❖ discuss the five drivers affecting the health of the planet: trends in human population, combined with economic development; growth of consumption; rapid urbanization; accelerating technological innovation; and climate change (Chapter 2);
- ❖ review the impacts of broad systemic activities (called cross-cutting issues in the GEO-6) and the health, equity and economic dimensions of these impacts (Chapter 3); collectively providing evidence that the planet is becoming increasingly unhealthy;
- ❖ review the literature and undertake case studies on policy implementation to show how policies are struggling to keep up with the rate and scale of planetary degradation (Chapter 4);
- ❖ assess the literature to demonstrate that there is a case to be made for transformative change linking the health of the planet to human health (Chapter 5) and
- ❖ examine the changing role of knowledge and data for a healthy planet (Chapter 6).

Throughout GEO-6 there is a focus on three key required systemic changes: in the food and energy systems, and in wasteful use of material resources.

**Agenda 2030 and its SDGs, adopted in 2015, call for environmental objectives to be better integrated with social and economic objectives.** The SDGs follow on from the Millennium Development Goals (MDGs), which between 2000 and 2015 focused global attention on key development objectives. However, the SDGs place



much more emphasis on the environmental dimension of sustainable development and stress the need for an integrated approach, in all countries, to the social, environmental and economic pillars of sustainable development.

The SDGs emphasize that improving environmental quality globally must be pursued along pathways that ensure that “no one is left behind” – and that activities undertaken to achieve these goals are rooted in human rights and dignity. In order to address the social, environmental and economic dimensions of the SDGs synergistically, they can be grouped according to how they address:

- ❖ social objectives or, more broadly, human well-being;
- ❖ sustainable consumption and production with respect to resource use and access; and
- ❖ protection and management of natural resources and the environment.

To address these goals, options are sought that will yield coherent and integrated progress towards a healthier planet *and* improved and more equitable human well-being. {20.3}

**Grouping the SDGs and their respective targets according to their area of focus reveals potential synergies, trade-offs and governance linkages between them.** It can also demonstrate that the desire for a healthy planet underpins all the SDGs (the environment provides the natural resource base on which human development and well-being are built), and that successful development and improved and more equitable human well-being cannot be sustained if they are obtained at the cost of environmental degradation. Moreover, failure in one direction can compromise progress in another direction. The decrease of the benefits from the environment is already having an adverse impact on people.

Where people live in poverty and hunger, the limited choices available to them increase pressure on nature and the planet. The linkage between human well-being and its environmental foundation underscores the need for policies that jointly and explicitly focus on sustainable consumption and production, as well as on equitable distribution of access to natural resources and their benefits. Such policies would take advantage of synergies and minimize trade-offs across the SDGs. {20.3}

**The GEO-6 emphasis on the theme that a healthy planet supports healthy people** is in line with the integrated approach of the SDGs. A healthy planet is necessary for human health and well-being – physical, psychological, emotional, social and economic (*well established*). Plants and animals that live in the physical environment provide us with food, energy and shelter. They clean the air we breathe and the water we drink, among many other essential ecosystem services. The natural environment directly supports the lives and livelihoods of 70 per cent of the proportion of the Earth’s population who live in poverty. {SPM 2.2.2; 6, 6.3.4, 6.6.3; Box: 6.5; Box 13.2} It also provides the basis for the production of the goods and services that underpin the global formal economy, which had a gross world product (GWP) value of US\$ 75 trillion in 2017. Because the biosphere is essential for human survival, there is no meaningful way to assign a monetary value to it. However, the global value of ecosystem services (the benefits provided by nature to human societies and economies) in 2011 has been estimated to be US\$ (2007 dollars) 125 trillion/year {1.3.1}. However, even this estimate does not fully capture, for example, the benefits of a climate suitable for agriculture; the impacts of melting glaciers on the water security of more than a billion people {4.2.2}; or the impacts of loss of land and property in coastal megacities as a result of rising sea levels. It is therefore clearly an underestimate. {Co-Chairs’ Message}

**Successive GEO reports and other assessments have shown that there is growing deterioration of the health of the planet, with associated impacts on people (*well established*).** Each GEO report has identified environmental challenges, as well as documented successes and failures in mitigating and preventing health and environmental problems. Many thematic assessments, along with the findings of regional GEOs (UNEP 2016a; UNEP 2016b; UNEP 2016c; UNEP 2016d; UNEP 2016e; UNEP 2016f), were integrated into GEO-6. Despite extensive analysis provided by previous assessments – and notwithstanding some policy successes in various areas – GEO-6 demonstrates that major environmental problems persist and, in many cases, are worsening. To find ways to support effective policy choices, including for the public health community, GEO-6 identifies drivers and cross-cutting issues that affect five socio-ecological systems: air, freshwater, land and soil, oceans and coasts, and biodiversity.

**The public health community has long-established ways of reflecting the complex web of relationships between a healthy planet and healthy people (*well***



established). GEO-6 treats health in line with the World Health Organization [WHO]’s 1948 definition as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” (GEO-6 Glossary) and considers well-being as having psychological, emotional and social dimensions. GEO-6 also focuses on the determinants of health. It recognizes that human health and well-being are mediated by multiple factors in the natural, social and built environments, including our sense of equity and safety, along with equitable access to environmental resources and human contact with nature {4.2.1} This nexus links health and well-being directly and indirectly to all of the SDGs {e.g. 20.3} and to issues addressed throughout GEO-6, including in the thematic chapters and with respect to other cross-cutting topics. {4.2.1} **Box 1.1** explains the methodology used in GEO-6.

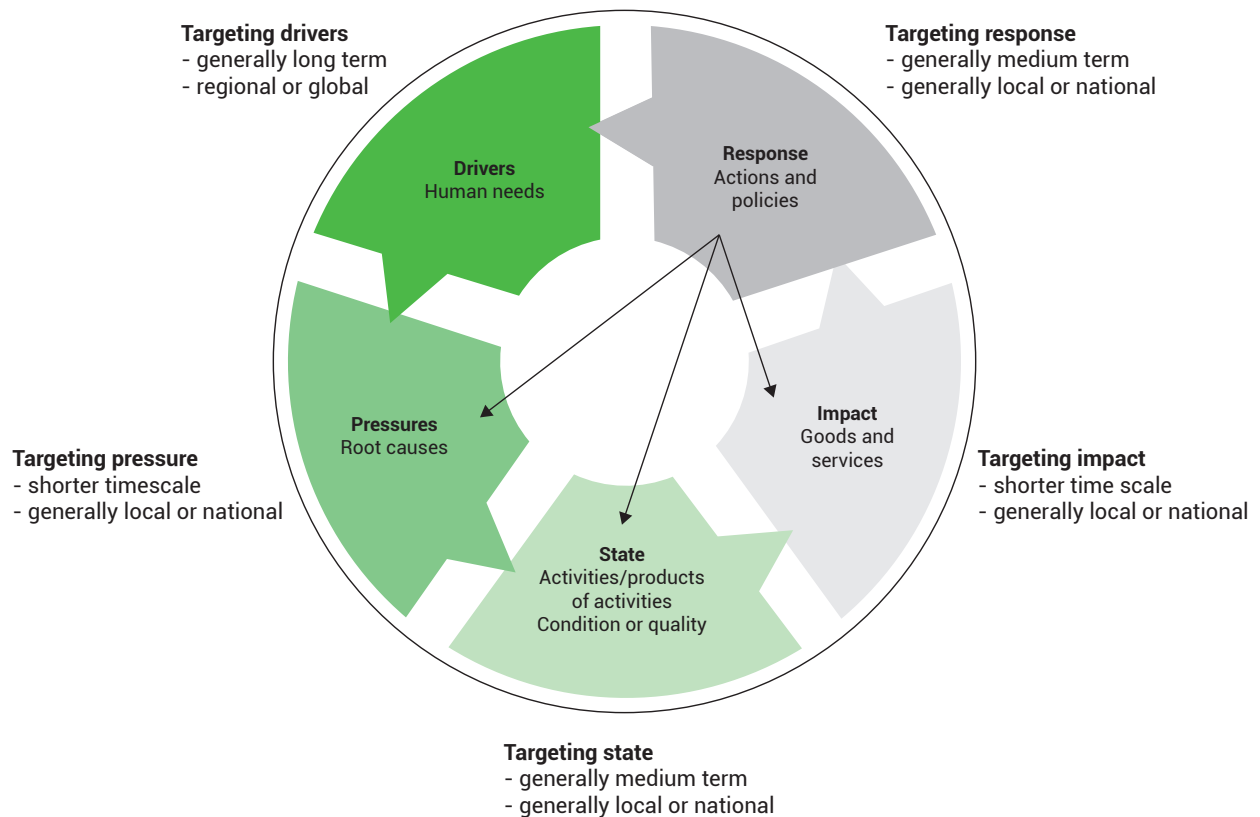
## 1.1 The Methodology of GEO-6

GEO-6 uses a modified Drivers-Pressures-State-Impact-Response (DPSIR) methodology. It combines this methodology with an expanded Response (policy) analysis approach, and an assessment of outlooks combined with bottom-up approaches.

For each of the environmental themes in Part A of GEO-6 (“State of the Global Environment”), the DPSIR approach has been modified from:

(i) a linear conception of the model, to incorporate an understanding of the interactions and feedbacks between the various aspects, as shown by its treatment of cross-cutting issues, and has moved towards a conceptual and systemic framework for integrated assessments (**Figure 1.1**);

**Figure 1.1: The DPSIR approach used in GEO-6**



In 1995, UNEP adopted the DPSIR causal framework approach for the GEO assessments. This represents a systems-analysis view in which the driving forces of social and economic development exert pressures on the environment, which change the state of the environment. The changing state of the environment leads to impacts on, for example, human well-being and ecosystem health, which then produces human responses to remedy these impacts, such as social controls, redirecting investments, and/or policies and political interventions to influence human activity. Finally, these responses influence the state of the environment, either directly or indirectly, through the driving forces or the pressures. Existing policies increasingly need to be assessed in terms of how they address the drivers and impacts of environmental challenges.

Source: UNEP (2017b).



(ii) a purely biophysical analysis of the planet, to an exploration of the links between the health of the planet and human health and well-being. This requires analyzing exposure to certain contaminants. Furthermore, analysis of environmental conditions and health and well-being can reveal underlying relationships between health and the environment. For example, data on underweight children, malnutrition and other food security indicators can inform our understanding of the relationship across climate change, food security and health and well-being; {3.6.2} and

(iii) an environment-only focus, to more explicit incorporation of equity and economic dimensions in the DPSIR framework. The more integrated policy context provided by the SDGs requires a more conscious effort to take the distribution of risks and benefits of action or inaction into account. There are questions of equity (Figure 1.2), such as: What factors result from, mitigate or exacerbate inequalities (drivers)? Who uses and pollutes resources, including sinks (pressure)? How is exposure to benefits and risks distributed (state of

Figure 1.2: Integrating equity and economic questions in the DPSIR framework



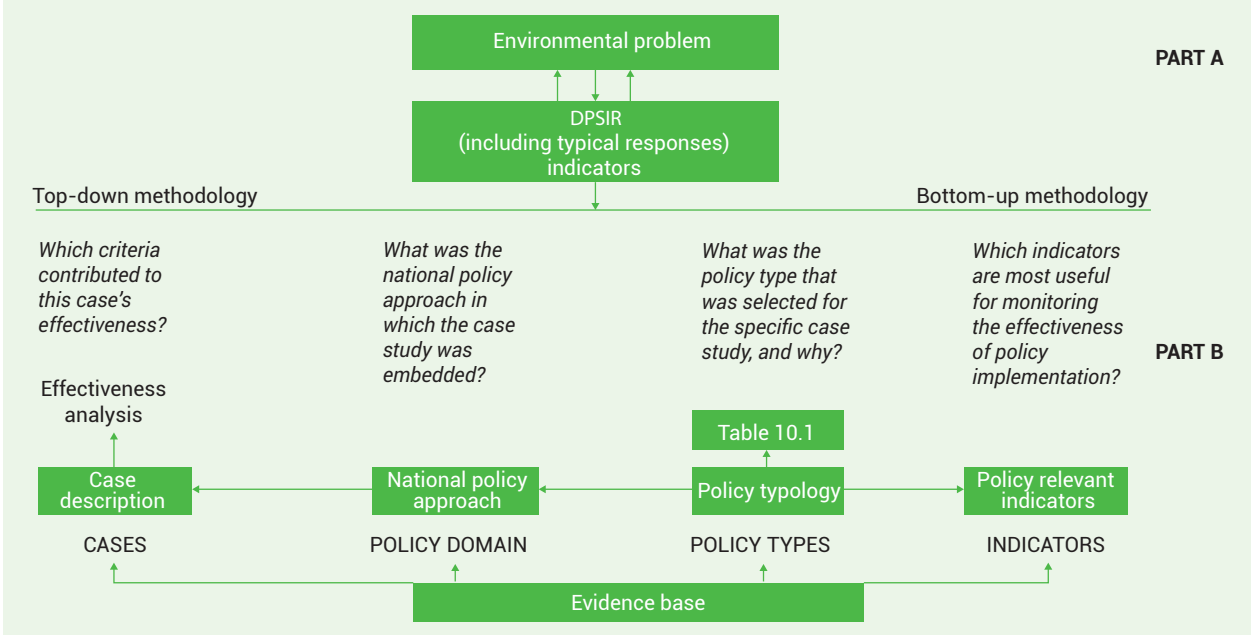
Source : Gupta et al. (2019)



Box 1.1: Approach to assessing policy effectiveness

Part B of GEO-6 (“Policies, Goals, Objectives and Environmental Governance: An Assessment of their Effectiveness”) assesses the potential effectiveness of existing policies and other responses to environmental degradation by applying to a number of case studies a top-down, literature-based evaluation with a bottom-up, indicator-based evaluation. The top-down approach identifies policies, instruments and policy mixes that may serve as examples of good practice which can be applied elsewhere; the bottom-up evaluation, based on policy-relevant indicators, complements the analysis and contributes, in particular, to the identification and quantification of action that could perhaps be scaled up (Figure 1.3). {10.5}

Figure 1.3: Methodological approach for assessing policy effectiveness: top-down and bottom-up





the environment)? How are the costs and benefits of environmental use distributed (impacts)? How is the ability to avoid, adapt to and pay for residual damage affected or taken into account (response)? (See **Table 3.3** in Chapter 3 of this Technical Summary) There are also economic questions (**Figure 1.2**), such as: How does the existing economic system contribute to, and mitigate or exacerbate, environmental change (drivers)? How does the existing economic system increase or decrease well-being (pressures)? How is exposure to economic benefit and risk distributed (state)? How large are the economic costs of the impacts, and how are these costs distributed (impacts)? How can rights, risks and responsibilities be redistributed to improve outcomes (response)?

**The emerging global architecture for sustainable development and its governance requires a new generation of tools and outlooks that take into account the complexities and interlinkages of human-environment systems in order to develop diverse adaptive policies and pragmatic solutions.** During the past several decades various methods and approaches have been developed to carry out environmental assessments and produce outlooks in support of policy decisions. The empirical literature on scenarios has evolved, while the policy context has shifted.

Model-based scenario analysis allows systematic exploration of different possible futures or the impacts

of proposed policies. However, in most cases the models provide little insight into the role of specific actors or the scope for scaling up current small-scale initiatives. In contrast, methods based on active participation by stakeholders and decision makers reflect their views, interests and expectations. GEO-6 benefits from a variety of future-looking methods, using a combination of scenarios and small-scale seeds of change approaches, and demonstrates how the engagement of stakeholders through participatory workshops and crowdsourcing platforms can benefit science-based assessments and outlooks through greater relevance of its findings and recommendations. {19.2}

In Part C of GEO-6 (“Outlooks and Pathways to a Healthy Planet with Healthy People”), in order to assess future pathways (“outlooks”) towards achieving the SDGs and related Multilateral Environmental Agreements (MEAs), the underlying goals are translated into a more concise and quantitative set of targets. Many of the 169 SDG targets have been formulated in clear, quantitative terms, but this is not always the case for some of the environment-related targets. For several issues, such as climate change and biodiversity loss, the MEA targets are more concrete. Accordingly, the quantification of SDG targets can build on related MEAs. When internationally agreed environmental targets are lacking, so-called “science-based” targets can be used that take into account biophysical limits established in





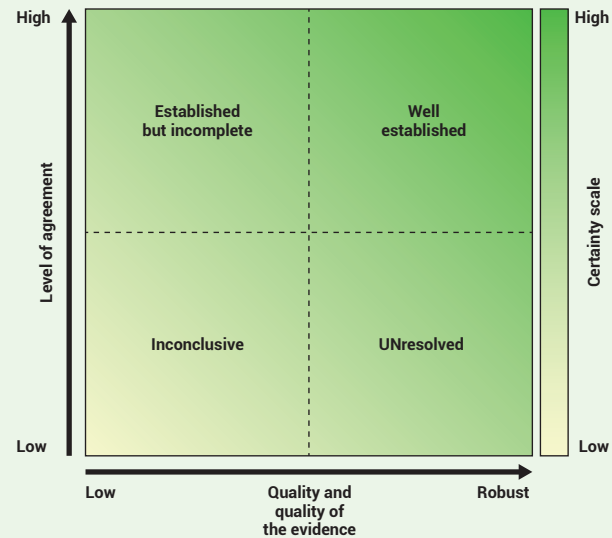


## Box 1.2: GEO-6 Theory of Change and Confidence Statements

UNEP uses a theory of change to identify, as a result of an intervention, “the causal pathways from outputs through outcomes via intermediate states towards impact” (UNEP 2017a). Strong environmental policies form an integral component of UNEP’s theory of change. The theory of change further defines the external factors that influence change along the major pathways to global sustainable development. {10.1, Annex 1-3} To facilitate the change process, UNEP is producing a number of supplementary publications: GEO for Business, GEO for Cities and GEO for Youth to mobilize change in these key domains.

GEO-6 assesses the literature using a qualitative communication of confidence levels (Figure 1.4): “well established” when there is high agreement in a substantial body of literature of high quality; “established but incomplete” when agreement is high, but there is only a low quantity of literature; “unresolved” when there is a low level of agreement across a significant literature; and “inconclusive” when both the level of agreement and the quantity or quality of the literature are low {Annex 1-4}.

**Figure 1.4 The four-box model for the qualitative communication of confidence**



Source: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] (2017).

the scientific literature. The collective set of targets can provide a common framework for policy dialogue when it is not possible to fully achieve social objectives and targets without compromising those for the resource base (or vice versa) and allow integrated pathways for progress towards both to emerge. {20.4}

The GEO-6 scenario assessment focuses on pathways for reaching particular sustainability targets (i.e. target-seeking scenarios) and through this links issues related to food, water and energy systems to the five GEO-6 environmental themes (air, freshwater, land and soil, oceans and coasts, and biodiversity) and the related multidimensional axes of poverty and health. The scenario assessment focuses on human use of natural resources, specifically the challenges addressed by and linked to the SDGs on food systems and agriculture (SDG 2), water (SDG 6) and energy systems (SDG 7). Thus, the use of natural resources is linked to the provision of adequate food, clean water and energy, of the quality and in the quantity required for healthy people (SDG 3), as well as minimizing the environmental impacts that can result from this use (SDGs 13, 14 and 15). Focusing on the use of natural resources can help define a set of environmental targets and pathways that are applicable to the SDGs and related agreements.

Given these complex contextual factors, GEO-6 addresses five policy questions:

- ❖ What is the state of the global environment, how is it changing, and what are the major factors and drivers, both positive and negative, influencing these changes?
- ❖ How are people and their livelihoods affecting and being affected by environmental change in terms of health, economic prosperity, social equity, food security and overall well-being?
- ❖ Are environmental benefits, responsibilities and risks distributed fairly across different regions, socioeconomic groups and genders?
- ❖ What are the main responses and policy measures that have been taken to strengthen environmental protection and governance at various levels? How effective have they been in terms of both protecting the environment and taking account of the social and economic dimensions of development?
- ❖ What are the critical opportunities and policies, including through the SDGs and MEAs, to transform the global human-environment system so that it becomes more sustainable and to contribute to a healthy planet for healthy people? What are possible pathways to the achievement of the SDGs? What are the likely consequences if no additional actions are taken?

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# 2

## Five Drivers Affect the Health of the Planet

**GEO-6 identifies five drivers affecting the health of the planet.** The trends in human population and demographics combined with economic development, and the growth of consumption that this can enable, have been acknowledged for many decades as the primary drivers of environmental change (*well established*). More recently, rapid urbanization, accelerating technological innovation, and climate change have been identified as additional drivers. There are wide disparities globally in the consumption and production patterns linked to those drivers. {2.1.1, 2.2; SPM, p. 6}

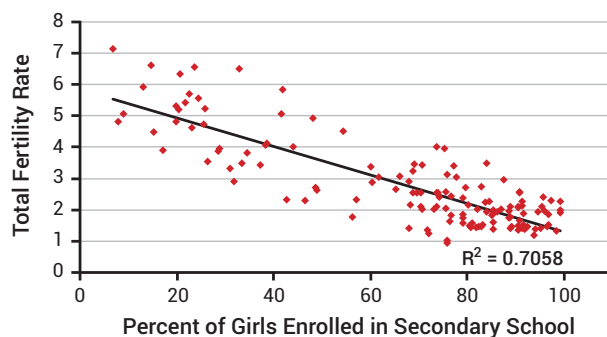
### 2.1 Population Dynamics

The global population in 2018 was 7.5 billion, with median projections estimating an increase to nearly 10 billion by 2050 and nearly 11 billion by 2100 (*well established*). Increases in life expectancy, and reductions in infant and other mortality, mean population growth rates will remain positive in all regions except Europe and certain parts of Asia. Unequal access to education (**Figure 2.1**) and lack of empowerment of women, as well as women's lack of access to sexual and reproductive health services, all contribute to high birth rates. {2.3}

Population growth is expected to be highest in countries that are very poor, have a low carbon footprint per capita, and have high gender inequity in terms of

access to education, work, and sexual and reproductive rights and health services (*well established*). {2.1, 2.3, 2.3.4, 2.1.1; SPM, p. 6} Such countries also have a low carbon footprint per capita (*well established*). {Chapter 2, ExecSum, 2.1, 2.3.1, 2.3.2; Co-Chairs' Message}

**Figure 2.1: Female secondary education and total fertility rates**



Source: Earth Policy Institute (2011).

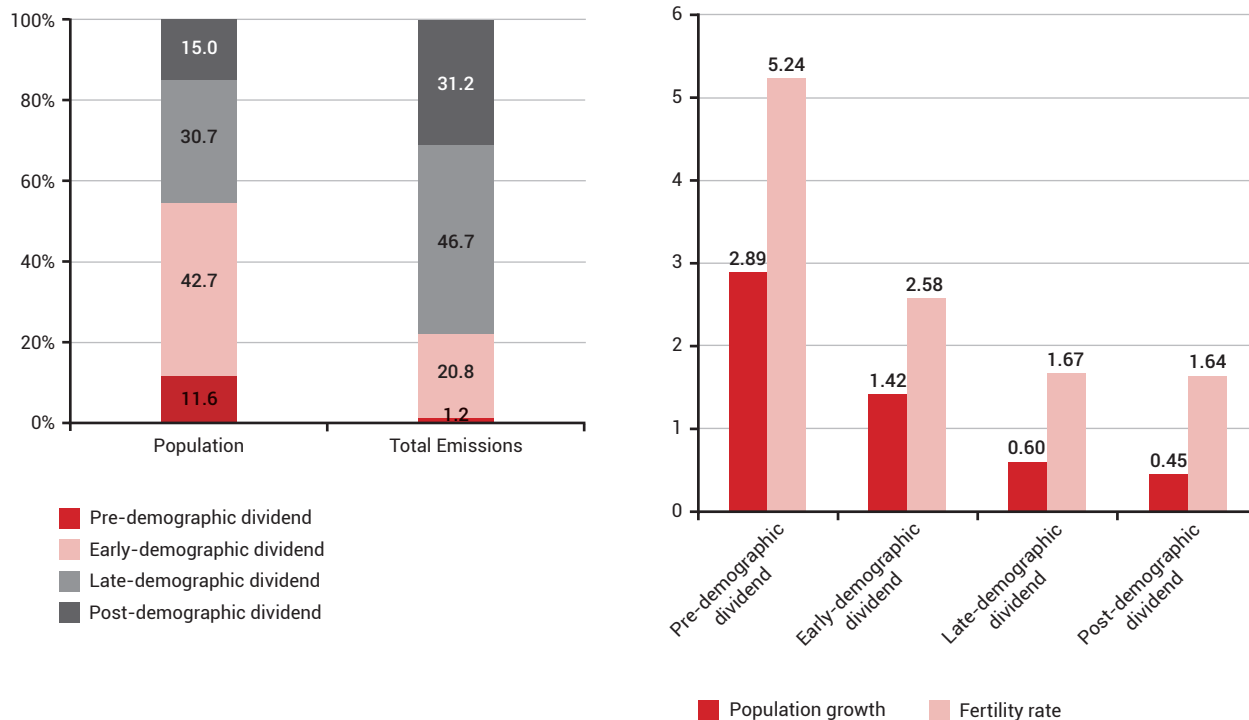




Population growth will remain important in countries experiencing an early or late demographic dividend<sup>1</sup> (most middle-income and upper middle-income countries) (Figure 2.2). These are also the countries that are projected to have the highest increases in carbon footprints per capita and in environmental footprints more broadly. {Chapter 2, ExecSum, 2.3.1}

The world population will become older on average (including in the global South), will become more urban, and will live in smaller households (well established). The trend of rapid urbanization is mainly in the global South.

Figure 2.2: World population, emissions and fertility



Source: Own elaboration based on World Development Indicators, World Bank (2017).



<sup>1</sup> The demographic dividend is the economic growth potential that can result from shifts in a population's age structure, mainly when the share of the working-age population is larger than the non-working-age share of the population.



## 2.2 Economic Development

**Economic development has lifted billions of people out of poverty and improved access to health and education in most regions of the world** (*well established*). Although income levels in developing countries lag behind those of developed countries, growth rates in the former are now outstripping growth rates in the developed world (**Figure 2.3**) and the welfare of large numbers of people is improving.

**The “grow now, clean up later” economic approach is still widely followed despite the economic, environmental, human and social costs it imposes – often on the most disadvantaged in society** (*well established*). Such an approach will not sustainably support 10 billion healthy, fulfilled and productive people in 2050. Sustainable development requires that economic development and environmental protection go hand-in-hand. {2.5.1; SPM, p. 6}

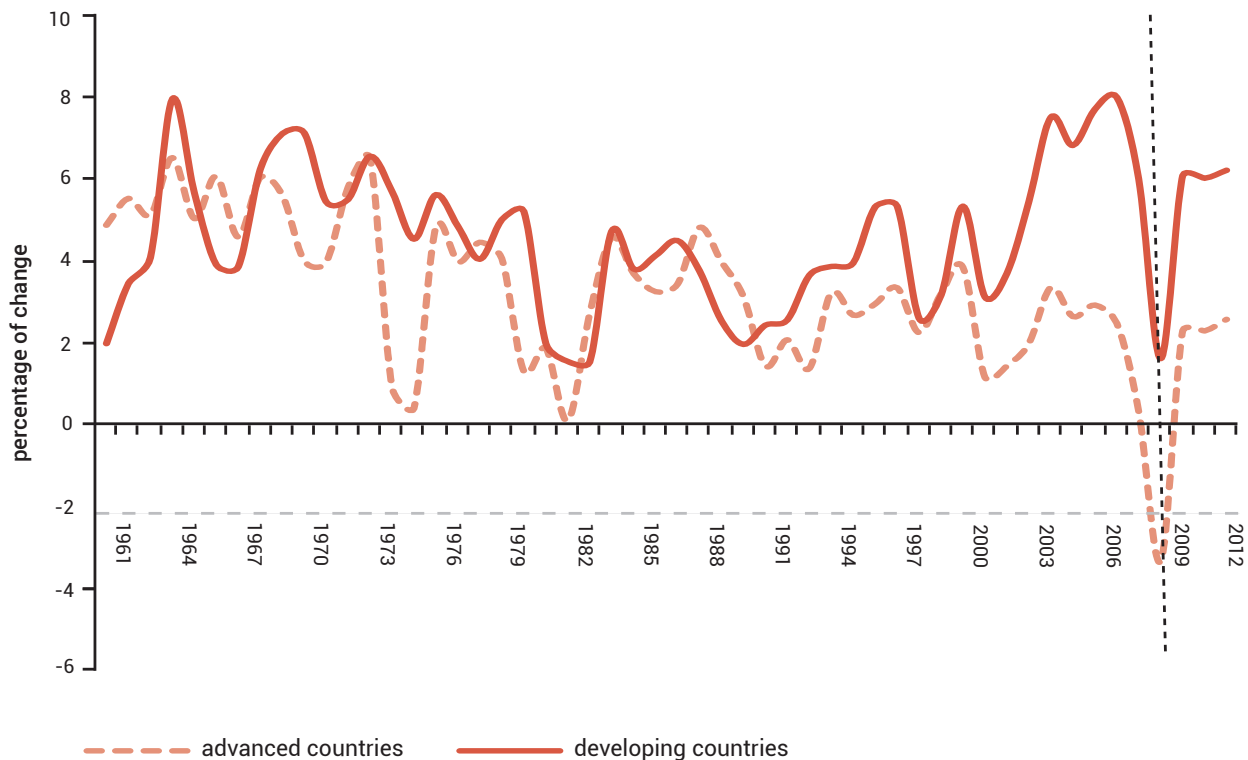
**Economic development in the past has driven increased resource use, harmful emissions and other causes of environmental damage** (*well established*). Economic growth and development continues to be the number one policy priority in most countries because of its material benefits and its contribution to employment

and social cohesion. However, the negative effects of economic growth on the environment are increasingly costly, sometimes impossible to remedy, and threaten to reverse many of the past achievements of economic development. {Chapter 2, ExecSum, 2.5.1, 2.5.4}

## 2.3 Urbanization

**Urbanization influences the nature and magnitude of environmental and development outcomes** (*well established*). People who live in urban areas generally have higher incomes and better access to political power. They also experience higher rates of economic growth. Per capita, their consumption rates are higher and they place greater pressure on natural resources. Cities use resources more efficiently per unit of income generated, and they have better potential for energy efficiency. Cities are also engines of economic growth: no country has made the transition from poverty to middle-income status without a period of rapid urbanization. Urbanization is generally associated with better access by women to reproductive health and economic capacities and choices, often resulting in lower fertility rates among urban women than those in rural areas. Managed effectively, urbanization can help achieve the SDGs efficiently and sustainably. {2.4}

**Figure 2.3: How economic growth rates in developing countries began to outstrip those in developed countries**



Source: Canuto (2010).



### Urban footprints have transboundary ramifications

(*well established*). The magnitude, scale and scope of contemporary urbanization is affecting global resource flows and planetary cycles. Current urbanization processes and prospects are not only a challenge; they also present an opportunity to improve human well-being with potentially decreasing environmental impacts per capita and per unit of production through sustainable urbanization. {Chapter 4, ExecSum, 4.2.5} Lower-impact urban lifestyles and economies can be facilitated through improved governance, infrastructure and services; sustainable land-use planning; and technological opportunities. At the same time, investment in rural areas can reduce pressure to migrate and rates of urbanization. {2.4.4, 17.3; SPM, p. 6}

### Urbanization is taking place at an unprecedented rate globally, and cities have become the foremost drivers of economic development

(*well established*). The average rate of urbanization globally between 1990 and 2015 was 2.3 per cent. If the relative change in the degree of urbanization is disaggregated by income class for this period, it can be seen that in Asia low-income countries (LICs) have been urbanizing at the fastest rates (15.5 per cent) in comparison with low to middle-income countries (LMCs) (1.2 per cent) and upper middle-income countries (UMCs) (1.5 per cent). A similar pattern is seen in Africa (where the urbanization rates

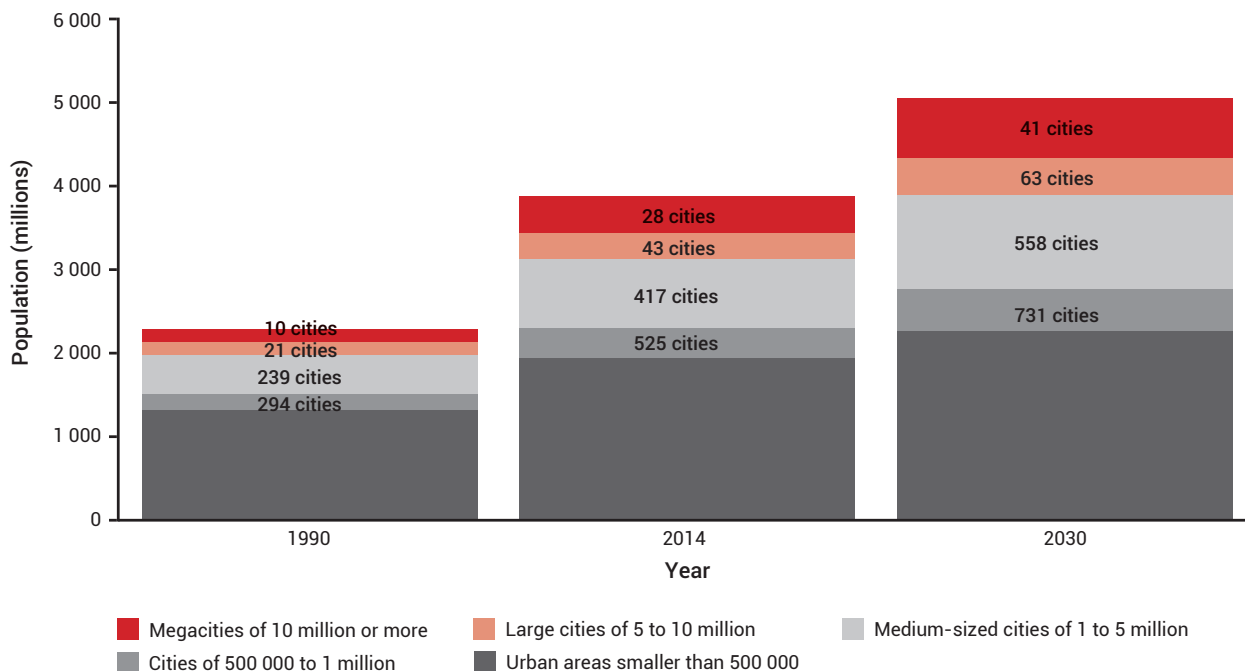
are 8 per cent for LICs, 3.6 per cent for LMCs and 5.7 per cent for UMCs) and in Latin America and the Caribbean (Melchiorri *et al.* 2018). {2.4.2}

### While megacities are economic powerhouses, the majority of the global urban population does not live in them.

More people, especially in emerging and developing economies, live in smaller cities and towns (Figure 2.4). By 2050 the share of the urban population in the total world population is expected to rise to 66 per cent (*well established*). Around 90 per cent of the growth in the urban population will take place in developing countries (United Nations Human Settlements Programme [UN-Habitat] 2014a). Africa, the most rapidly urbanizing region, is expected to experience the highest urban population growth (*well established*). European cities grew least rapidly in the period 1995-2015 (UN-Habitat 2016a). Migration is the critical factor accounting for increased urbanization rather than fertility or age structure, which are, respectively, lower and older in urban areas (UN-Habitat 2016a). {2.4, 2.4.3; SPM, p. 6}

Small and medium-sized cities account for roughly 50 per cent of the world's urban population and their populations are growing at the fastest rate (*well established*). According to UN-Habitat, these cities will "deliver nearly 40 per cent of global (urban population) growth by 2025, more than the entire developed world and emerging market megacities combined". Small

Figure 2.4: Global urban population growth propelled by cities



Source: United Nations (2014, p. 13).



and medium-sized cities are more vulnerable to natural hazards than large cities and megacities. Cities of medium to very high vulnerability are growing fastest (Figure 2.5). Many small and medium-sized cities “lack the technical capacity to lead a major urban development process” (UN-Habitat 2012, p. xiv) and

have devolved responsibilities without corresponding resources, hampering their capacities to plan and manage growth and supporting infrastructure. The result is that the ability of urban governments to protect both natural resources and the rights of their citizens is severely circumscribed. {2.4.2}

**Figure 2.5: City growth rates and urban vulnerability**



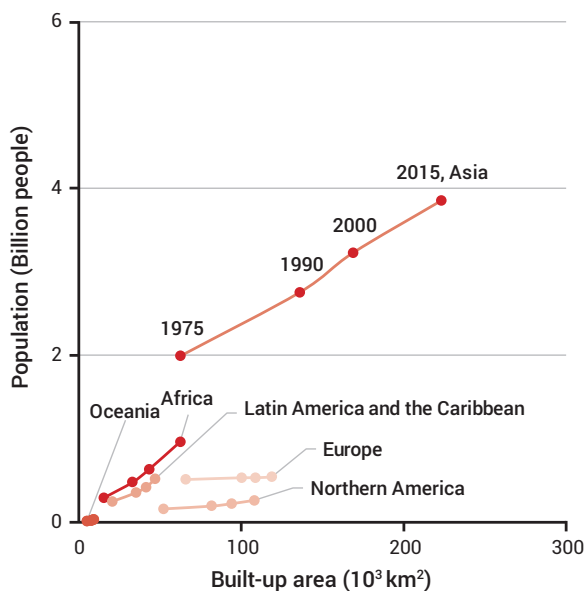
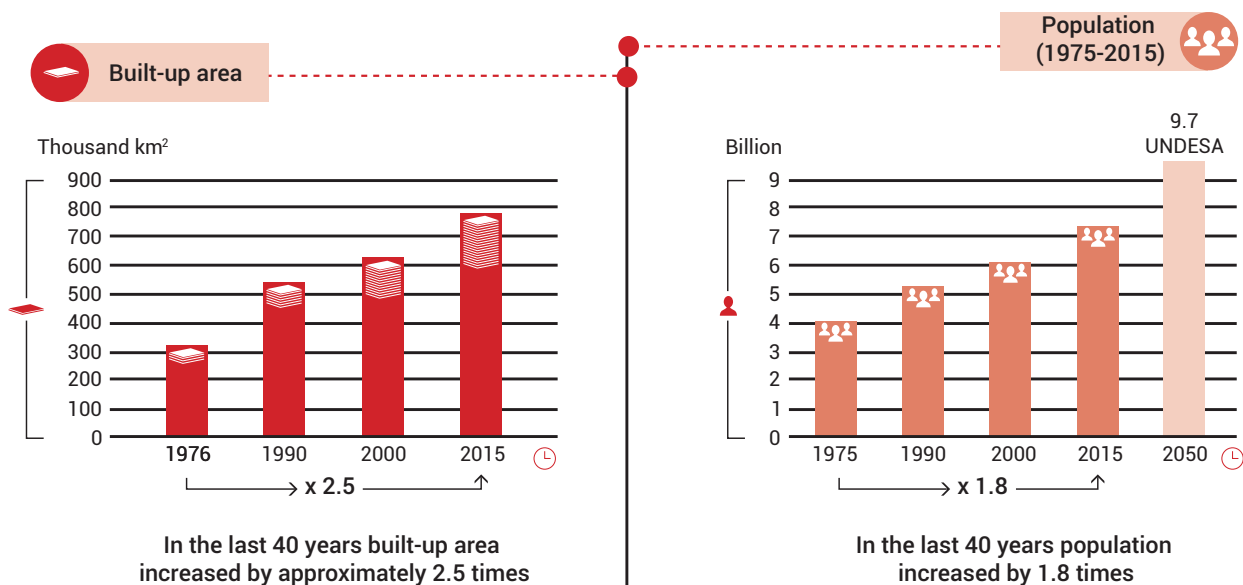
Source: Birkmann et al. (2016).







Figure 2.6: Built-up area vs. population (1975-2015)



Source: Pesarasi et al. (2016).



Globally, the built-up area has grown faster than the population. However, the extent of the built-up area varies according to region (Figure 2.6) (well established).

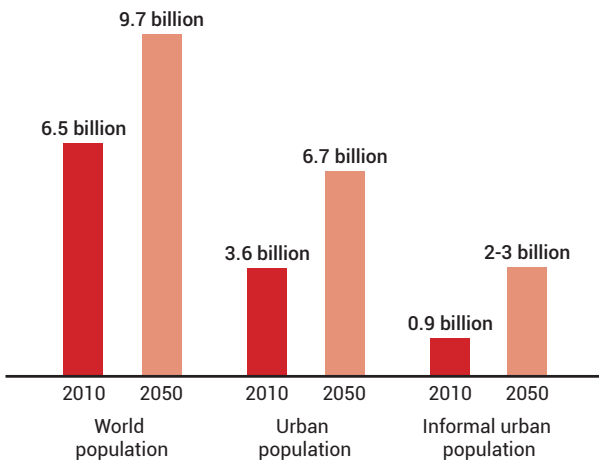
Serious social and environmental challenges of urbanization remain unmet in many urban areas, particularly (but not only) in the global South (well established). Urbanization has been accompanied by increases in informal urban populations (Figure 2.7), many of which lack access to basic services. Some 30 per cent of urban residents globally do not have access to basic services or social protection, with poor

women in low-income urban neighborhoods especially vulnerable. {2.4, 2.4.3; SPM, p. 6} These challenges will be exacerbated by climate change, as well as by rapid urban growth in cities and regions that currently lack the capacity to manage and adapt to these mounting pressures. {2.4}

Almost all coastal cities of any size, particularly those in small island developing states (SIDS), are increasingly vulnerable to rising sea levels, floods and storm surges caused by climate change and extreme weather events (established but incomplete). In general,



Figure 2.7: World urbanization trends



Source: Own elaboration based on UN-Habitat (2014b); UN-Habitat (2016a); UN-Habitat (2016b); United Nations (2018).

the cities in developing countries that are urbanizing most rapidly are the most vulnerable to these pressures. {2.4.4, 17.3; SPM, p. 6}

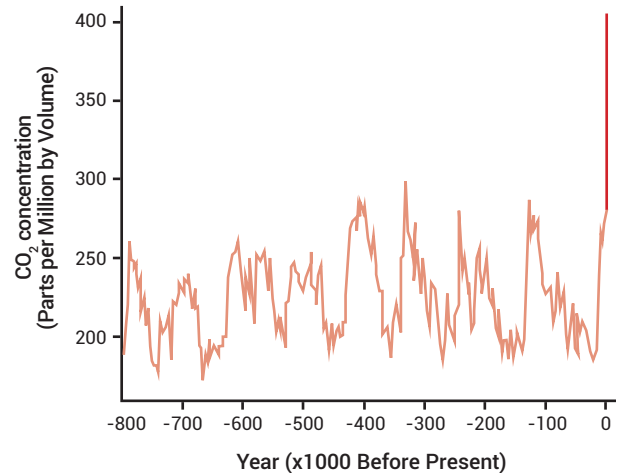
**The coming decades will be crucial.** The current period of global urbanization has not just been dramatic, but also very quick. It took 200 years for the urban share of the world's population to increase from 3 per cent (around 30 million people) to 50 per cent (3.5 billion people in 2010) (United Nations 2014). With the world's urban population expected to increase to 6.7 billion by 2050 (Figure 2.7), some models estimate that urban infrastructure could more than double by 2030 based on the 2012 urban area. {2.4, 2.4.3; SPM, p. 6}

## 2.4 Climate change

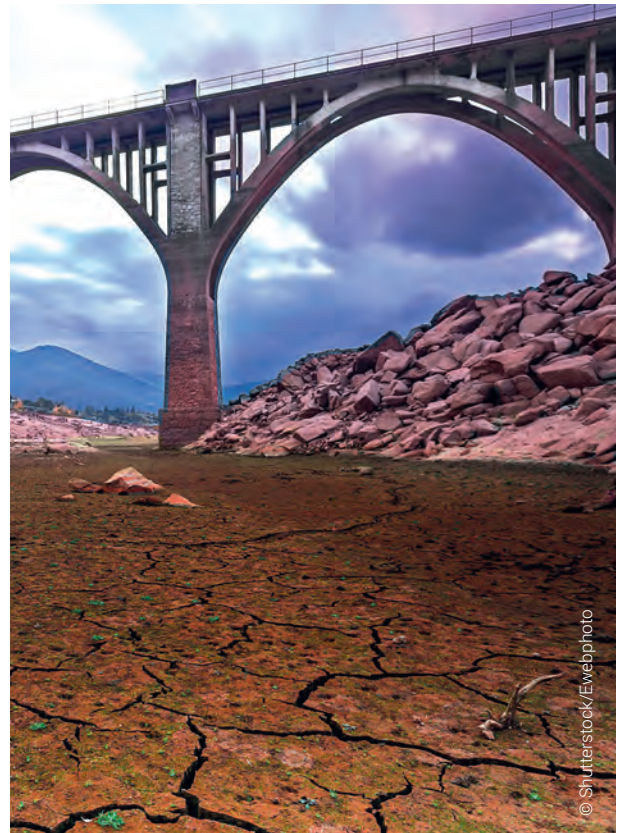
**Climate change is a priority issue, affecting human and natural systems directly and altering the complex interactions among them (well established).** Historical and ongoing greenhouse gas (GHG) emissions and rising mean atmospheric carbon dioxide (CO<sub>2</sub>) concentrations (Figure 2.8) are propelling us towards a global future with an extended period of climate change (well established). Climate change is causing warming of the air and ocean; rising sea levels; melting glaciers, permafrost and Arctic sea ice; changes in carbon, biogeochemical and global water cycles; food security crises; freshwater scarcity; and more frequent and more extreme weather events such as storms and wildfires. Higher atmospheric and marine concentrations of CO<sub>2</sub> also lead to ocean acidification and affect the composition, structure and functionality of ecosystems. The types of impacts listed above are becoming increasingly dangerous. Climate change is therefore a global driver of environmental, social, health

and economic impacts and heightened society-wide risks. Unless GHG 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 (UNFCCC). {2.7.3; SPM, p. 6}

Figure 2.8: Mean atmospheric CO<sub>2</sub> concentrations



Source: Based on (light red) NOAA data from <https://www.ncdc.noaa.gov/data-access/paleoclimatology-data> and (in red) data provided by Pieter Tans, NOAA/ESRL ([www.esrl.noaa.gov/gmd/ccgg/trends/](http://www.esrl.noaa.gov/gmd/ccgg/trends/) and [scrippsco2.ucsd.edu/](http://scrippsco2.ucsd.edu/))

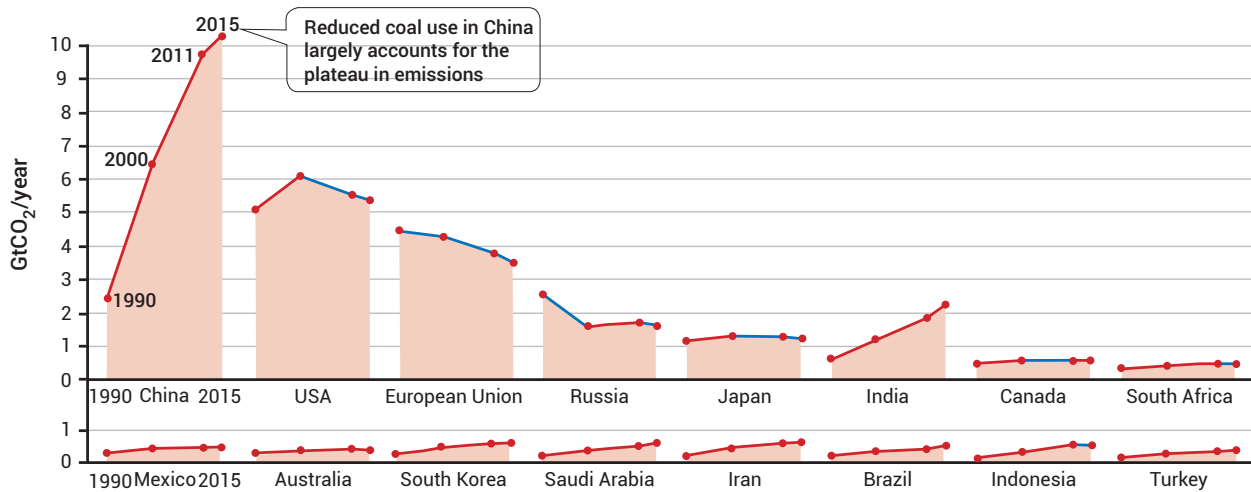




**Countries vary widely in their production of GHG emissions** (*well established*). Figure 2.9 shows emission trends for selected countries in the period 1990-2015. The richest 10 per cent of the world population emits 45 per cent of total GHG emissions, while the poorest 50 per cent emits only 13 per cent (Figure 2.9). Patterns of wealth and lifestyles associated with GHG emissions also reflect other social inequalities, including those related to gender and race/ethnicity.

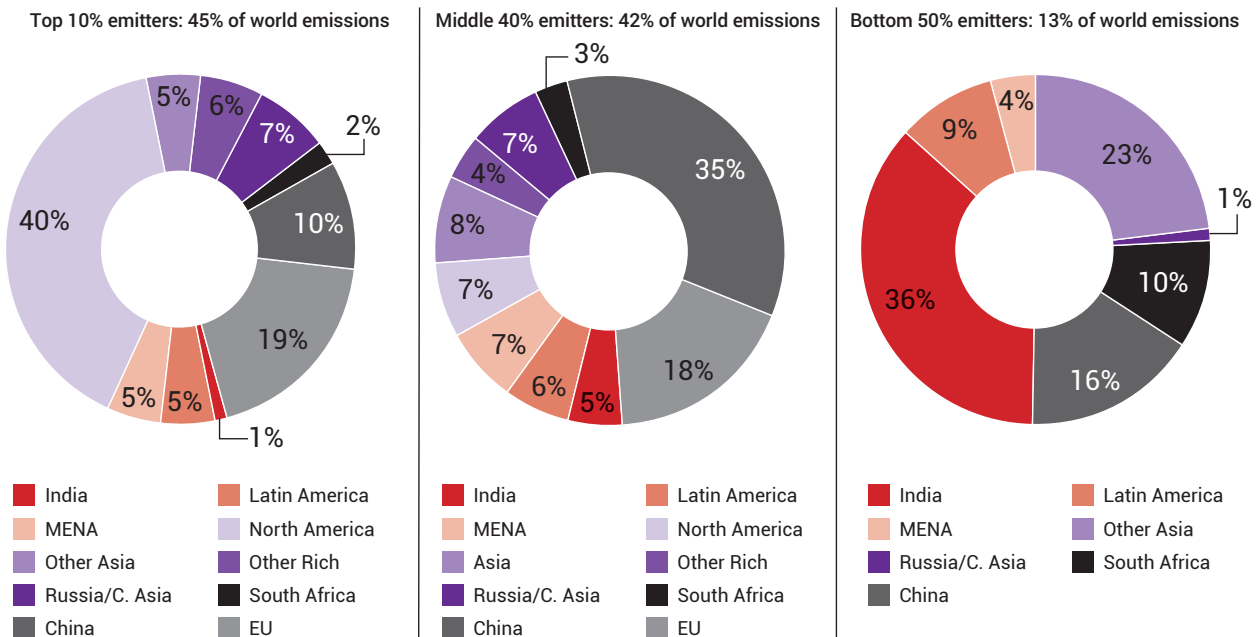
**Climate change presents a serious challenge to future economic development** (*well established*). As the climate impacts already under way continue to increase, countries will incur heavy social and economic costs (Figure 2.11 and Figure 2.12), {Chapter 2, ExecSum, 2.7.1, 2.7.2}

**Figure 2.9: Emission trends in different countries from 1990 to 2015: red lines show growth and blue lines show reductions**



Source: Le Quéré et al. (2016).

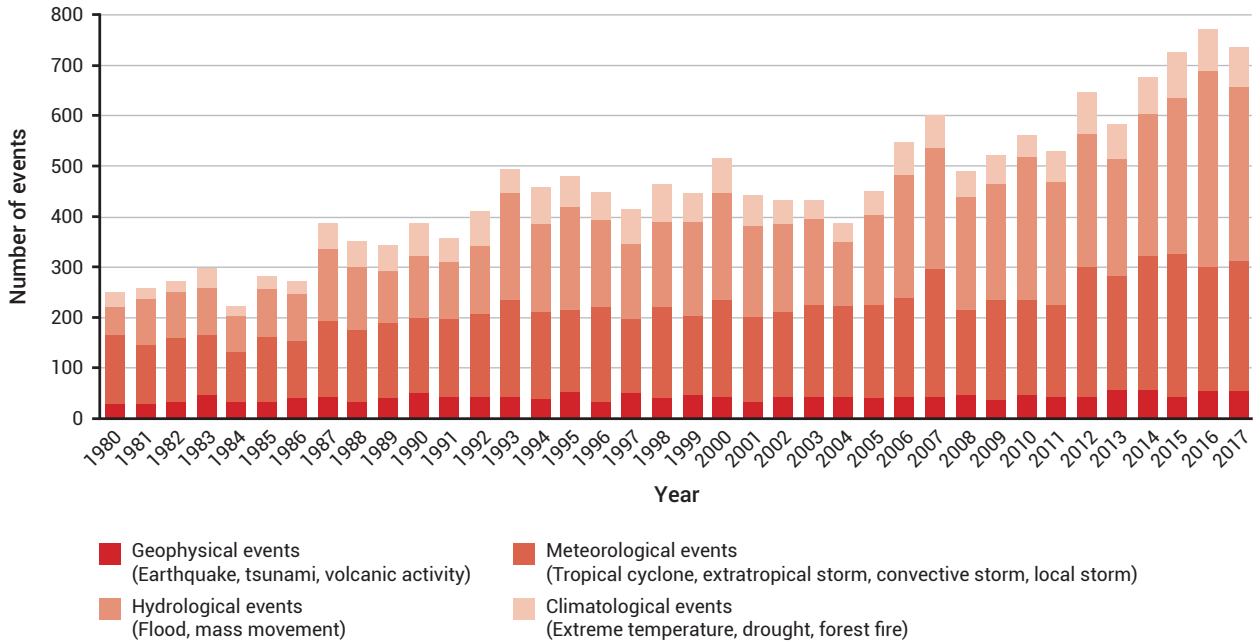
**Figure 2.10: Consumption and associated environmental pressures are unequally distributed across nations**



Source: Chancel and Piketty (2015).

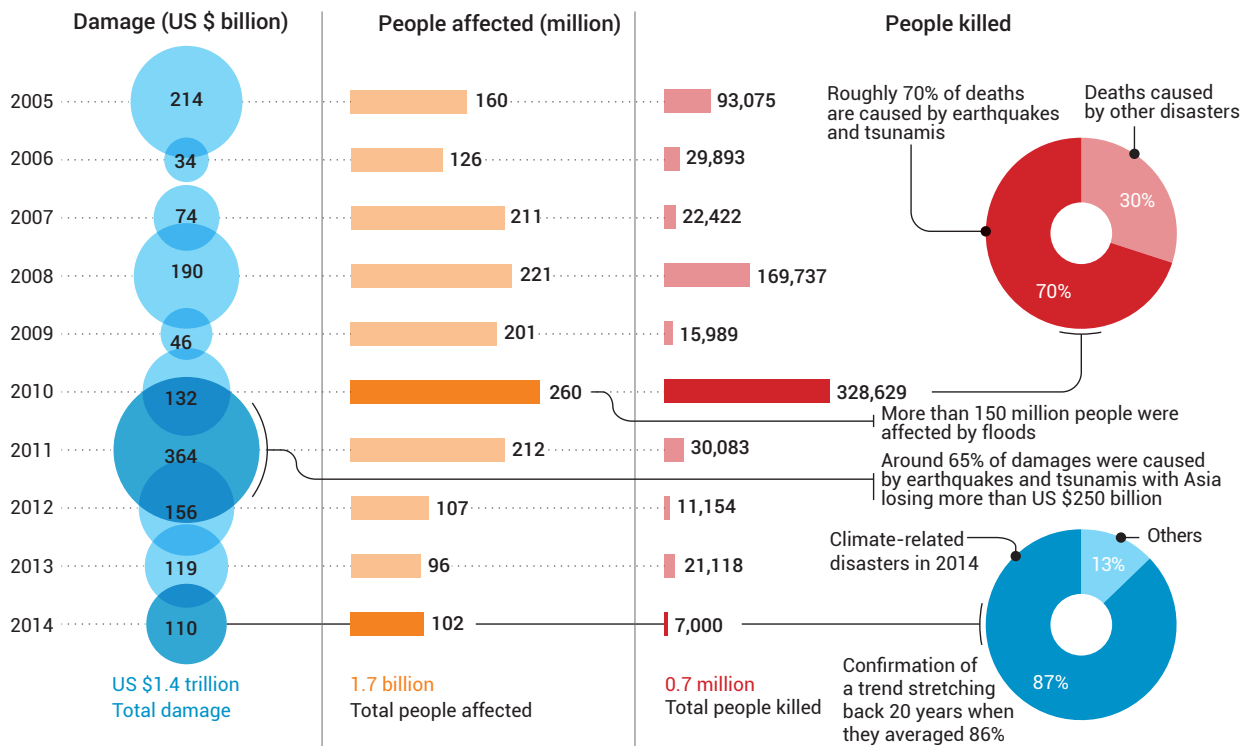


Figure 2.11: Trends in numbers of loss-relevant natural events



Source: Munich Re (2017).

Figure 2.12: The economic and human impact of disasters from 2005-2014



Source: United Nations Office for Disaster Risk Reduction [UNISDR] (2014).



**Climate change affects the environmental fate, behaviour and toxicity of chemicals and heavy metals** by modifying the physical, chemical and biological conditions that determine how they move through and behave in the environment (atmosphere, water, soil/sediment and biota). These changes have the potential to produce adverse impacts on human health and other life on Earth. {4.3.1}

**Peatlands store twice as much carbon as all global forest biomass combined. Climate change is thawing permafrost in boreal peatlands in and around the Arctic Circle, producing high carbon emissions. In addition, drainage and agricultural use of tropical peatlands is causing wildfires and releasing significant quantities of CO<sub>2</sub> and methane** (*established but incomplete*). Altogether, about 15 per cent of peatlands worldwide had been drained by 2015. Peatlands currently contribute approximately 5 per cent of annual global carbon emissions. {9.6}

**Climate change will amplify existing risks and create new ones for natural and human systems; these risks are unevenly distributed** (*well established*). Risks are generally greater for developing countries (particularly SIDS) and for disadvantaged people and communities in countries at all levels of development. Climate-related hazards interact with and amplify existing factors that contribute to differential vulnerability and to the exposure of human and natural systems: both the resilience of these systems and their ability to adapt are negatively affected. {Chapter 2, ExecSum, 2.7.4}

**Society-wide risks associated with environmental degradation and the effects of climate change are generally more profound for people who are already socially and economically disadvantaged, particularly in developing countries** (*established but incomplete*). {SPM, p. 6} These risks are greatest for people who are directly dependent on natural resource sectors (e.g. agricultural, pastoral and forest communities). Those experiencing multiple forms of inequality, marginalization and poverty, including poor women, sexual minorities and disadvantaged racial/ethnic minorities, are most exposed to these risks and are least able to recover from economic and environmental losses. {Chapter 2, ExecSum, 2.7.3}

**Climate change poses risks to human societies through impacts on food and water security** (*established but incomplete*), as well as impacts on human security, health, livelihoods and infrastructure. Rising temperatures will generally diminish crop yields, particularly in low-latitude developing countries, although some temperate regions may benefit from

warmer temperatures and longer growing seasons in the medium term. Water scarcity may limit the extent to which the expansion of irrigation could counter climate threats to crop yields and force reversion to rain-fed agriculture in a number of important crop-producing regions by the end of this century, with further consequences for crop production. Overexploitation is already compromising groundwater in several large aquifers critical to agriculture. {4.4.3}

**The increasing scale, global reach and speed of change of the drivers of environmental change present urgent challenges with respect to managing environmental problems, including those specifically related to climate change** (*well established*). Many of the impacts of environmental change are serious or irreversible and may lead to loss of livelihoods, increased morbidity and mortality, and economic slowdown; in many instances climate change is already driving loss of social resilience, human mass migration and violent conflict. Scientific understanding of adverse, increasingly high-impact change continues to grow. Although existing knowledge is still incomplete, it can contribute to the development of the measures urgently required for more effective adaptation, especially in the case of populations and regions in vulnerable situations. {2.7.3; SPM, p. 7}

## 2.5 Technology

**Growth in technological innovation since the 1990s has been unprecedented both globally and historically, providing many benefits but with negative impacts on some people's lives** (*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. {SPM p.6}

**Technological advances have had both positive and negative effects** (*well established*). Fossil fuel burning has accelerated economic development and lifted the standard of living of billions of people in both industrialized and developing countries. However, it is also a major driver of climate change. There are now current and emerging technologies that provide emission-free energy, creating more efficient and less



resource-intensive processes and helping to clean up the environment. {Chapter 2, ExecSum, 2.6.1, 2.6.2}

**Technological advances have unintended consequences, making it difficult to determine whether they will have long-term positive and/or negative impacts** (*established but incomplete*). Scientific analysis of technology issues often fails to capture the full implications of new technologies, especially when these technologies are widely diffused. {Chapter 2, ExecSum, 2.6.3, 2.6.4} For example, geo-engineering proposals designed to remove GHG emissions from the atmosphere require increased energy use. {23.3.2} Nanotechnology, by decreasing the particle size of a material and increasing its reactivity, may change the material's properties in ways that are not yet

understood. A number of questions remain concerning the toxicity of nanoparticles to humans and the environment (United Nations Environment Programme [UNEP] 2019a, pp. 313-315). {4.3.3}

## 2.6 Interactions across the five drivers

**The driving forces of environmental degradation are strongly intertwined, complex, and spread widely and unevenly across the world (Table 2.1)** (*well established*). Responses by established governance structures at all levels – urban and rural, local, national, regional, global and supranational – have so far been inadequate to constrain or redirect these forces to better align them with the principles of sustainable development. {2.1.1; SPM, p. 6}

**Table 2.1: Interrelationships across the drivers**

	Population growth	Economic growth	Technological change	Climate change	Urbanization
Population growth	–	Negative impact due to delay in the demographic window of opportunity	Population growth fosters technological innovation, to accommodate the additional demands. Alternatively, it could lead to lower savings and investment due to high dependency rates	Population growth increases environmental pressure, and climate change	Increased pressure on urban areas, more people might move to urban areas
Economic growth	Higher GDP and development in general is associated with lower fertility rates	–	Economic growth is associated with increased investment and technological innovation	Increased economic output is associated with increased environmental pressure	Growth will push towards increased urbanization
Technological change	Technological innovation is associated with increased capacity to lower fertility rates	Innovation is associated with increased growth in GDP	–	Current trends show an increase in green technological innovation, thus lowering pressure per unit of output	Technological change can contribute to processes of urbanization or it can help to decrease the migration patterns through better access to technologies and communication
Climate change	Climate change increases mortality rates and negatively affects health	There are costs associated with climate change that limit economic growth	Climate change pressures foster adaptive technological innovation	–	Effects of climate change on rural communities puts pressure on migration towards urban areas
Urbanization	Urbanization is associated with lower fertility rates (due to access to better health care and education)	Urbanization is strongly associated with higher economic output	Urbanization will lead to intensification of technology use due to greater population density	There is no clear causal link, but there is an association between urbanization and higher emissions	–

Source: UNEP (2019b, p. 49).



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# 3

## An Increasingly Unhealthy Planet Affects Everyone's Health

### 3.1 Cross-cutting issues

**GEO-6 identifies three key socioeconomic systems with far-reaching environmental impacts: the food, energy and waste systems** (*well established*). These systems are closely interlinked. The processes of producing, distributing and using both food and energy, and materials in general, generates significant waste. These processes and the waste they generate pollute the environment. They also impact biodiversity and ecosystems. Transformative change in these systems will require policy coherence and synergies implicitly addressing issues related to air and freshwater quality, land and soil degradation, oceans and coast integrity, and biodiversity loss. {Chapter 17, ExecSum, 17.3.2, 17.4.3, 17.5.1}

#### 3.1.1 Food

**The current food system is inadequately providing nourishment to millions of people in the world, while it is responsible for major diet-related diseases in millions of others** (*well established*). Over 800 million people are undernourished and more than 2 billion suffer from micronutrient deficiencies. Patterns of inequity in access to food correspond to other social inequities, including those based on gender, age, class and the marginalization of racial and ethnic groups. At the same time, 39 per cent of the global adult population (1.9 billion people) is overweight and 13 per cent (650 million people) is obese (World Health Organization [WHO] 2018a). Diet-related diseases such as type 2 diabetes, colorectal cancer and cardiovascular disease are globally pervasive and, especially in rich countries, associated with overconsumption of saturated fats and processed foods. These diseases are becoming increasingly prevalent in LMICs as animal protein, and products high in fats and sugars, become more widely available and affordable. {4.4.3}

**Demand for food from land and the sea is growing, with impacts on the planet and human health.** Feeding a growing population of 9-10 billion by 2050, in the context of climate change and without making environmental degradation and social problems worse, is a key

challenge (*well established*). Current land and ocean management and food production practices cannot achieve this goal and also prevent the loss of natural capital, preserve ecosystem services, combat climate change, address energy and water security, and promote gender and social equality (*established but incomplete*). (SDG 12) The proportion of the global population living in low-income food-deficit countries (LIFDCs) rose from 72 per cent in 1965 to 80 per cent in 2005. Population growth, urbanization and shifting dietary preferences have increased dependency on food imports. {4.4.3, 8.5.1}

**The global food system has an immense environmental footprint and is highly energy-inefficient** (*well established*). Food production systems are also a leading cause of fish stock depletion, as well as of land and soil degradation and deforestation, particularly in agricultural systems where there is heavy or poorly managed use of chemical pesticides and fertilizers. They also account for 19-29 per cent of GHG emissions. Farming is the most expansive human activity in the world, consuming 38 per cent of global land area. Agriculture is also responsible for 70 per cent of freshwater withdrawals. Food production is the main driver of biodiversity loss and a major polluter of air, freshwater and seawater. Yet the global food system is estimated to convert only 38 per cent of harvested energy and 28 per cent of harvested protein into the energy and protein required for food consumption, after accounting for losses from food waste, trophic losses from livestock, and human overconsumption. {4.4.3}

**Within the global food system's environmental footprint, the impacts of raising livestock are disproportionately large** (*well established*). While the livestock sector supplies only 18 per cent of calories and 32 per cent of protein to the world food supply, it accounts for about half of GHG emissions from agriculture and almost 80 per cent of agricultural land use: one-third of all cropland is used to produce feed crops (**Figure 3.1**). Owing to the livestock sector, food production is the principal cause of habitat destruction and the main disrupter of the nitrogen and phosphorus cycles





that produce most of agriculture's pollution. Similarly, intensive aquaculture and overexploitation of wild fish stocks have detrimental effects on marine and terrestrial ecosystems. Like other resource extraction activities, the environmental burden of food production is localized and often spatially dislocated from the consumption that drives demand. Around 20 per cent of cropland and of agricultural water use is devoted to the production of agricultural commodities consumed in other countries. {4.4.3}

**Achieving the SDGs calls for urgent action to reduce the agrifood system's environmental footprint of the marine and terrestrial food systems and increase its overall efficiency and resilience.** {17.4.1}

Addressing the environmental impacts of the food system will require: (i) incorporating the cost of negative environmental externalities into market prices through the polluter pays principle; (ii) incentivizing farmers and fishers to minimize negative externalities or create positive externalities through payments for ecosystem services; and (iii) creating consumer pressure for more sustainable global supply chains. {17.4.2}

**Changing consumption patterns are increasing environmental pressures and presenting new food security challenges.** This results in malnourishment (over-nourishment as well as undernourishment). Climate change, natural resource constraints and demographic trends suggest that producing and distributing nourishing and sustainable food for all will continue to be increasingly challenging and will necessitate significant changes in food production and consumption. {4.4.3}

**Without changes in global dietary trends, the growth in food system emissions may mean that the Paris Agreement goal of limiting the increase of global average temperature to well below 2°C is unlikely to be reached** (*established but incomplete*). Environmental policies in this area are currently oriented mainly towards addressing the sustainability of food production, with less attention paid to consumption and waste. However, there are signs of sustainability criteria being incorporated into dietary guidelines to convince consumers to adjust their consumption patterns in order to optimize nutritional outcomes while reducing the environmental burden of doing so. {17.4.3, 17.4.4}

### 3.1.2 Energy

**The global energy system makes inefficient use of heavily polluting fuels, yet billions of people still do not have access to modern energy sources or rely heavily on traditional fuels** (*well established*). Nearly 1.2 billion people remain without access to electricity and around

3 billion use traditional fuels for cooking and heat, which means they are exposed to indoor air pollution. Global energy consumption in 2017 reached over 14 billion tonnes of oil equivalent, of which 81.3 per cent was provided by fossil fuels (coal, oil and natural gas). {International Energy Agency [IEA] 2020, 4.4.2}

**The environmental footprint of the energy system is enormous** (*well established*). At the global scale, energy-related GHG emissions in 2017 amounted to 32.8 billion tonnes of CO<sub>2</sub> equivalent due mostly to burning of fossil fuels. {IEA 2020, 4.4.2, 17.5.5} Energy demand also leads to competition for water and land, local air pollution, destruction of ecosystems, and disputes and conflicts (see also Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES] 2019). {4.4.2}

**Demand for energy is increasing.** In 2018 energy consumption increased at nearly twice the average rate of growth since 2010; it is expected to increase another 28 per cent by 2040 (IEA 2019). Different scenarios in the BP Statistical Review of Energy show primary energy consumption in 2040 reaching 16-22 billion tonnes of oil equivalent (toe) (BP 2019). To avoid catastrophic climate change, a major shift is needed towards affordable and sustainable energy resources. {2.5.4}

**Fossil fuels continue to dominate global energy systems** (*well established*). Long-term planetary sustainability requires policy and technological interventions across energy systems to bring about changes in the choice of fuels, as well as in the way they are produced and consumed at every stage of the energy system (*established but incomplete*). {17.5.1, 17.5.2, 17.5.5}

**Potential competition between biofuels and food highlights the need to understand the nexus between food, water, energy and land use** (*well established*). Biofuels can make a limited sustainable contribution to a low-carbon energy supply, but the impact of their production on food supply, environmental health, and land use requires careful management through integrated policies. {4.4.2}

**Meeting energy demand while reducing emissions will require supply side management, including phasing out of fossil fuels and shifting to renewable energy and demand side management (which would lead to an increase in resource and energy efficiency).** Much of the increased demand is expected to come from consumption in countries that currently depend on fossil energy sources (*well established*). This makes accelerated efficiency a crucial strategy to mitigate



energy-related impacts. {4.4.2} Equity and gender issues, including universal access to improved energy services, are still far from resolved. Despite the rapid deployment and cost reduction of renewables and improvements in efficiency to date, energy-related GHG emissions will result in the Paris Agreement's goal of holding the increase of global average temperature to well below 2°C being missed without further effective, ambitious measures (*well established*). {4.4.2}

### 3.1.3 Resources, chemicals, waste and the circular economy

**The use of natural resources has grown rapidly** during the last two decades and global resource supply chains have become more complex, resulting in increasing environmental pressures and impacts (*well established*). Global resource use reached 92 billion tonnes in 2017 (International Resource Panel [IRP] 2019) while high-income countries consume 10 times the amount of resources per person as low-income countries. Resource efficiency has not been increasing in many countries, while the environmental impacts of resource use have been growing at a rate in line with overall resource use. {Exec Sum Ch. 4}

**Finding and exploiting new sources of primary resources has a growing global reach** (*well established*). As with energy, the scale of resource extraction and use has grown dramatically in recent years, especially in the case of metals (e.g. iron and copper) and minerals (e.g. sand and limestone for cement). Over time, this has led to a decline in good-quality resources leading to large amounts of lower grade ore being extracted and processed to meet global demand. {4.4.1} Material extraction and processing is responsible for 50 per cent of global CO<sub>2</sub> emissions and 90 per cent of biodiversity loss and water stress (mainly from agriculture) (IRP 2019).

**The environmental footprint of resource use is substantial** (*well established*). For example, to meet global demand in 2014 the global metals and mining industry produced around 90 billion tonnes of mine waste excluding construction materials. Much mine waste is currently stored at mine sites, where it is exposed to changing environmental and management conditions. While some mined resources (including sand, gold, copper and lead-zinc) are widely distributed around the world, others such as nickel, rare earth elements and phosphorus are concentrated in a small number of countries. {4.4.1}.

**The disposal and discharge of waste is damaging human and ecosystem health** (*well established*). Issues of global concern include the increasing distribution

and impact of marine litter, particularly plastic, in the oceans; loss and wastage of approximately one-third of food produced for human consumption; and increased trafficking of waste from developed to developing countries. While developed countries transition to reduced waste generation and greater resource efficiency, developing countries are grappling with basic waste management challenges including uncontrolled dumping, open burning, and inadequate access to waste services. {4.3.4}

**Waste generation from extractive industries is becoming unmanageable, with impacts on air, water, soil, biodiversity and human health.** Extractive industries produce the world's largest waste streams. They are responsible for extensive air, water and soil contamination and land-use change. {8.5.2} Mining activities not only contaminate soil but have impacts on many ecosystems. Toxic and radioactive dust emissions from mining waste pose serious health problems in many parts of the world. Water pollution also results from mining (e.g. acid metalliferous drainage and leakages from tailing management facilities). While mining operations generate employment and provide essential fuels and raw materials, they also produce toxic substances found in the environment such as lead. Lead (from mining and other sources) is a health hazard especially to children, who are more likely than adults to ingest it and are at risk of developing cognitive behavioural function problems even when they are exposed to low concentrations. Mining of some rare minerals, such as tantalum, may involve human exploitation and even slavery. Heavy metals such as lead, mercury, chromium, cadmium and arsenic in untreated mining waste discharged into rivers and lakes can bioaccumulate in rice, vegetables and other edible plants irrigated with contaminated irrigation water, with toxic effects on humans and other organisms. {8.5.2}

**The environmental and social costs of mineral extraction are typically greatest at the places where extraction takes place** (including disruptions when land is cleared, or populations displaced) (*well established*). The greatest benefits accrue at the other end of the supply chain. It is important to consider the environmental consequences of global trade in resources, including the repercussions for local communities in areas of resource extraction. Interest is growing in tracing the origins and added value of supplied resources through sustainable supply chain management. Traceability would support action on issues such as conflict minerals, chemical and pharmaceutical waste, food contamination, and illegal trade in endangered species. {4.4.2}



**The global economy currently operates predominantly in a linear mode** whereby resources are extracted, converted through manufacturing to products, and then disposed of, despite the existence of many economically attractive opportunities for resource efficiency even in the short term (*well established*). {17.6.1} In the medium to long term, resource efficiency creates better economic outcomes compared with business as usual; resource efficiency can also make a substantial contribution to the mitigation of climate change. {4.4.1}

**A global shift is needed to a circular economy in which resource efficiency contributes to economic growth and human well-being, with reduced environmental pressures and impacts (*established but incomplete*).** This shift would have substantial co-benefits for GHG emissions abatement and pollution and waste minimization. {17.6.2}

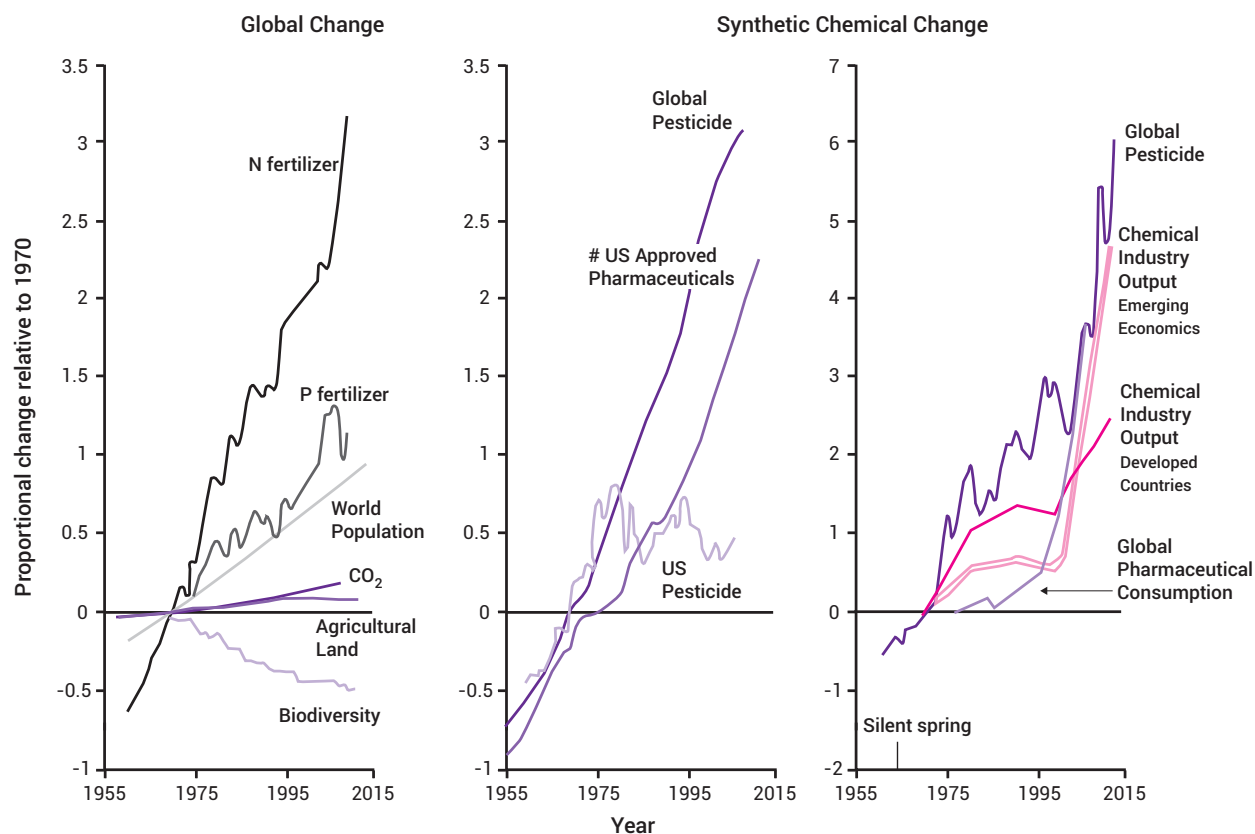
**Not all resources can be recycled (*well established*).** Some metals such as iron, copper, gold and lead are recyclable; minerals like phosphorus are dispersed in soils and water bodies, ultimately washing away and being lost for any further use (while at the same time

producing substantial pollution). This kind of material dissipation has raised alarms about the eventual depletion of essential resources. {4.4.2}

**We are living in the most chemical-intensive era in human history (Figure 3.1). The pace of production of new chemicals largely surpasses the capacity (and political will) to fully assess their potential adverse impacts on human health and ecosystems (*well established*).** These chemicals are becoming ubiquitous, transported through the global water cycle as well as air and soils. The risks to human health and ecosystem integrity posed by the combined effects of certain chemicals are poorly understood. Green and sustainable chemistry, which aims to achieve the sustainable design, production, use and disposal of chemicals throughout their life cycle, is not keeping pace with the scale of conventional chemical production and use (United Nations Environment Programme [UNEP] 2019a, pp.515-541). {Chapter 4, ExecSum, 4.3.3}

**Common categories of chemicals that pose risks to the environment and human health include pharmaceutical and veterinary chemicals, pesticides, antibiotics, flame**

Figure 3.1: Chemical intensification, 1955-2015



Source: Bernhardt, Rossi and Gessner (2017).



**retardants, plasticizers and nanomaterials** {4.4.3} Pollutants of particular concern, because of their impact on human health and ecosystems, include metals, such as mercury, and persistent organic pollutants (POPs), including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polychlorinated naphthalene (PCNs), organochlorine pesticides (OCPs), polybrominated diphenylethers (PBDEs) and perfluorinated chemicals (PFCs) UNEP 2019b). {16.2.1}

**Mercury emissions are increasing, polluting the air, freshwater and oceans, with severe consequences for human health and the environment, particularly biodiversity (e.g. mercury bioaccumulation)** (*well established*). The UNEP Global Mercury Assessment estimated that anthropogenic mercury emissions to air were 2,220 (2000-2820) tonnes/year in 2015, approximately 20 per cent higher than in 2010. {5.2} Heavy metals associated with water-intensive mining are problematic in Africa, Latin America and other parts of the world. Mercury and arsenic used in gold mining can pollute surface and groundwater; water drainage from active and abandoned mines can cause significant water degradation. {9.5.5} Mercury can travel long distances in both air and water, bioaccumulate and biomagnify up food chains, and reach levels that can be dangerous to humans and ecosystems. Populations who rely on marine organisms (e.g. fish, seafood) for nutrition may experience particularly high exposures to methylmercury and POPs. These risks are highest in areas where food security is not assured. {9.5.5} For example, methylmercury concentrations in the blood of populations that consume top marine predators, such as indigenous Arctic people, are among the highest recorded globally, giving rise to serious health concerns (UNEP 2019a). {5.4.2}

**Pharmaceuticals are commonly mishandled “from cradle to grave”, with over 200 different pharmaceutical substances reported in river waters globally.** Antibiotics reach the aquatic environment from a wide range of sources, including treated and untreated human waste, agriculture, animal husbandry and aquaculture. Antibiotic-resistant bacteria are found in both source water and treated drinking water. Wastewater treatment plants have varying capacities to remove antibiotic-resistant bacteria, and only a limited capacity to remove antibiotic drugs. {4.3.3, 9.5}

**The multitude of industrial chemicals challenges our ability to test their potential impacts on human health and the environment, including on future generations.** The cumulative effects (social and environmental) of multiple chemical exposures are largely unknown, and environmental and health regulatory and testing

systems are unable to keep up with the sheer scale of chemical production and use {4.2.1}

**Substances regulated in some regions may be redistributed elsewhere, especially in developing countries, with little guidance on health and safety issues and proper use.** For example, total health-related pesticide costs for agricultural smallholders in sub-Saharan Africa from 2015 to 2020 were estimated to be US\$ 90 billion. Further studies evaluating the combined effects of chemical mixtures and seeking to understand the cumulative effects of chemicals over time, are required. More information is also needed on causal linkages between exposure to certain chemicals and related health effects. Promoting safer and sustainable alternatives to chemicals, especially biodegradable replacements for plastics, and sound cradle-to-cradle chemicals management are essential. Institutions and instruments are available, and coordination through United Nations agencies is an objective of the Strategic Approach to International Chemicals Management (SAICM) (UNEP 2019a). Measures are required to detoxify the environment and create a safe chemical future in the coming decades. The costs of inaction will be high. {4.2.1, 4.3.3}

**Recycling is usually, but not always, environmentally preferable to final disposal** (*well established*). Recycling a metal typically has lower environmental impacts than that metal's primary production. For example, recycled aluminum uses one-twentieth of the energy required for production of primary aluminum. This means recycling should lead to reduced environmental pressures and risks, mainly through lower energy and raw material needs. However, for some chemicals and toxic metals (e.g. POPs and mercury) final disposal may be a better option than recycling and reuse. {17.6.3}

## 3.2 State of the Global Environment

### 3.2.1 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 substances (PBTs)** (*well established*). {5.1, 5.3.2} An increasing amount of information about emissions to the atmosphere is publicly available in some regions. However, no global reporting programme is applicable to all sources and pollutants. Neither is there a comprehensive emissions data repository. GEO-6 used the latest global anthropogenic emissions data developed using the Community Emissions Data System, an open source global system developed to provide consistent long-term emission trends for

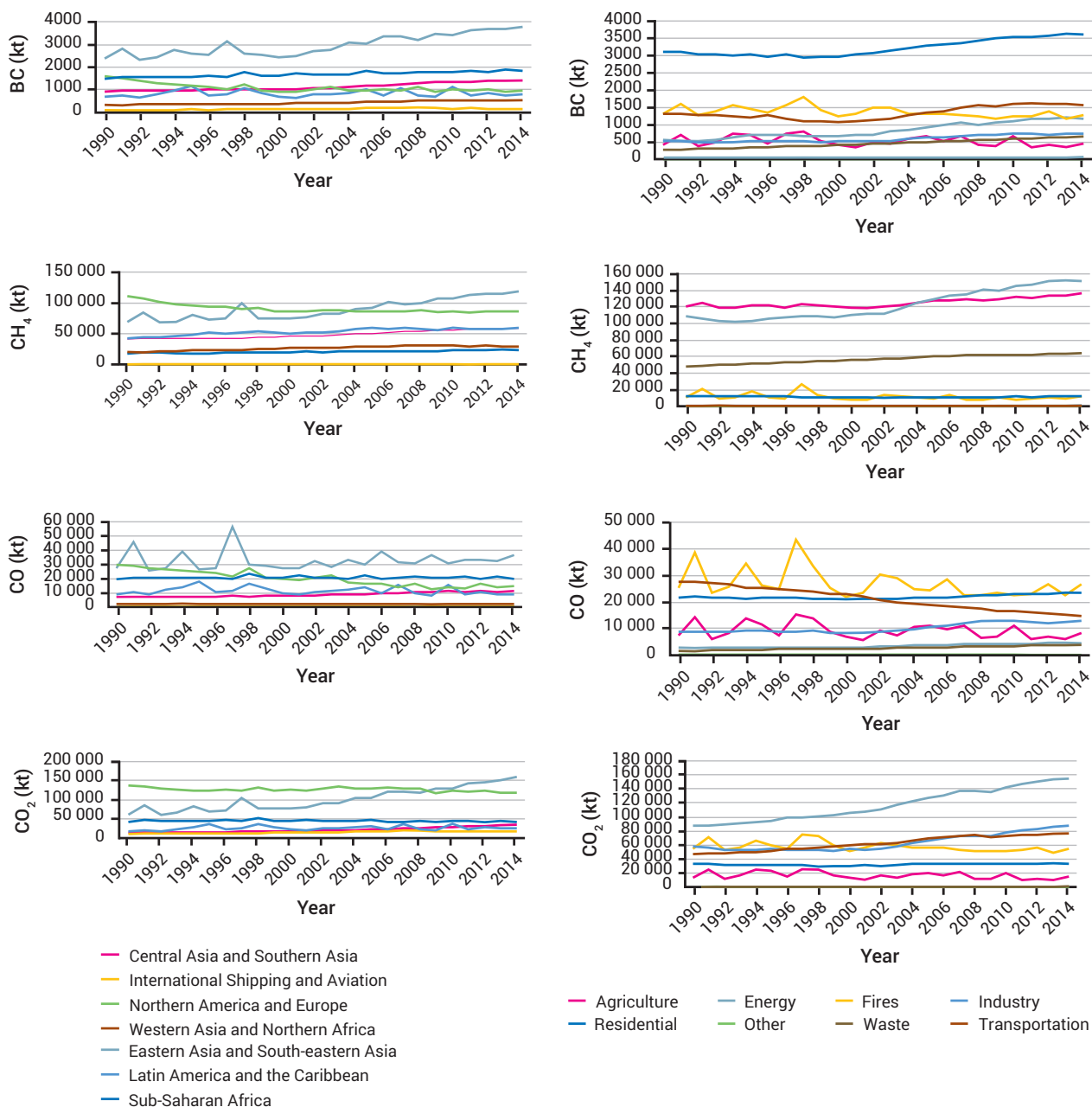


use in atmospheric modelling efforts such as those supporting the preparation of IPCC's 6th Assessment Report. Emissions from open biomass burning are taken from a separate inventory. Together these data sets provide an up-to-date and consistent basis for examining emission trends for many air pollutants and GHGs (Figure 3.2). Globally, decreasing emission trends in some sectors and regions have been offset by trends of increasing emissions in rapidly developing and

emerging economies and areas where there is rapid urbanization (*well established*). {5.2}

**Global increases in anthropogenic GHG emissions and climate impacts are occurring despite some mitigation efforts. Concentrations of CO<sub>2</sub> and other long-lived greenhouse gases continue to increase globally, driven mainly by burning of fossil fuels to satisfy ever-increasing energy demand (*well established*). {Chapter 5, ExecSum, 5.2.4}**

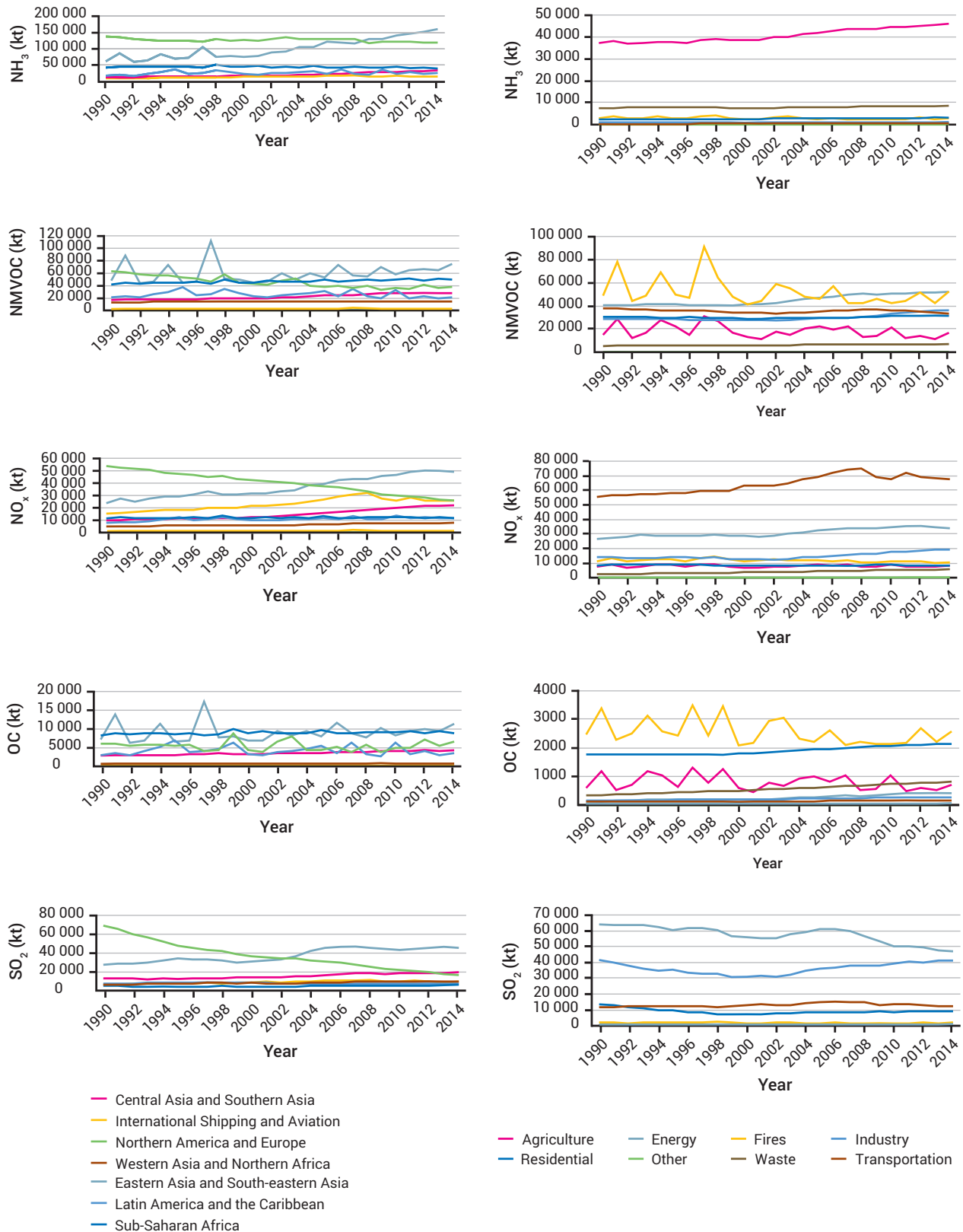
**Figure 3.2: Annual emission trends of GHG and air pollution from 1990 to 2014 in kilotonnes/year by pollutant, region and sector**



Source: Hoesly et al. (2018).



Figure 3.2: Annual emission trends of GHG and air pollution from 1990 to 2014 in kilotonnes/year by pollutant, region and sector (Continued)



Source: Hoesly et al. (2018).



Given current GHG concentrations and their lifetime in the atmosphere, significant changes in climate and sea levels are unavoidable, with widespread consequences for people and the environment (*well established*). Since 1880 the global average surface temperature has increased by between 0.8°C and 1.2°C (*well established*) (**Figure 3.3**). There is robust evidence that climate change and increased climate variability worsen existing poverty, exacerbate social inequalities and trigger new vulnerabilities. Even greater changes are expected in the future if action is not taken soon to halt GHG emissions. {Chapter 5, ExecSum, 5.3.4}

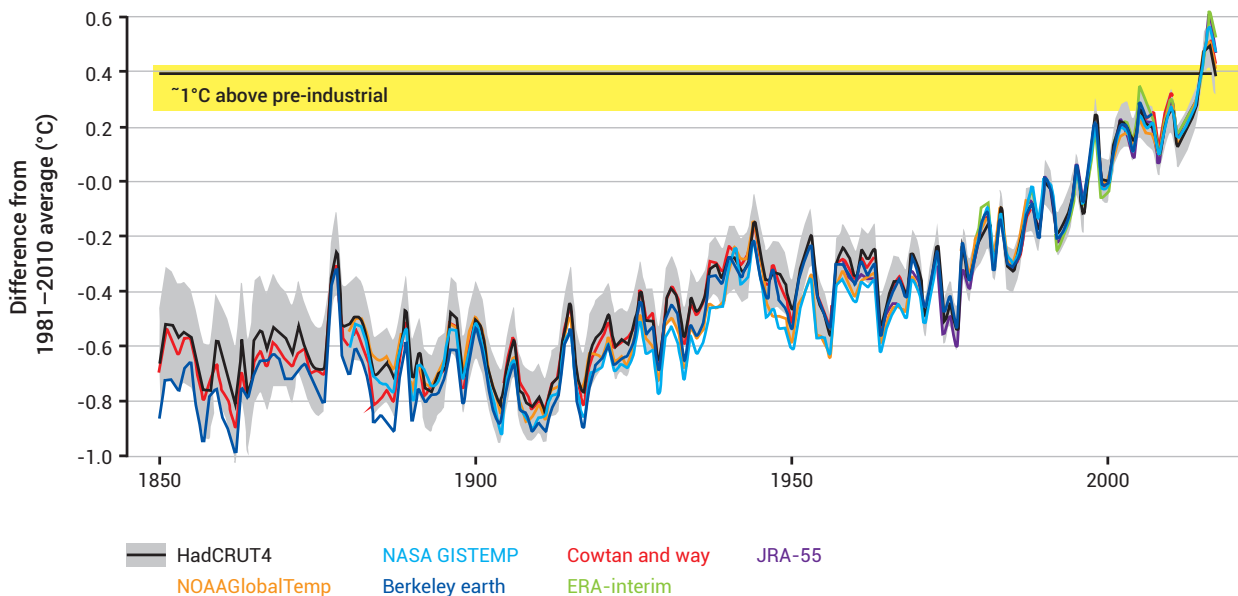
**Current observations and climate model experiments indicate that increases in Arctic polar surface temperatures exceed twice the mean global temperature rise (*well established*).** This amplified warming has cascading effects on other components of the polar climate system. Arctic sea ice is retreating (**Figure 3.4**), permafrost is thawing, snow cover extent is decreasing, ice sheets are decaying, and ice shelves and mountain glaciers are continuing to lose mass, contributing substantially to sea level rise. {4.3.2}

**Air pollution is the main environmental contributor to the global burden of disease. Exposure to indoor and**

**outdoor air pollution led to between 6 and 7 million premature deaths in 2016 (*well established*).** **Welfare losses, as a result of these premature deaths, have been estimated at US\$ 5 trillion in 2013 (*established but incomplete*).** Exposure to air pollution, especially 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 fuels such as wood, coal, crop residue, dung and kerosene for cooking, heating and lighting (*well established*). In households dependent on biomass for cooking, women’s daily exposure to particulate pollution is considerably higher than that of men. Overall, the very young, elderly, ill and poor are especially susceptible to the impacts of air pollution (*well established*) (**Figure 3.5**). {5.2.4, 5.4.1; SPM, p. 7}

**Air pollution in one region may be associated with consumption of goods elsewhere (*established but incomplete*).** East and South Asia have the highest number of deaths attributable to air pollution owing to their large populations and cities with high levels of pollution (*well established*). These regions also bear the largest health burden caused by production of goods consumed in other regions of the world,

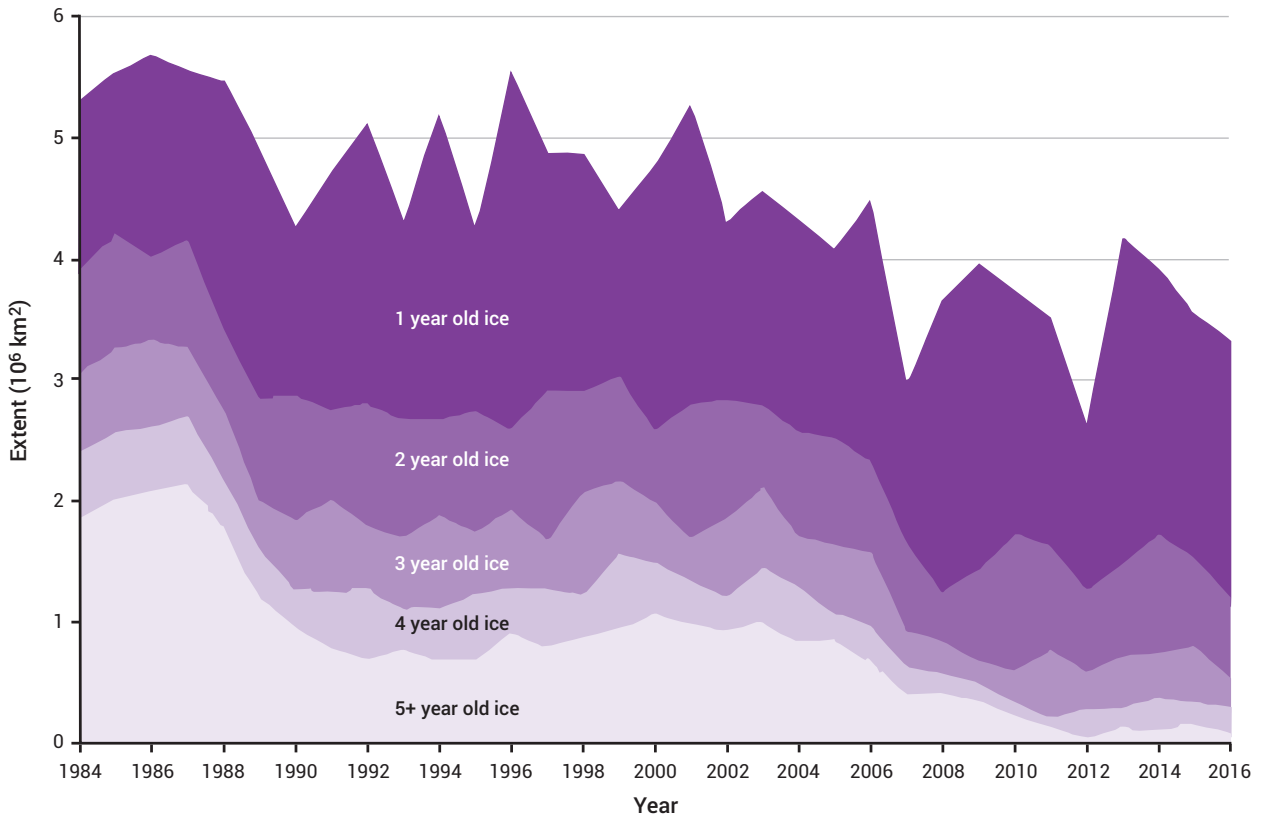
Figure 3.3: Global annual average temperature anomalies (relative to the long-term average for 1981-2010)



Source: United Kingdom Government Met Office (2018).

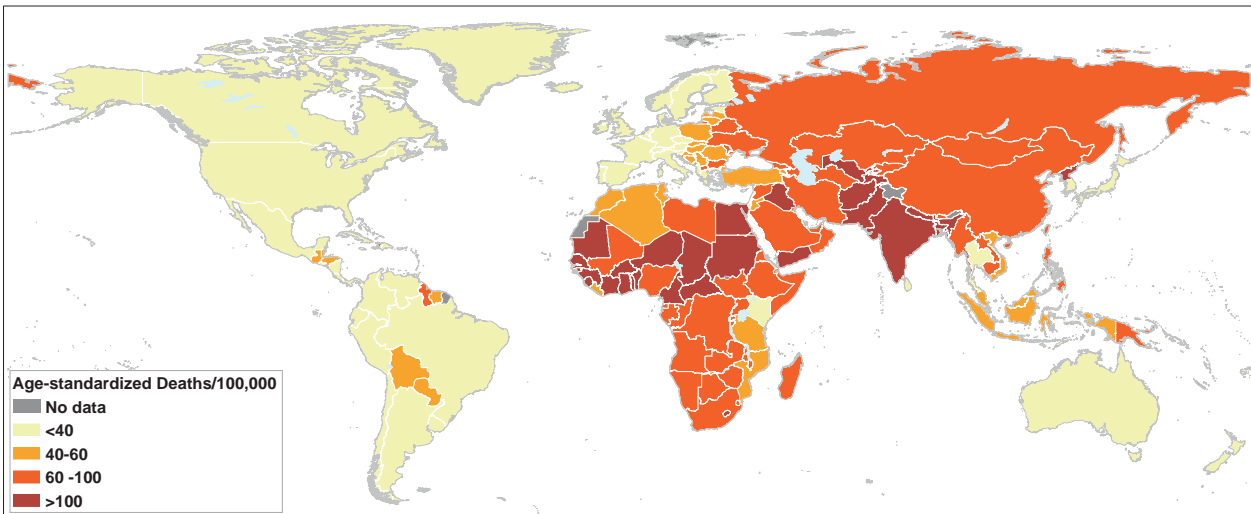


Figure 3.4: Arctic sea ice age and extent



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

Figure 3.5: Deaths per 100,000 people in 2016 attributable to ambient PM<sub>2.5</sub> air pollution; age standardized data



Source: Adapted from Health Effects Institute (2018).





primarily Western Europe and North America. For example, 97 per cent of deaths related to PM<sub>2.5</sub> in East Asia were associated with emissions, but only 80 per cent with goods or services consumed in that region. Consumption in Europe, Russia and North America of goods made in East Asia was estimated to contribute 6-7 per cent to the PM<sub>2.5</sub> mortality burden in East Asia (Figure 3.6) {Chapter 5, ExecSum, 5.3.1}

**Emissions of ozone-depleting substances (ODSs), leading to stratospheric ozone depletion, have decreased dramatically as a result of the Montreal Protocol (well established).** Stratospheric ozone over Antarctica has started to recover. Although stratospheric ozone concentrations in other regions have increased since 2000, the expected increase in total atmospheric column ozone and decrease in ultraviolet (UV) radiation reaching the Earth's surface

have not been observed outside Antarctica due to natural variability, increases in GHG concentrations, and changes in attenuation of UV radiation by tropospheric ozone, clouds and aerosols. {5.3.3, 5.2.3}

### 3.2.2 Biodiversity

**Biodiversity is in crisis: a continuing and irrevocable decline of genetic, species and ecosystem diversity is occurring at multiple scales. Scientists are increasingly concerned that we could be entering a sixth mass extinction event.** Biodiversity (the rich diversity of life within species, between species and between ecosystems) is essential for the functioning and resilience of earth systems and human well-being (Figure 3.7). For example, biodiversity helps regulate the climate through carbon storage and control of local rainfall, filters air and water, and

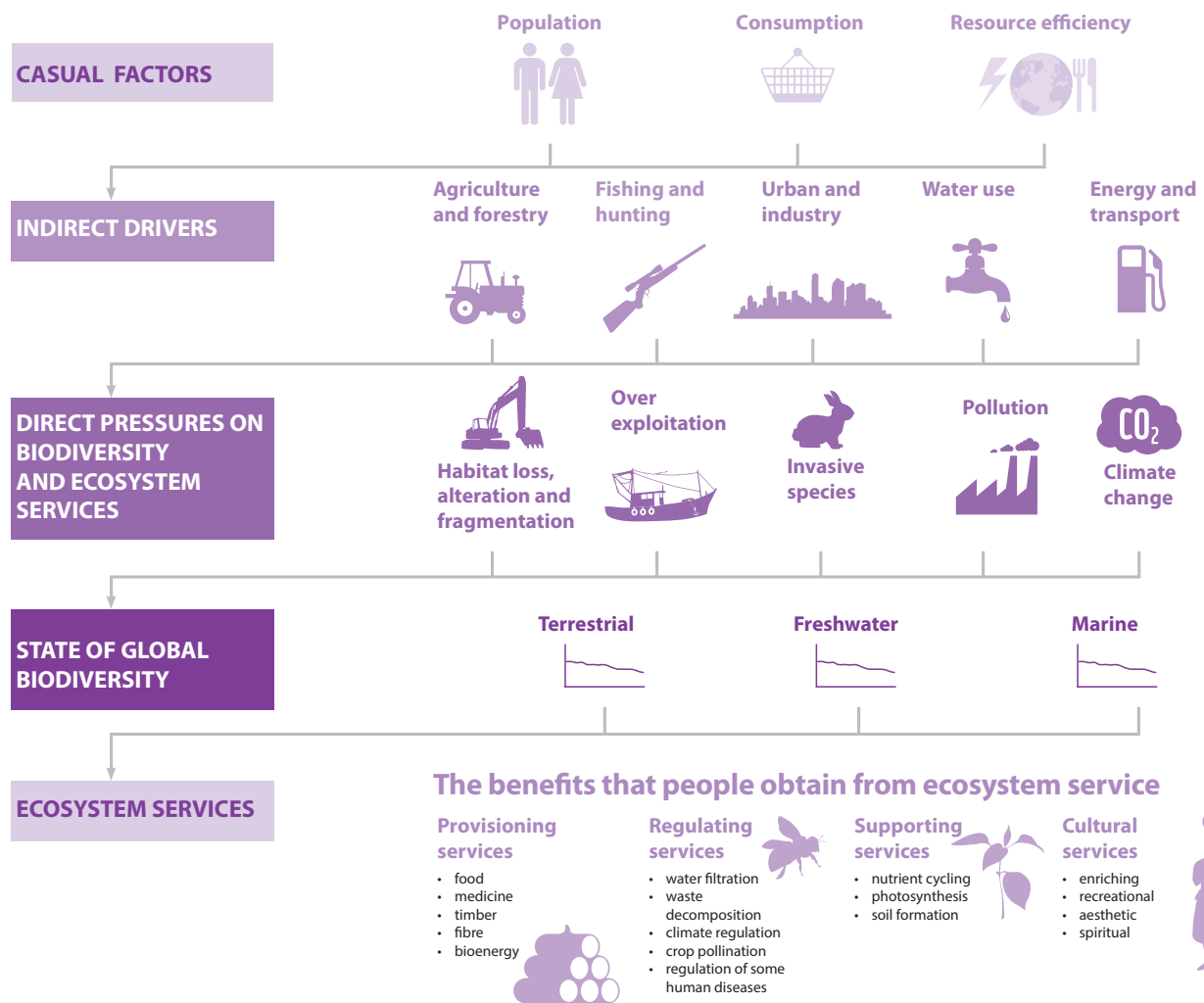
**Figure 3.6: Percentage of PM<sub>2.5</sub> related deaths in a region, indicated by the column due to (a) emissions produced or (b) goods and services consumed in the region indicated by the row**

		China and East Asia	India and Rest of Asia	Europe and Russia	Middle East and North America	North America	Latin America	Sub Saharan Africa and Rest of World
<b>Where air pollution was emitted</b>	China and East Asia	97%	3%	1%	1%	2%	1%	0%
	India and Rest of Asia	1%	93%	1%	2%	0%	0%	2%
	Europe and Russia	1%	0%	94%	18%	1%	0%	1%
	Middle East and North Africa	0%	3%	2%	78%	0%	0%	5%
	North America	0%	0%	1%	1%	95%	2%	0%
	Latin America	0%	0%	0%	0%	1%	97%	0%
	Sub Saharan Africa and Rest of World	0%	0%	0%	0%	0%	0%	93%
<b>Where associated goods were consumed</b>	China and East Asia	80%	4%	3%	3%	6%	4%	2%
	India and Rest of Asia	3%	84%	2%	3%	1%	1%	2%
	Europe and Russia	7%	4%	86%	24%	5%	6%	4%
	Middle East and North Africa	2%	3%	4%	64%	2%	1%	4%
	North America	6%	3%	3%	4%	82%	12%	2%
	Latin America	1%	0%	1%	1%	4%	75%	1%
	Sub Saharan Africa and rest of World	1%	1%	1%	1%	1%	1%	84%

Source: Based on Zhang et al. (2017).



Figure 3.7: The causal factors, drivers and direct pressures contributing to the degradation of global biodiversity and the ecosystem services provided by it



Source: World Wide Fund for Nature, Zoological Society of London, Global Footprint Network and European Space Agency (2012).

mitigates the impact of natural disasters such as landslides and coastal storms. *(well established)*. {6.1}

**Biodiversity loss greatly reduces nature’s contributions to people** *(well established)*. It has direct and negative consequences for indigenous peoples who rely on it for their subsistence and traditional livelihoods. Pollinator declines, invasive pests, and disease are impacting agricultural production while forest loss and habitat transformation are reducing the Earth’s capacity to moderate climate change and buffer the impacts of increasing GHG emissions. {6.4.3, 5.4} The direct benefits of biodiversity include timber from forests, fish from freshwater systems and the oceans, food and medicines from plants, and the mental health benefits of access to nature. Never before has so much knowledge existed about the biodiversity that enables ecosystems

to function. Yet biodiversity loss and habitat decline continue to accelerate, potentially leading to a catastrophic loss of ecosystem functioning. {6.1}

**Biodiversity loss is both a human health issue and an equity issue** *(well established)*. Concerns about equity and environmental justice are intra- and inter-generational. It is estimated that more than 70 per cent of the world’s 1.2 billion people who live in poverty depend directly on natural resources to some extent, and that 35 per cent (2.5 billion people) depend directly on fisheries, forests, hunting and agriculture for their livelihoods. The vulnerability of all these people is increased when natural resources are depleted and ecosystem services are reduced. {6.5} Failure to address existing pressures on biodiversity now will pass on higher costs to future generations and could even

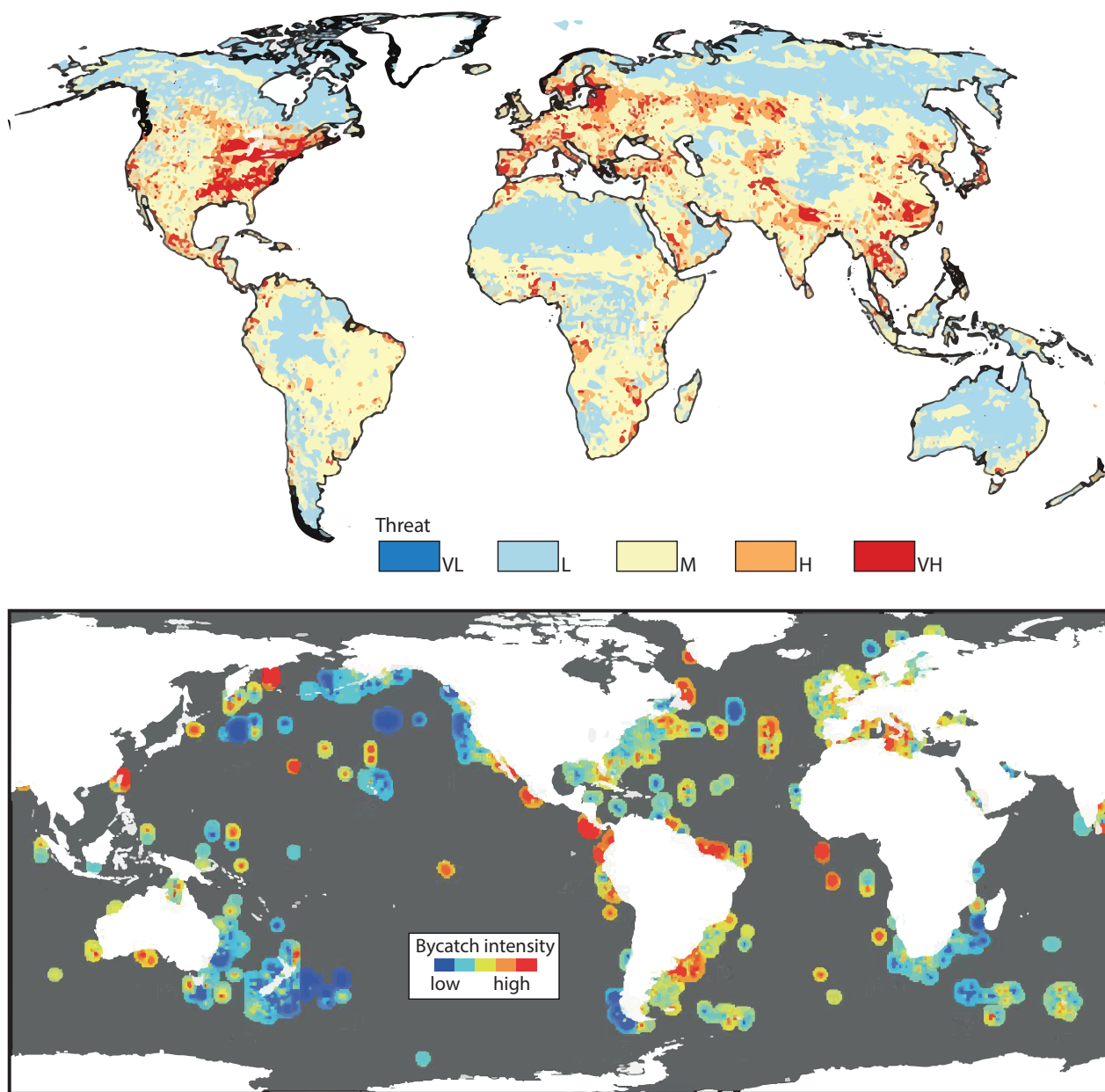


make it impossible to take remedial action to prevent species extinctions. {6.3.2}

**There is inequity in access to natural areas** (*well established*). The location of both terrestrial and marine parks aimed at conserving biodiversity can negatively affect local peoples, particularly vulnerable and indigenous communities. The issues of access and benefit sharing are considered in the Nagoya Protocol of the Convention on Biological Diversity. {6.6.1}

**Five major pressures affect biodiversity on a global scale** (*well established*). These are habitat transformation and land-use change, invasive species, pollution, over-exploitation, and anthropogenic changes to the climate system. Although there have been reductions in the intensity of these pressures in some regions, they are increasing on a global scale. For example, while conservation areas (including terrestrial and marine protected areas) are expanding in many countries, wildlife habitat continues to decline globally.

Figure 3.8: Examples of global distribution of pressures on (a) threat intensity (H:High; L:Low; M:Medium; VH:Very High; VL:Very Low) from terrestrial invasive species; and (b) cumulative fisheries by-catch intensity for seabirds, sea mammals and sea turtles by all gear types (gillnet, longline and trawl)



Source: (a) Early *et al.* 2016; (b) Lewinson *et al.* (2014).



Energy production, resource extraction, wildlife trade and poaching, and the presence of chemical waste and plastics in the marine environment are newly recognized and/or exacerbating factors. Pressures are often simultaneous and there are positive feedback loops between many of them. For example, forests are experiencing transformation due to agricultural expansion, forestry and mining with the resulting habitat fragmentation and loss of biodiversity lowering forest resilience to climate change impacts and the introduction of invasive species. {6.4}

**Land-use change and alteration of the marine ecosystem can reduce the habitats of wild species and the ecosystem services they provide** (*well established*).

The loss of natural habitats has a direct effect on the species found within them, as well as an indirect effect on the ecosystem services these areas support (e.g. through loss of pollinators and the predators of agricultural pests). In addition, habitat degradation may increase exposure to pollutants, exotic pathogens and emerging infectious diseases harmful to humans, livestock and wildlife, reduce human access to nature, and increase human conflict. {6.4.1, 6.4.3}

**Invasive species have a direct impact on the provisioning of key ecosystem services** (*well established*). For example, invasive aquatic plants can disrupt access to clean water through the congestion and eutrophication of waterways. The ecological impacts of invasive species result from habitat degradation, direct and indirect competition, predation, and these species' role as disease agents and vectors (**Figure 3.7**) {6.4.2}

**The economic costs of invasive species are substantial, amounting to many billions of dollars annually, and these costs will escalate unless more is done to control their introduction and spread** (*well established*). Future bio-invasion threats include increased transport in the Arctic (from the loss of sea ice associated with climate change), commercial use of microbes in crop production, horizontal gene transfer from genetically modified organisms, and the emergence of invasive microbial pathogens. {6.4.2}

**Pollution has long-term impacts on natural systems** (*well established*). Local sources of pollution include chemical leaks, oil and gas production and transport, and mine wastes (e.g. tailings and waste rock dumps). Pesticides, fertilizers and other chemicals used in agriculture can harm soil microbes, pollinators and natural pest predators. Eutrophication in water systems (a major cause of which is nutrient pollution from agriculture) can lead to mass die-offs of marine

species. Bioaccumulation of toxins may have cascading impacts across the entire food chain, while plastic fragments in freshwater and marine environments threaten seabirds, fish, crustaceans, and even the plankton which are the basis of the marine food web (established but incomplete). The accumulation of endocrine-disrupting chemicals (EDCs) and POPs in natural ecosystems poses additional threats to wildlife, particularly in aquatic systems. {6.4.3}

**Overexploitation, both legal and illegal, continues to cause biodiversity loss** (*well established*). Revenues from illegal, unreported and unregulated fishing, illegal and unsustainable logging, unregulated bushmeat consumption, and wildlife poaching (partly for foreign markets) have been estimated at over US\$ 150 billion per year. The legal, but unsustainable, exploitation of natural populations (most noticeably through overfishing) is also depleting fish stocks and is a considerable greater threat to biodiversity. Although some species, such as the North American bison, have made remarkable recoveries from near-extinction, climate change and land-use change will make such recoveries more challenging in the future {6.4.4}

**Climate change influences many factors that determine the distribution of species and ecosystems, and it will affect them increasingly in the future** (*well established*). In the terrestrial environment, species' seasonal phenologies (i.e. the timing of cyclic life-history events such as flowering and leafing in plants) are advancing. Their geographical distributions are also evolving poleward and to higher elevations as global temperatures rise. The ecological impacts of such shifts remain an area of intense scientific research. In the marine environment warming and acidifying oceans are associated with coral bleaching events. Unprecedented pan-tropical bleaching was recorded in 2015-2016. Warmer waters also impose direct metabolic costs on reef fish, reducing swimming capacity and elevating mortality rates. {6.4.5}

**Genetic diversity is being lost with the declining population sizes of many species** (*well established*). The loss of genetic diversity increases vulnerability to future change. It is the vital raw material that allows adaptation to changing environments. {6.5.1}

**The ongoing long-term loss of crop and livestock genetic diversity is a threat to food security** (*well established*). The genetic diversity of crops and their wild relatives (as well as that of livestock) is necessary for the adaptation and resilience of agricultural systems in changing environments; however, this



diversity is at risk due to population declines and over-reliance on a few crop varieties and genotypes. {6.5.1}

**The risks from species extinction continue to increase, and there is no slowing of the rate of population declines globally** (*well established*). The status of species decline, and trends in species populations, remain the components of biodiversity that are best documented. Extinction risks are well documented for many taxonomic groups, and trends through time are showing negative trajectories for many species that are currently at risk. {6.5.2} Nevertheless, there are some documented success stories of species conservation and recovery, notably of whale species (Zerbini 2019).

**Rates of population decline and risks of extinction are not uniform across all species** (*well established*). The taxonomic groups with the highest proportion of species at risk of extinction are amphibians from the vertebrate classes, reef-forming corals (which are marine invertebrates), and magnolias from the plant groups. {6.5.2}

**The picture emerging from available localized trends data is that terrestrial invertebrate abundance is in decline.** However, invertebrate groups remain poorly studied. While they represent most of animal diversity, less than 1 per cent of invertebrates have been assessed for extinction risk. Declines in wild and managed invertebrate pollinators (e.g. bees) have been highlighted as a growing problem, with potential broad economic, ecological, cultural and health consequences. {6.5.2}

**The current biodiversity crisis is leaving a large and growing footprint across all of the Earth's major biomes** (*established but incomplete*). In the oceans, despite improved fisheries management and recovery in some places, elsewhere continuing over-exploitation of fish stocks is intensifying the threat of fisheries collapse. In addition, warming is destroying coral reefs (which are the most biodiverse marine ecosystems), and habitat destruction of coastal systems such as mangrove forests is exposing coastal communities to greater risks of erosion and extreme weather events. Marine pollution is a major and growing threat to biodiversity; an estimated 51 trillion microplastic particles, a number 500 times greater than that of the stars in our galaxy, litter our seas. {6.4.3, 6.5.1, Box 6.2} In freshwater systems agricultural and chemical pollution have greater impacts, with increased input of nutrients like nitrogen and phosphorous resulting in harmful algal blooms and lower drinking water quality. Invasive species are spreading through waterways; wetlands are being drained; and freshwater species are declining

at a faster rate than those in any other biome. {6.5.2} In terrestrial ecosystems rising temperatures are converting grasslands into deserts, while unsustainable irrigation has turned drylands into inhospitable landscapes that are unsuitable for agriculture or wildlife. {6.5.3, 6.5.4, 6.5.5} Mountain ecosystems and polar regions are especially vulnerable to climate change, and extinctions may be likely for species at the upper limits of their thermal ranges and those dependent on sea ice. Loss of sea ice will expose polar regions to additional pressures, including those from potential new fishing zones, oil and gas development, and shipping, with further cascading impacts on the environment. {6.6.8} Tropical forests, which are some of the world's most biodiverse terrestrial ecosystems, continue to suffer from deforestation and degradation in many regions in response to demand for wood products, food (e.g. beef, soy and palm oil), fuel and fibre, as well as other drivers. {22.3}

**Although biodiversity policy responses are visible and operate at local, national and international levels, they have not successfully slowed or reversed the decline in global biodiversity.** (*well established*) To reverse trajectories of biodiversity loss and degradation, and meet globally agreed targets, biodiversity policies need to advance equity rather than placing disproportionate burdens on already-vulnerable populations or on future generations. More planning and action are needed at and across all levels of governance (Stoett 2019). {6.6.3, 6.7}

**At the local scale, indigenous peoples and local communities (IPLCs) have a key role to play in biodiversity conservation and are specifically identified and promoted in the Convention on Biological Diversity (CBD)** (*well established*). IPLCs can offer bottom-up, self-driven and innovative solutions in comparison to standard conservation and development approaches. Their contributions have the potential to be upscaled, to inform national and international practice, and to provide a practical governance approach as a complement to top-down policy setting. {6.6.3}

**The costs of inaction on biodiversity conservation far exceed financial quantification.** Biodiversity provides multiple ecosystem services that are essential to life. While it is possible to assign a monetary value to some provisioning services, other contributions remain largely invisible to society. A reduction in biodiversity could result in a catastrophic loss of ecosystem functioning. The costs of such a failure cannot be evaluated in traditional market terms. In many cases, such as the spread of invasive species and species extinctions, inaction today risks committing us to future scenarios in



which damage to ecosystems and biodiversity would be difficult if not impossible to reverse. {6.5.4}

### 3.2.3 Oceans and coasts

**Human pressures on the health of the oceans continued to increase over the last decade, along with human population and its use of ocean resources** (*well established*). Multiple stressors give rise to cumulative impacts that affect the health of marine ecosystems and reduce nature's benefits to humans. However, there has been success in the management of some pressures, with associated improvements in ocean health, providing lessons on which to build. Out of numerous existing pressures, three were selected for attention in GEO-6: bleaching of coral reefs; marine litter; and challenges to achieving sustainable fisheries in the world's oceans. {Chapter 7; ExecSum, 7.1}

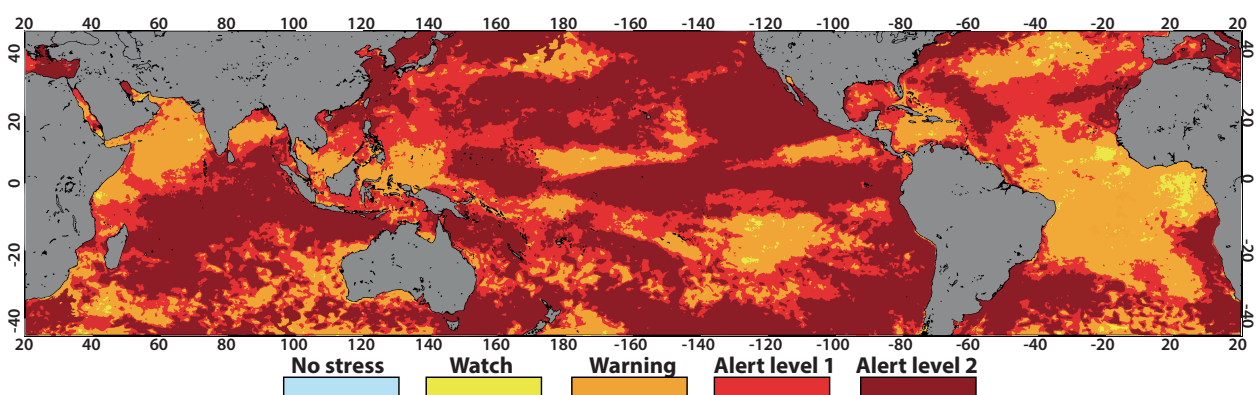
**The main pressures on oceans and coasts are ocean warming and acidification; ocean pollution; and the increasing use of oceans, coasts, deltas and basins for food production, transportation, settlement, recreation, resource extraction and energy production** (*well established*). The impacts of these pressures include marine ecosystem degradation and loss, such as the death of coral reefs (*well established*); reduced marine biodiversity and the disturbance of marine and coastal ecosystem food chains (*well established*); increased nutrient and sediment run-off (*well established*); and marine litter (*established but incomplete*). These impacts interact in ways that are incompletely understood, and some of their interactions may amplify the consequences. If these impacts remain unaddressed, there is a major risk that they can combine to produce a destructive cycle of degradation and could affect vital ecosystem services. {Chapter 7}

**GHG emissions are driving rising sea levels, changes in ocean temperatures and ocean acidification. Warm-water coral reefs are being devastated by these changes** (*well established*) (Figure 3.9). Ocean warming lags behind GHG emissions by several decades, such that the tipping point for coral reef bleaching was already passed in the 1980s at a time when atmospheric concentration of CO<sub>2</sub> exceeded about 350 parts per million (ppm) compared with today's 414 ppm, recorded in May 2019 (United States National Oceanic and Atmospheric Administration 2019). {Chapter 7, ExecSum, 7.3.1}

**Reef bleaching events currently have a recurrence interval of about six years, while reef recovery takes more than ten years** (*established but incomplete*) (Figure 3.8). This means that, on average, reefs will not have enough time to recover between bleaching events. Consequently, a steady downward spiral in reef health is anticipated in coming decades. SDG target 14.2 ("by 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans") may not be attainable for most tropical coral reef ecosystems. The limited resilience of coral reef ecosystems to climate change could be further reduced if other pressures on them are not managed sustainably (*established but incomplete*) {Chapter 7, ExecSum, 7.3.1}

**The oceans play an important role in the global economy and are likely to become increasingly important. Fisheries and aquaculture generate US\$ 362 billion annually; small-scale fisheries support the livelihoods of between 58 million and 120 million people** (*established but incomplete*). The majority of

Figure 3.9: Map showing maximum heat stress during the 2014-2017 period of the global coral bleaching event (ongoing at the time of writing)



Source: United States National Oceanic and Atmospheric Administration (2017).



these livelihoods are provided by small-scale fisheries (this has been stable for over a decade). Yet commercial harvesting accounts for a large majority of commodity value, including more than US\$ 80 billion per year exported from developing countries to international markets (Table 3.1). {Chapter 7, ExecSum} Fish provide 3.1 billion people with over 20 per cent of their dietary protein and contain nutrients important for human health. They are particularly important in parts of the world where food insecurity is widespread (*established but incomplete*). {7.3.2.}

**To meet future challenges related to food security and healthy populations (and to use all-natural products harvested for food more efficiently), more fish, invertebrates and marine plants will need to be taken as food from the oceans and coastal areas. Capture fisheries and aquaculture are therefore expected to expand.** {7.5.2} Improving the sustainability of capture fisheries and aquaculture requires significant investment in monitoring, assessment, and operations management, as well as, in many cases, enhancement and empowerment of strong local community-based approaches. Investment in fisheries monitoring and

fishing technologies can improve selectivity for target species during harvesting and reduce habitat impact, both in ocean fisheries and aquaculture (*established*). {14.2.4; SPM, p.9}

**Marine litter is found in all the world's oceans at all depths** (*established but incomplete*). The scale and importance of this problem have received increasing attention in recent years, but there are still large gaps in knowledge. Marine litter has a significant economic impact on a range of coastal sectors, including tourism and recreation, shipping and recreational boating, fisheries, aquaculture, agriculture and human health (*established but incomplete*). Damage to fishing gear from marine litter in Europe alone has been estimated at more than US\$ 72 million per year, and the cost of cleaning beaches has been estimated at US\$ 735 million per year and growing (*established but incomplete*). {7.4.4; SPM, p. 9} Abandoned, lost or otherwise discarded fishing gear can continue to “fish” (killing animals including protected species such as marine turtles, cetaceans and seabirds) and, in a few cases, has been documented to damage vessels. {7.3.3, 7.4.3; SPM, p. 9} Current estimates suggest that the input of plastic





**Table 3.1: Estimates of economic value, employment and major environmental impacts of the major ocean-related industries**

Sector [and World Ocean Assessment chapter]	Economic value or scale of operation	Employment/ livelihoods	Major environmental impacts if inadequately regulated
Fishing [9,11,12]	US\$ 362 billion: includes mariculture and freshwater aquaculture (US\$ 232 billion in total).  Competent IGOs: FAO and RFMOs	58-120 million (depending on how part-time employment and secondary processing employment are counted)	Changes of food web structure and function if top predators or key forage species are depleted or fishing is highly selective. By-catches of non-targeted species, some of which can sustain only very low mortality rates (e.g. sea turtles, many seabirds and small cetaceans). Gear impacts on seabed habitats and benthos, especially structurally fragile habitats (e.g. corals, sponges). Continued fishing by lost fishing gear.
Shipping [17]	50,500 billion tonne-miles of cargo; 2.05 billion passenger trips  Competent IGOs: IMO and MARPOL; Regional Seas Conventions	> 1.25 million seafarers	Shipping disasters and accidents that may result in release of cargos, fuel and loss of life. Toxicity of cargos ranges from nil to severe. Chronic and episodic release of fuel and other hydrocarbons. Infrequent loss of containers with toxic contents. Discharge of sewage, waste and "grey water". Transmission of invasive species through ballast water and bilge water. Use of anti-fouling paints. Noise from ships. Maritime transport responsible for about 3 per cent of global GHG emissions.
Ports [18]	5.09 billion tonnes of bulk cargo  Competent IGOs: IMO and MARPOL, but mostly local jurisdiction	Technology development has made consistent dockworker statistics unavailable	Concentration of shipping and potential environmental impacts of shipping. Need for dredging and access to deep water passages. Impacts on seabed and coastline from construction of infrastructure. Noise.
Offshore hydrocarbon industries [21]	US\$ 500 billion (at US\$ 50 per barrel)  ISA, but not yet tested in practice as production is within national jurisdictions	200,000 workers in offshore production	Release of hydrocarbons particularly during blowouts or platform disasters, with potential for very large volumes to enter marine systems, with high persistence impacting on tourism and aesthetic and cultural values. Oiling of marine and coastal organisms and habitats. Contaminants entering food webs and potential human food sources. Chronic release of chemicals used in operations. Episodic release of dispersants during spill clean-up. Local smothering of benthos. Noise from seismic surveys and shipping. Disturbances of biota during decommissioning.
Other marine-based energy industries [2]	7.36 megawatts (MW) Produced  Unresolved: no development yet in areas beyond national jurisdiction	7-11 job years per MW generated	Competition for space for infrastructure and displacement of biota. Localized mortality of benthos due to infrastructure. Mortality of birds, fish in energy turbines and windmills. Noise and physical disturbance during construction and decommissioning of infrastructure.
Marine-based mining [23]	US\$ 5.0-5.4 billion  Competent IGO: ISA	7100–12,000 (incomplete)	Mortality, displacement or extinction of marine species, particularly benthos. Destruction of seabed habitat, esp. if fragile or sensitive. Creation of sediment plumes and deposition of sediments. Noise. Potential contamination of food chains from deep-sea mining. Creation of microhabitats vulnerable to sediment concentration and anoxia [23.3].
Marine-based tourism [27]	US\$ 2.3 trillion (35 per cent of coarse estimate of all tourism, including multiplier effects)  Competent IGO: none, although disposal of wastes at the sea is regulated by IMO and MARPOL	Not estimated due to lack of common treatment of multiplier effects. Overall tourism considered to comprise 3.3 per cent of global workforce, but breakout of marine and non-marine not consistent	Construction of coastal infrastructure changing habitats, increasing erosion, mortality and displacement of biota, noise. Contamination of coastal waters by waste and sewage. Disturbance of organisms by increased presence of people, especially diving in high-diversity habitats, and watching marine megafauna. Increased mortality due to recreational fishing. Increased boating with all the impacts of shipping at local scales.

IGO: Intergovernmental organizations; IMO: International Maritime Organization; ISA: International Seabed Authority (2017); MARPOL: International Convention for the Prevention of Pollution from Ships; RFMOs: Regional Fisheries Management Organizations.

Sources: Unless indicated otherwise, all information is taken from the First Global Integrated Marine Assessment (United Nations 2016), with chapter(s) indicated in first column. For some industries, economic value is recorded so differently by different countries that global economic value cannot be estimated meaningfully; other indicators of scale of the industry are therefore used. The reporting year is not standardized for all rows, but all estimates are for 2012 or later. Table entries should be taken as indicative of global scale, with large variations regionally and nationally (IMO 2015).





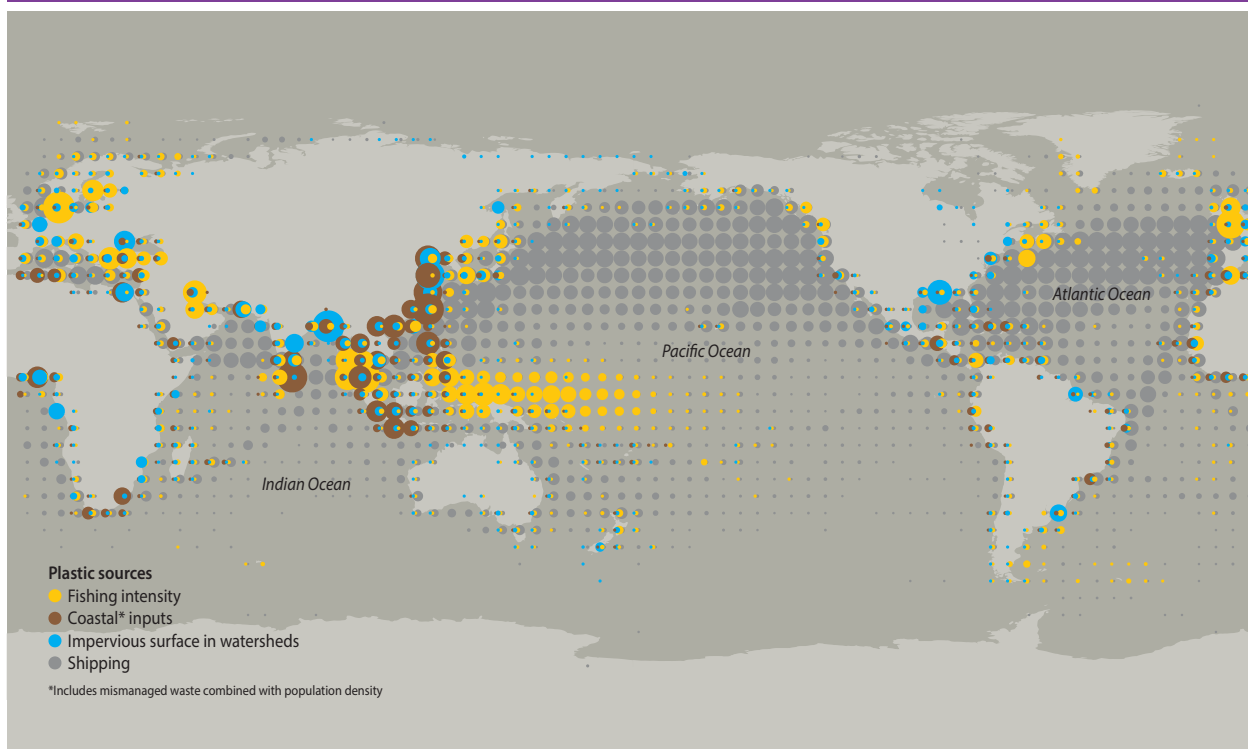
marine litter linked to domestic waste mismanagement in coastal areas amounts to some 8 million tonnes annually (*established but incomplete*), of which 80 per cent originates from land-based sources (**Figure 3.10**). Marine plastic litter (**Figure 3.11**) can have significant wildlife impacts because of entanglement and ingestion. It can also act as a vector for the transport of invasive species and pollutants (*established but incomplete*). The environmental, social and economic costs of all types of marine litter are continually increasing; together with the direct economic costs of clean-up, they include loss of revenue from industries such as tourism and fishing (*unresolved*). Social and health costs are more difficult to quantify beyond local scales, as are environmental costs (e.g. loss of ecosystem function and services). {Chapter 7, ExecSum, 7.4.4}

**The growing presence and abundance of microplastics (particles smaller than 5 mm in length), has created concerns about potential adverse effects on the health of both marine organisms (*established but incomplete*) and humans (*unresolved*) (UNEP 2019a). {7.4.4}**

**Coastal sand mining could become a serious problem (*well established*).** Coastal sand and gravel, a non-renewable resource, is being mined at the rate of 40-50 billion tonnes per year. Humans are using sand at four

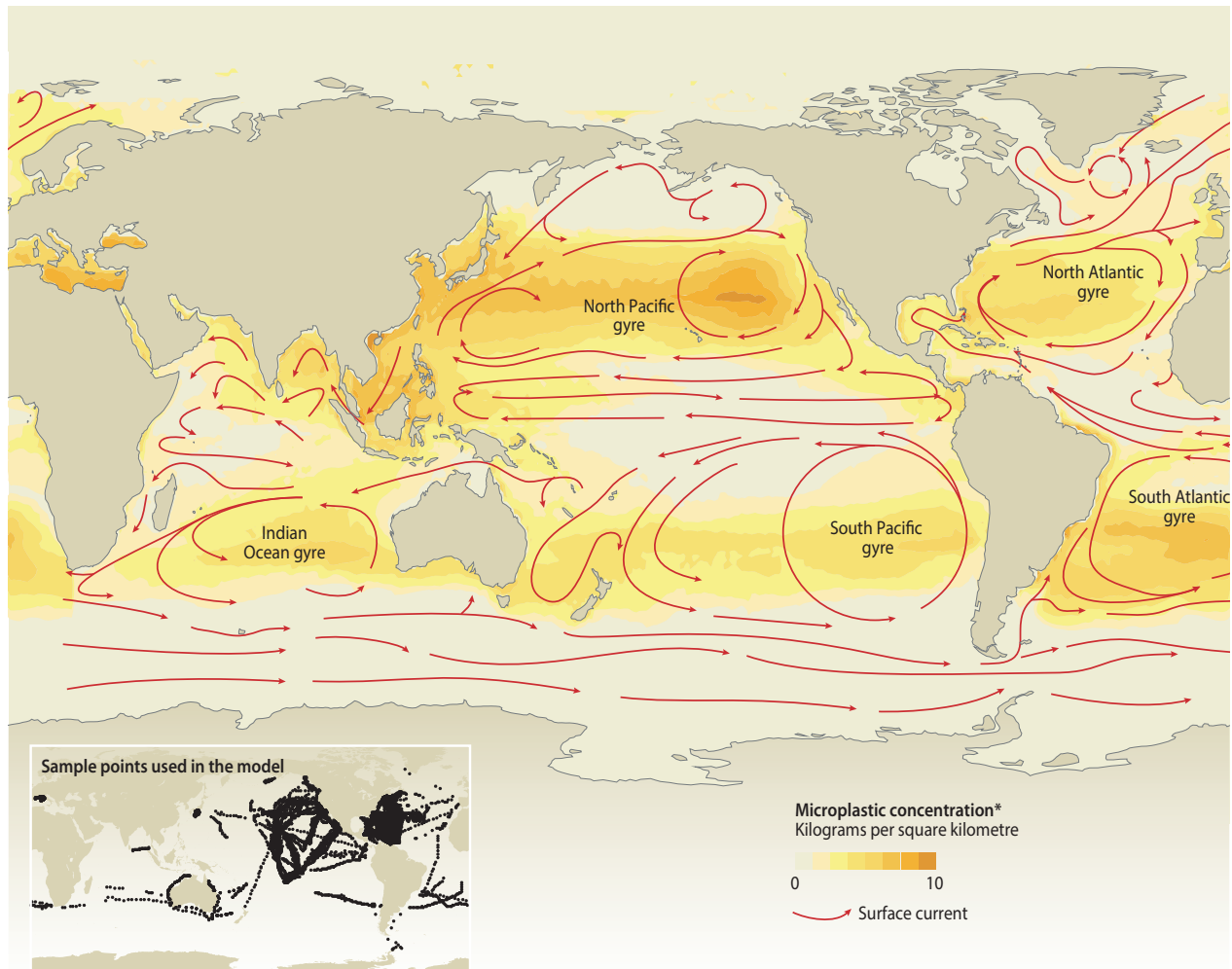


**Figure 3.10: Global map of potential marine plastic input to the oceans, based on human activities and watershed characteristics**



Source: Map produced by GRID-Arendal (2016a), based on data from Halpern *et al.* (2008), Watson *et al.* (2012) and Jambeck *et al.* (2015).

Figure 3.11: Plastic litter in the open ocean



Source: GRID-Arendal (2016b), based on data from van Sebille *et al.* (2015).

times the rate at which it is produced by nature. Sand removal causes significant damage to ecosystems and landscapes. {7.4.5}

**A potential future pressure is deep-sea mining** (*unresolved*). While commercial deep-sea mining has not begun, the growing number of contracts for deep-sea exploration can lead to future mining in the oceans. The potential impacts have not been completely studied. However, direct and indirect impacts on benthic communities are expected, as well as damage throughout the water column. Strategies and measures to limit and manage these impacts are under development. To be effective, they need to be finalized and in place before commercial seabed mining begins. {7.4.5}

### 3.2.4 Land and soil

**Land resources are essential to achieve several of the SDGs.** (*well established*) They contribute to ensuring

access to sufficient, healthy and nutritious food, especially by the most vulnerable groups. Land is complex to define, as it has multiple interconnected dimensions (e.g. as a provider of resources and services, as shelter, as property, and as a key to cultural identity). In this section land as a source of food, fodder, fibre and forest products is emphasized. Its ability to provide ecosystem services that regulate ecological processes is discussed in section 3.2.2 above. {Chapter 8, ExecSum}

**Current land management strategies are not conducive to achieving the SDG 15.3 target of Land Degradation Neutrality** (*well established*). Land degradation continues to increase more rapidly than it decreases (*established but incomplete*). Degradation entails the decline or disruption of land ecosystem services, including net primary production. Annual ecosystem losses resulting from land degradation have been estimated to range



from US\$ 6.3 trillion to US\$ 10.6 trillion. Assessments based on satellite data have shown land degradation hotspots to cover about 29 per cent of the global land area. About 3.2 billion people live in areas that are being degraded (*unresolved*). {8.6.1, 21.3.2}

**With improved seeds, machinery and fertilizers, based on current trends we are still unlikely to be able to supply future demands for food, energy, timber and other ecosystem services according to even moderate projections for land-resource availability** (*well established*). The world needs to produce at least 50 per cent more food to feed the projected global population of 10 billion people by 2050 (*well established*). At the aggregate level, yields are not increasing fast enough to meet demand without significant expansion of agricultural area. {Chapter 8, ExecSum}

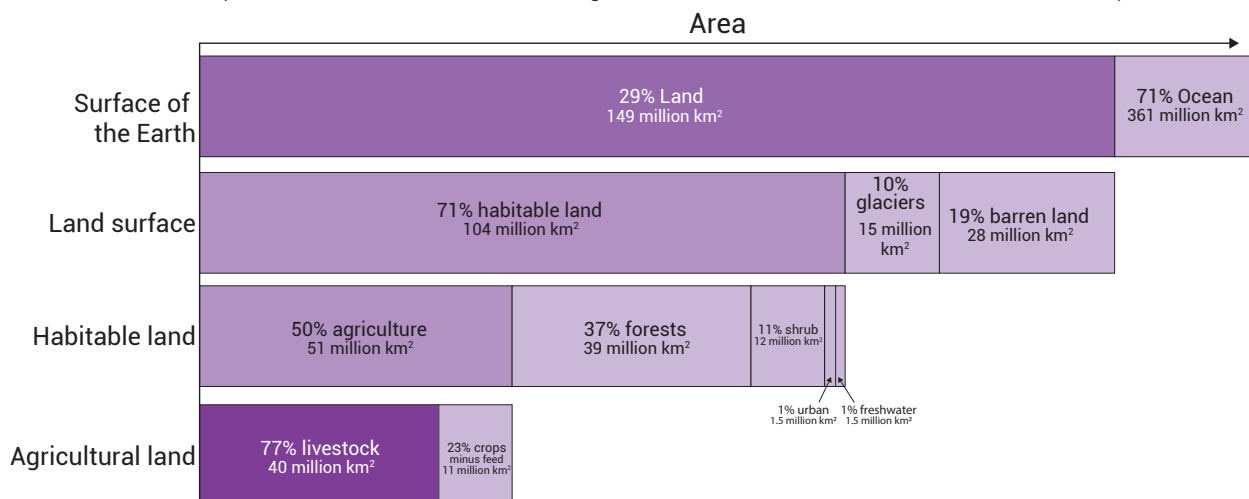
**Food production is the largest anthropogenic use of land, accounting for 38 per cent of all ice-free land** (*well established*). Land is extremely dynamic. Changes in land cover occur as a result of climatic, geological or ecological processes. However, human land use, mainly for agriculture, is currently responsible for most of these changes (**Figure 3.12**). Livestock production uses more than three-quarters of agricultural land for feed production, pasture and grazing (**Figure 3.12**) (*well established*). The livestock sector provides only 18 per cent of calorie intake and 32 per cent of dietary protein demands. Using 80 per cent of agricultural land for feed production is therefore inefficient (*well established*). {8.4.1}

**The expansion of agricultural area has slowed down with increasing productivity** (*established but incomplete*). While the harvested crop area increased 23 per cent between 1984 and 2015, global crop production rose 87 per cent (*well established*). On average, daily food supply in the world per person increased 10 per cent between 1993 and 2013 (*well established*). However, this expansion has mostly been the result of monocultural farming systems, which are sometimes assumed to be more efficient than polycultural systems although they are responsible for environmental degradation and biodiversity loss (*established but incomplete*). As demand for flexible crops has grown, many areas have been converted to cropland. Between 2000 and 2014, while the human population grew by nearly 19 per cent, the number of cattle and buffalo, goats and sheep, poultry birds, and pigs increased by 13.8 per cent, 21.9 per cent, 45.4 per cent and 15.1 per cent, respectively. The increase in livestock numbers has been accompanied by a decrease in pastureland and permanent meadows. These high growth rates are mostly associated with more intensive livestock production systems that rely on efficient use of animal feed. {8.4.1}

**Deforestation rates differ across regions. There is a global trend towards forest loss, but in some regions there has been an increase in forest cover (especially in more developed countries), although mostly as single-species plantations** (*well established*). In the 1990s about 10.6 million hectares per year (ha/yr) of natural forests were lost. In the period 2010-2015 this fell to 6.5 million ha/yr (*well established*). Simultaneously, the

**Figure 3.12: Global 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 [FAO] (2017a); Roser and Ritchie (2018).

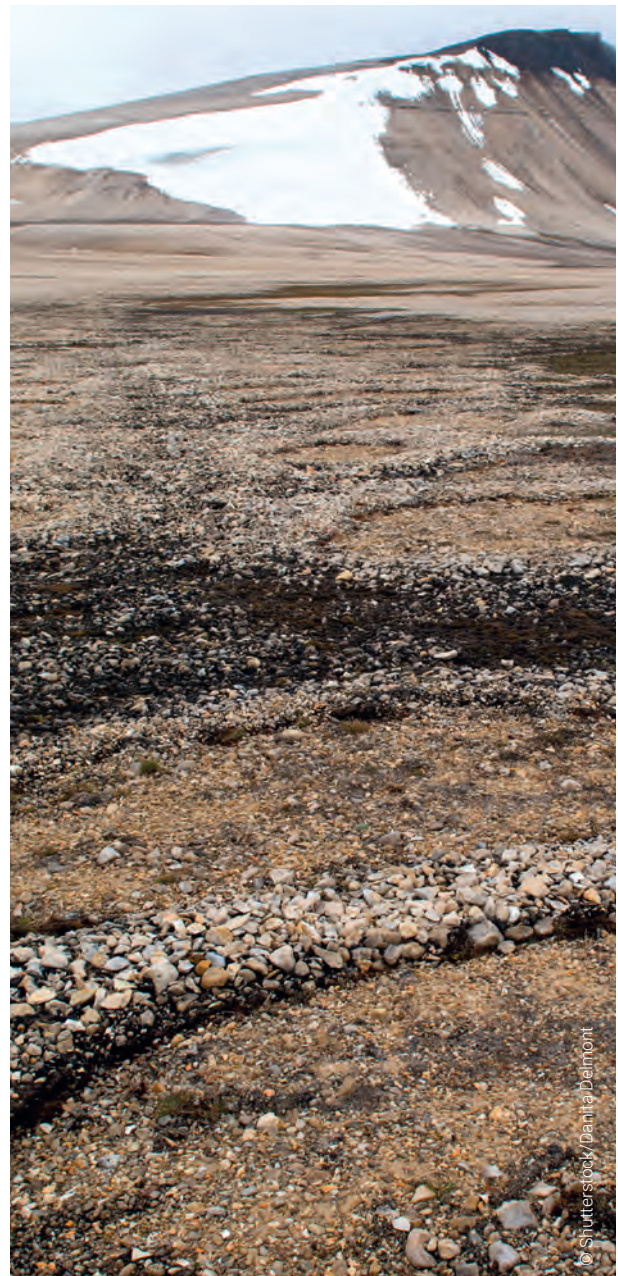


growth rate of forest plantation is about 3.2 million ha/yr, accounting by 2015 for 7 per cent of the global forest area, which was mostly concentrated in high-income countries (*well established*). The area of natural forests continues to decline in most parts of the world, threatening the provision of essential benefits. For example, as deforestation proceeds in the Amazon rainforest, the amount of rainfall has been decreasing. Recent estimates indicate that a critical tipping point for the hydrological cycle in this part of South America will be reached if deforestation reaches 20-25 per cent of original forest cover in the Amazon basin. During the last 50 years, 17 per cent of the original extent of the Amazon rainforest has been lost to deforestation and that area continues to decrease (Mongobay 2019; World Wildlife Fund 2019). {Chapter 8, ExecSum, 8.4.1}

**Developed areas occupy a very small fraction of the world's total land, but they have environmental impacts well beyond their borders** (*well established*). Since 1975 urban settlements have expanded approximately 2.5 times, accounting for 7.6 per cent of the global land area in 2015. Cities expand differently in different regions (*well established*). Most studies recognize the crucial importance of rural-to-urban migration for the mitigation of population pressure on land resources. Urban demand for food, water, fibre and construction materials, among other products, has established strong linkages between cities, rural areas, and even locations in other countries. These linkages, also known as “teleconnections”, mean that land use in rural areas increasingly depends on demand from distant urban agglomerations. Urban infrastructure (energy, water, buildings and transportation) and food supply are particularly reliant on transboundary supplies. Cities, with their impervious surfaces, affect the hydrological cycle and soil function as well as creating urban heat islands. Since 2000 cities have been creating more green space and planting more trees, which has the potential to provide multiple benefits that can enhance biodiversity and human well-being. About 3 billion urban dwellers in the world lack access to controlled waste disposal facilities, posing health risks and generating environmental impacts (*well established*). Much of the population increase in built-up areas has taken place in disaster-prone areas such as low-elevation coastal zones. {Chapter 8, ExecSum, 8.4.1, 8.5.2}

**Global food supply has become dependent on the growing trade in a small number of crops grown in a few regions, with increasing crop specialization** (*well established*). The share of global wheat, maize and soybean production that was traded internationally in 2014 was 24, 11 and 60 per cent, respectively (*well established*). This global trade leads to lower food

prices, and low-income food-deficit countries (LIFDCs) have benefited from cheap food imports. However, geographic concentration of production increases systemic risk, as illustrated by recent spikes in international commodity prices due to poor harvests in certain regions. As a result of climate change, such events may become more likely. Some LIFDCs have the capacity to increase their food productivity. In others, including countries where food insecurity is high (e.g. Burundi, Eritrea and Somalia), food availability from domestic production is falling and the capacity to increase production is limited. Most developing countries are increasingly reliant on imports to meet





domestic demand, a trend that will likely continue to 2050 (Figure 3.13). {Chapter 8, ExecSum, 8.5.1}

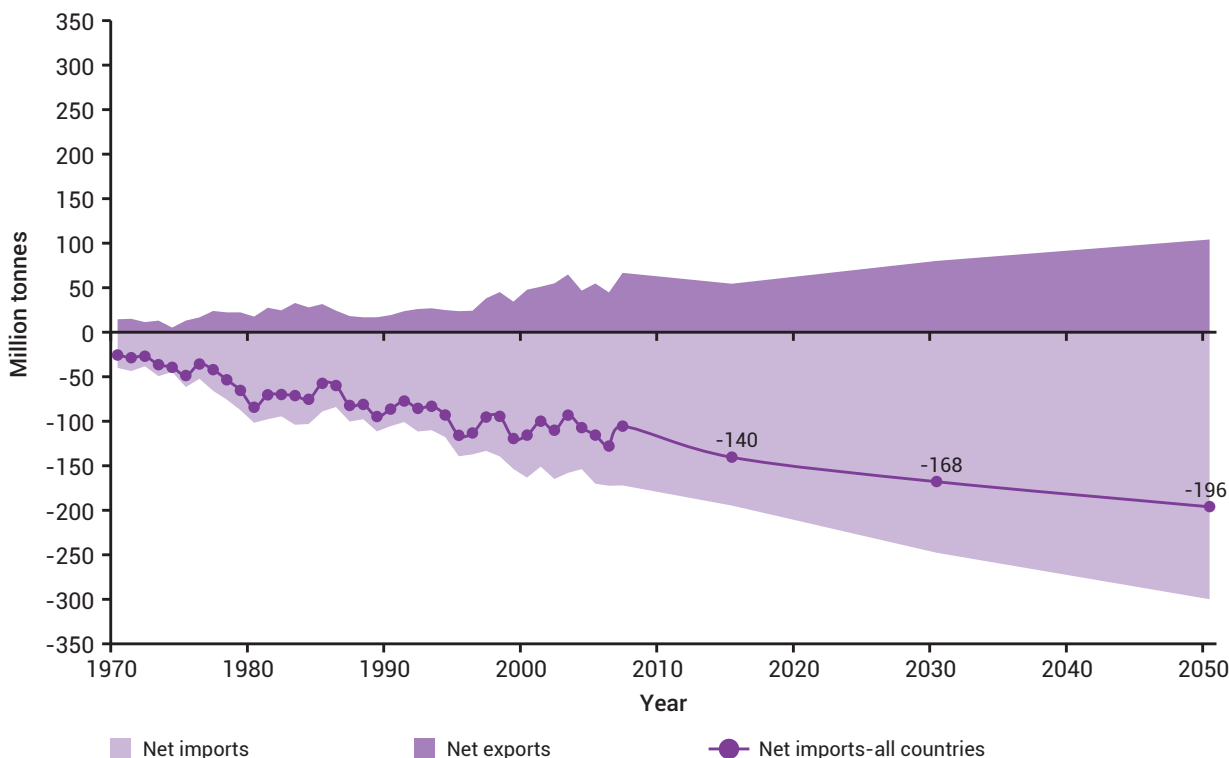
**Unequal access to land resources is a critical challenge for sustainable land management** (*well established*). According to the Land Rights Now initiative, 2.5 billion people depend on land resources that are held, managed or used collectively. As industrial, monoculture agriculture has expanded, competition for land between industry, governments and communities has increased, putting pressure on forests and drylands and threatening local people's livelihoods in some parts of the world. Many governments recognize rights to only a fraction of these lands (Figure 3.14). {8.5.3}

**There is a significant gender gap in access to and control over resources such as land and production inputs, as well as in access to information and technology** (*well established*). Agricultural contributions by women tend to be underestimated or not considered in official statistics, which usually focus on formal employment in agriculture and on commercially related agriculture. In 2011 women represented 43 per cent of those who were

"economically active" in agriculture. However, they held titles to less than 20 per cent of the world's agricultural land (less than 10 per cent in most of Africa) (Figure 3.15). The role of seed keeper and collector has traditionally given women a special status. However, this activity has been transformed by the shift to hybrid seed varieties, as they are bought rather than collected. Transformations associated with industrial agriculture, mostly through habitat conversion and loss of agricultural diversity, also directly affect the agricultural roles of women, not only with regard to their knowledge of seeds but also their participation in food production, cooking and crop processing. {Chapter 8, ExecSum, 8.5.4}

**Amid fears about food scarcity and rising food prices, some countries have also been experiencing the effects of large-scale transnational land acquisitions ("land grabbing") and leasing** (*well established*). Although estimates vary, since 2000 at least 26.7 million to 42 million hectares of agricultural land around the world came under the control of foreign investors. As of 2016, Africa was the most significant area of foreign investment, with 42 per cent of all such deals and 10 million hectares (37 per cent of

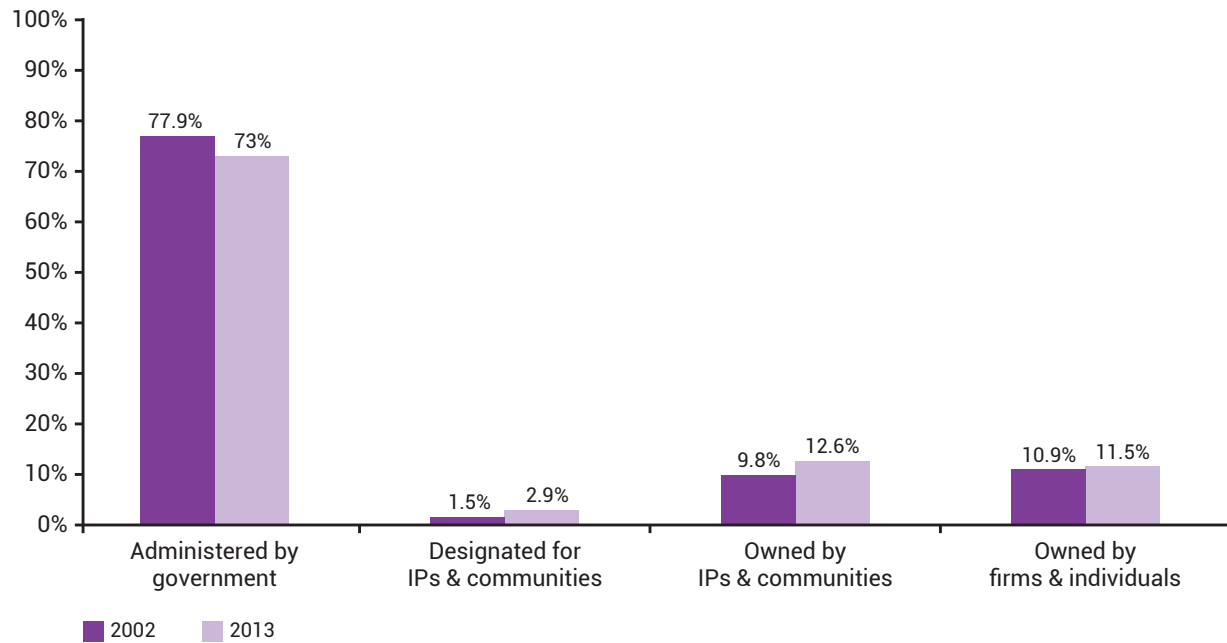
**Figure 3.13: Developing countries: net cereals trade (million tonnes). Net cereal imports have increased since 1970 and are expected to rise**



Source: Alexandratos and Bruinsma (2012).

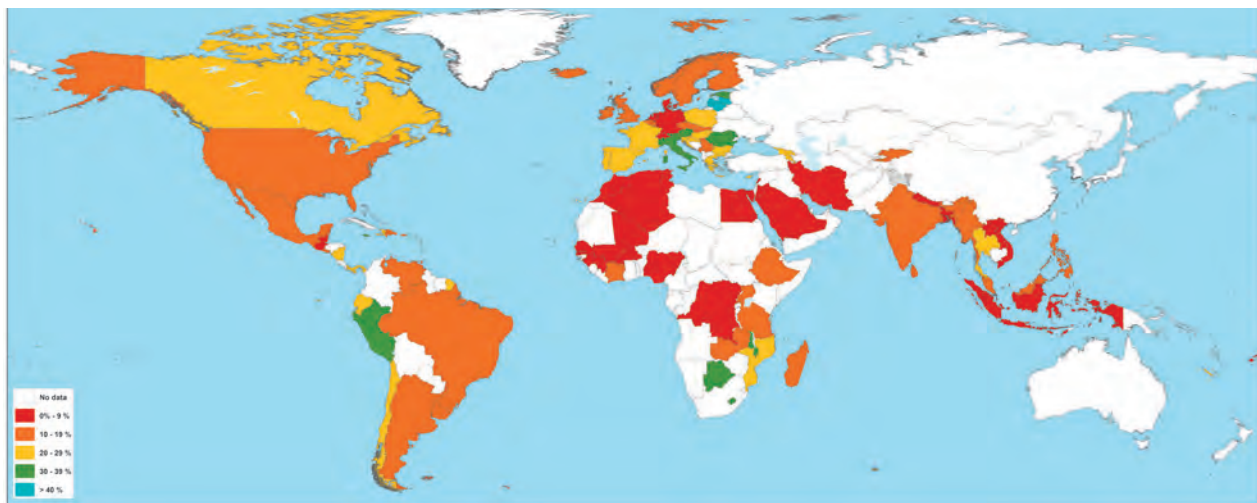


Figure 3.14: Global forest ownership, 2002-2013



Source: Rights and Resources Initiative (2015).

Figure 3.15: Distribution of agricultural land holdings: females



Source: FAO (2017b).

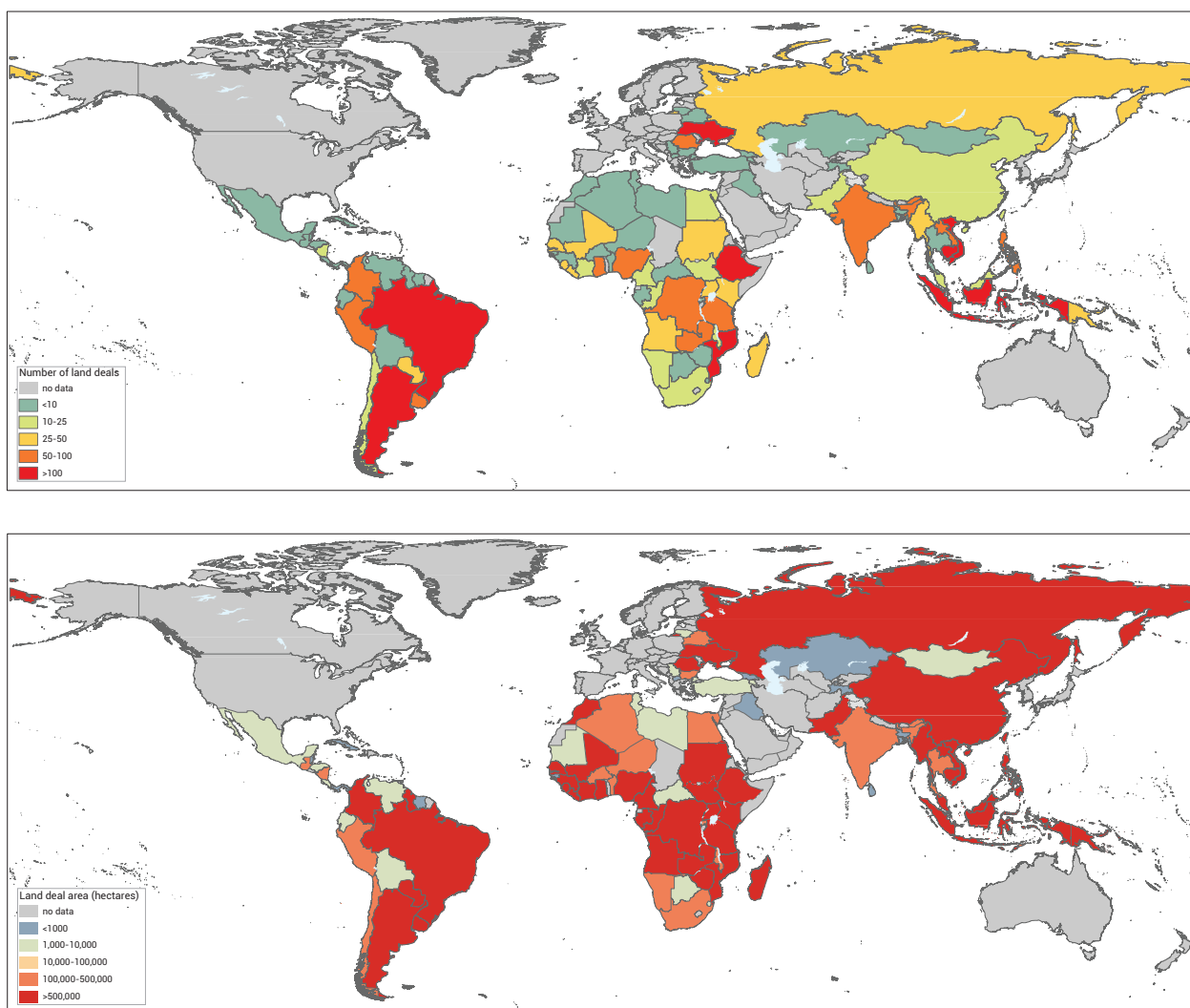


total area covered by the land acquisitions worldwide (Figure 3.16). Food and biofuels produced on this land are unlikely to reach local communities. Most such land acquisitions do not include domestic shareholders or local community negotiations, despite often targeting relatively highly populated areas that are dominated by cropland. {Chapter 8, ExecSum, 8.5.4; 15.4}

**There is growing competition between the economic production value of land and its commodification as a global financial instrument.** The market price of crops has long been the standard for determining land prices. However, speculation in land and land grabbing can distort the actual economic value of land. With increasing land scarcity, the trend to consider land

as a commodity is only strengthened. As land prices increase, more farmland will be sold to outsiders for speculative purposes. This land could be left idle for some time, leading to lower agricultural production and exacting a significant social cost if the practice becomes widespread. In the European Union (EU) inflationary pressures have fueled land speculation and the acquisition of agricultural land. This rapid inflation has been attributed to the rise of “new investors”, some of whom have little connection with farming. Loss of prime agricultural land, expansion of cities, urban development, tourism and other commercial undertakings have been referred to collectively as “land artificialisation”. Speculation and “artificialisation” contribute to farmland concentration in the EU by

Figure 3.16: Global map of land deals

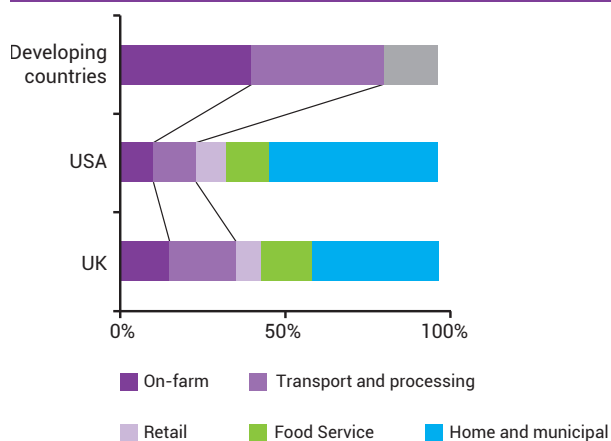


Source: Godfray et al. (2010).

raising the stakes and increasing barriers for prospective farmers. {8.6.1}

**Approximately one-third of the edible parts of food produced globally for human consumption is lost or wasted and with it the resources used in production (land, water and energy) (well established).** Food losses and food waste in 2007 utilized almost 1.4 billion ha of land, equivalent to about 28 per cent of the world's total farmland. Based on food crop data for the period 2005-2007, food losses and food waste consumed 23 per cent of total global fertilizer use (28 megatonnes/year) and 24 per cent of total freshwater resource use. They were also associated with substantial environmental impacts and generated a high amount of GHG emissions. It has been estimated that 99 per cent of food wastage at the agricultural production stage occurs in areas where soils are experiencing medium to strong land degradation, placing further stresses on these areas. Approximately 56 per cent of total food loss and waste has been estimated to occur in developed countries, with 44 per cent occurring in developing countries (well established). Losses in the global South are mainly due to the absence of food-chain infrastructure and lack of knowledge of (or investment in) storage techniques. Pre-retail losses are lower in the global North, but losses arising at later stages along the food chain (retail, food service, home) have increased in recent years (Figure 3.17). {8.5.1}

**Figure 3.17: Make-up of total food waste in developed and developing countries**



Note: Retail, food service and home and municipal categories are presented together for developing countries.

Source: Godfray et al. (2010).

### 3.2.5 Freshwater

**Freshwater mobilizes and amplifies the risks to human health and the environment associated with human activities (established but incomplete).** Freshwater is both a public good and a risk multiplier, affecting human and ecosystem health through excessive abstraction, pollution and climate change. Water scarcity is a key contributor to political instability and conflict. There is an urgent need to improve governance of every aspect of the water cycle to prevent, mitigate and manage these increasing risks. {9.2}

**Water scarcity can exacerbate social conflicts, particularly when adequate legal instruments are lacking (e.g. in transboundary water systems) (well established).** An increasing number of people are at risk of slow-onset disasters such as water scarcity, droughts and famine. Such events can lead to increased migration and social conflicts (well established). There is evidence that water scarcity stimulates greater competition for available resources, which is reflected in food insecurity, trade and prices (established but incomplete). Groundwater comprises a much larger freshwater volume than surface water and is becoming increasingly important for water security in many countries (established but incomplete). {9.2}

**Climate-related events such as cyclones, storm surges, tsunamis and sea level rise can result in the degradation of coastal land and aquifers (well established).** Floods and storms can destroy infrastructure, cost lives, damage agriculture, and have water quality impacts with cascading impacts on health (well established). The increasing severity and frequency of water-related disasters pose growing risks to economic and social stability, as well as to ecosystems and their life-supporting ecosystem goods and services. {9.2}

**Increasing glacial melting and retreat are occurring due to climate change, with major potential longer-term impacts on regional surface water availability, especially in the case of the Asian and Latin American glacier-dependent river systems that provide water to about 20 per cent of the global population (well established).** Limited capacity exists at present to control the long-term impacts of glacial melting and aquifer over-abstraction (established but incomplete). Some significant aquifers at the sub-regional and regional scale are threatened by poor management, resulting in unsustainable abstraction levels driven by irrigation water for food production needs (established but incomplete). {9.9}







**Water pollution from both point and non-point sources occurs worldwide.** The presence of pathogens, nutrients, sediments, heavy metals, plastic waste, organic compounds (including POPs) and salinity are causing pollution problems globally, which vary in severity across regions and continents. Water pollution has worsened since the 1990s, including in rivers in Latin America, Africa and Asia, where severe pathogen pollution affects approximately one-third of river systems (*well established*). Approximately 1.4 million people die annually from treatable diseases associated with pathogen-polluted drinking water and inadequate sanitation and many others become ill (*well established*). Some 2.3 billion people still do not have access to safe sanitation. Women bear the greatest burden of inadequate sanitation. The total global disease burden could be reduced by as much as 10 per cent through improved drinking water quality and access, sanitation, hygiene, and integrated water resources management. {9.5} Investments in water and sanitary services can produce more than four times that amount in health returns {9.9.1}

**New pollutants that are not easily removed by current wastewater treatment technologies are of emerging concern; these include some veterinary and human pharmaceuticals, insect repellents, antimicrobial disinfectants, fire retardants, detergent metabolites, microplastics and nanoparticles** (*well established*). Endocrine-disrupting chemicals are widely distributed throughout the freshwater system on all continents. The long-term generational impacts of these chemicals on human health include foetal underdevelopment, neurodevelopmental problems, elevated risk of breast cancer in women, and male infertility. In addition, human illnesses and deaths due to antimicrobial and antibiotic-resistant infections are increasing rapidly; they are projected to become the main cause of death worldwide by 2050 unless effective measures are taken (*well established*). While causes include antibiotic use in intensive livestock production and aquaculture, a major reason is the excretion of antibiotics which then enter the environment. Antibiotic and antimicrobial compounds are found in nature at a wide range of concentrations, but even at low concentrations they can cause bacterial selection for antibiotic resistance. Wastewater treatment plants are currently unable to remove most antibiotics, and their capacity to remove antibiotic-resistant bacteria is variable. Antibiotics are now found in both source water and treated drinking water worldwide. {9.7}

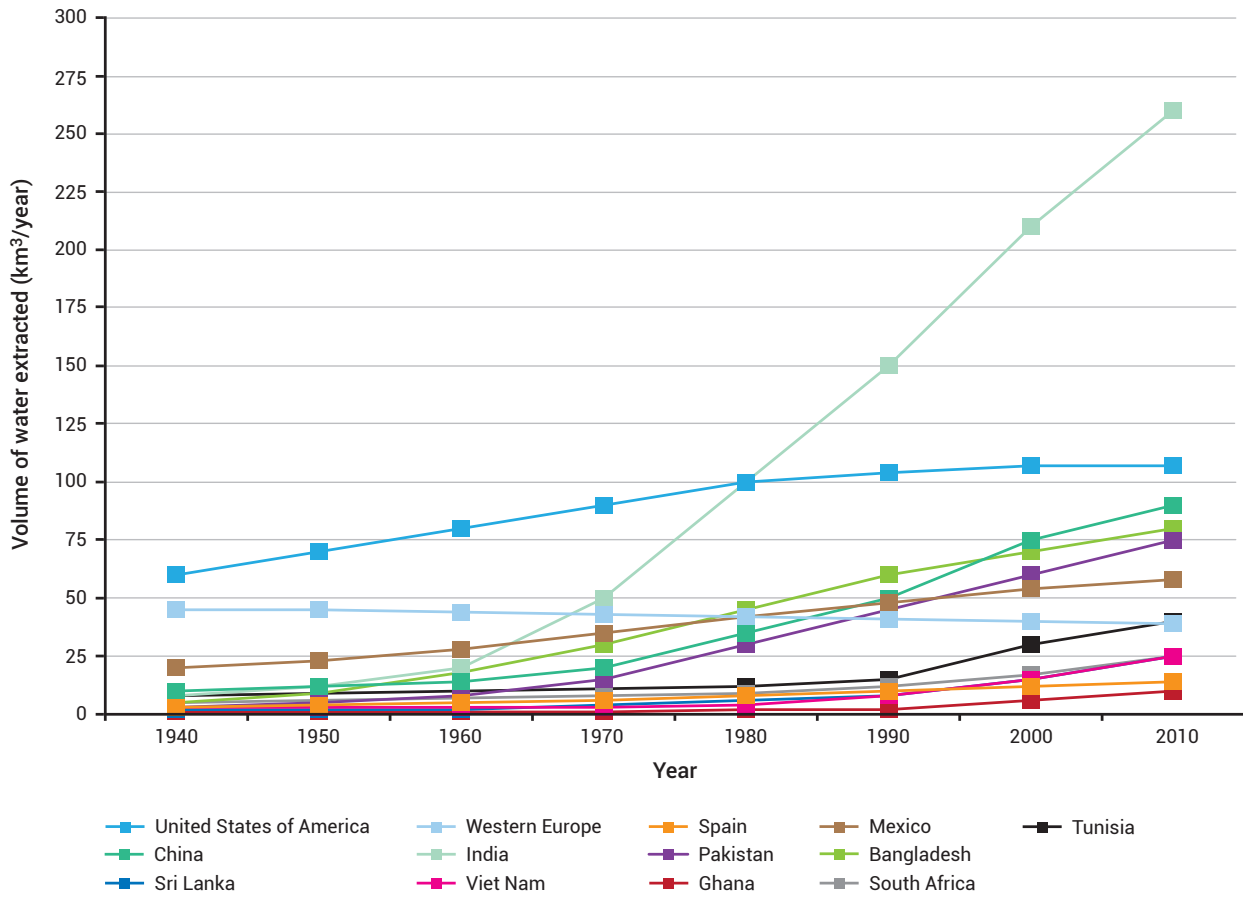
**Freshwater ecosystems are among the world's most biodiverse habitats, and provide a very wide range of ecosystem goods and services to humanity, but they are also the natural areas most affected by increasing urbanization, agricultural expansion and deforestation** (*well established*). Ecosystem resilience is increasingly impacted by water infrastructure (e.g. dams and reservoirs), groundwater abstraction (**Figure 3.18**) and land-use change (e.g. conversion of wetlands to agricultural or urban land). It is further affected by extreme climate events such as droughts. Lakes, reservoirs, wetlands and other lentic (standing) water systems are particularly important for the provision of ecosystem goods and services of all the freshwater ecosystems. Wetland habitat losses and river fragmentation (e.g. resulting from dam construction and water diversion) have significant impacts on freshwater fish populations (especially migratory fish), affecting the livelihoods of millions of people (*established but incomplete*). Approximately 40 per cent of the world's wetlands were lost between 1997 and 2011. This loss is linked to an 81 per cent freshwater decline in species populations in the same period – the highest biodiversity decline of any habitat type (*established but incomplete*). The annual economic cost of wetland, swamp and floodplain (a subset of the full range of freshwater ecosystem services) losses between 1996 and 2011 has been estimated at US\$ 2.7 trillion (*established but incomplete*). {9.6}

**Women and girls still bear most of the physical burden and social responsibility of transporting water in many developing countries, reducing the time available for them to participate in productive activities and education** (*well established*). The beneficial effects of taking part in other activities should be widely acknowledged. Economic surveys indicate that women typically reinvest up to 90 per cent of their income in their families, improving family health and nutrition and increasing access to schooling for children. On the positive side, 1.5 billion people gained access to basic drinking water services during the 15-year period from 2000 to 2015 (*well established*). {9.7.1}

**Worldwide, agriculture uses an average of 70 per cent of all freshwater withdrawals, rising to 90 per cent in many poorer countries** (*well established*) (**Figure 3.19**). Agriculture is responsible for water pollution through run-off containing excess fertilizers and pesticides. Competition for more water from cities and industry creates an imperative to improve the efficiency of agricultural water use while using fewer and less harmful inputs (*well established*). {4.4.3}

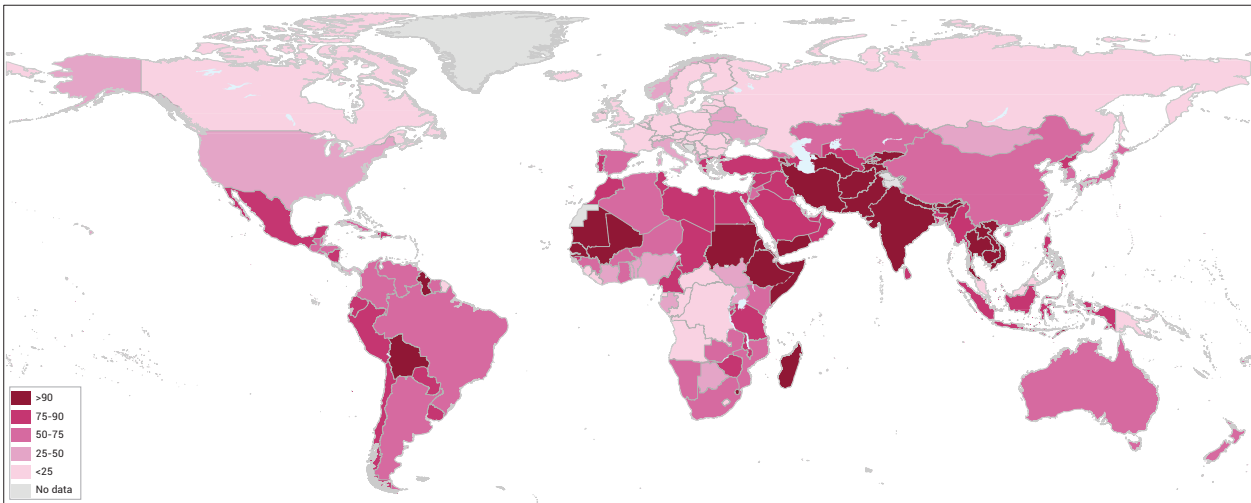


Figure 3.18: Global trends in increasing groundwater use



Source: Shah (2014).

Figure 3.19: Proportion of total water withdrawn for agriculture



Source: Adapted from FAO (2015).



### 3.3 Human health, equity and economic dimensions

#### 3.3.1 Health of the planet and human health

The combined evidence shows that the planet is becoming increasingly unhealthy due to the negative impacts of climate change, air pollution, water pollution, land transformation and degradation, ocean pollution and depletion, and biodiversity loss (including the loss of pollinators, coral reefs and mangroves) (*well established*). Some of the GEO-6 authors looked at the different earth system components individually and ranked impacts from 1 to 5 (worst to least affected) for the period 2018-2050, with a focus on degrees of irreversible damage (**Table 3.2**). Biodiversity was the worst affected (with very significant irreversibility), followed by air (the impacts of climate change are mostly irreversible), oceans (the impacts of climate change are largely irreversible and over-exploitation of fish stocks are partly irreversible),

freshwater (the impacts of groundwater abstraction could be irreversible in the medium term) and land. These impacts on environmental components may have feedback effects and cascading impacts which could push systems past planetary boundaries (Gupta *et al.* 2019a).

**The poor health of the planet is affecting human health (*well established*).** Degradation of the environment adversely affects food and water security, together with other aspects of health and well-being (e.g. through air pollution, contamination of food and/or water, insufficient or excessive exposure to sunlight, noise pollution, and conflict and war). {3.6.2}

**An unhealthy planet also affects people's ability to work and their productivity (*well established*).** The impacts of air quality on human health received attention in the Global Burden of Disease Study, a

**Table 3.2: Ranking the health of the system components of the planet (2018-2050)**

	Key issues <sup>1</sup>	Evaluation	Rank
Atmosphere	Climate change	Reaching irreversibility globally; rapid onset disasters worldwide: unpredictable/irreversible	2
	Indoor air pollution	Critical locally in poor households, occurring in developing countries: reversible	
	Outdoor pollution	Critical locally especially in urban areas, occurring worldwide: reversible	
Land	Land degradation	Critical locally, occurring worldwide, partially reversible	5
	Landscape transformation	Critical locally, occurring mostly in the global South, partially reversible	
	Waste and chemical pollution	Critical locally, occurring worldwide, partially reversible*	
Freshwater	Slow onset disasters (water scarcity, drought)	Critical locally and regionally, occurring worldwide, predictable and partially reversible	4
	Changing precipitation patterns	Reaching irreversibility globally	
	Freshwater pollution and quality	Critical locally, occurring worldwide, partially reversible locally, partially irreversible globally	
	Fossil water extraction	Critical locally, occurring worldwide, irreversible	
Oceans	Ocean warming, acidification, sea ice melting, sea level rise	Reaching irreversibility globally	3
	Coral bleaching	Reaching irreversibility globally	
	Plastics	Reaching irreversibility globally	
	Fish stocks	Critical locally, occurring worldwide, partially reversible	
Biodiversity	Loss of genes, species, ecosystems	Irreversible globally	1
	Invasive species	Reaching irreversibility, occurring worldwide, critical locally	
	Illegal wildlife/timber/fisheries trade	Critical locally, occurring worldwide, partially reversible	

\*There is preliminary evidence that the more than 100,000 chemicals in use are contaminating earth systems and exacerbating disease. However, for most of these chemicals there has been relatively little research on their overall health impacts.

Note: The key issues are listed in no particular order within each environmental topic.

Source: Adapted from Gupta *et al.* (2019a)

1. Ocean warming, acidification, sea ice melting, sea level rise



global study of factors influencing human health which elevated the reduction in air pollution to a top priority. {3.4.2}

There is a number of new challenges, to which sound, relevant scientific research may be able to respond. (well established) These include the growth of pathogen resistance (antimicrobial resistance) to antibiotics that have been and still are used heavily in agriculture, aquaculture and human medical treatment; the large number of industrial chemicals, which challenges our ability to meaningfully test these chemicals' potential impacts on human health and

the environment (including for future generations), even if not all these chemicals are widely used; the cumulative effects (social and environmental) of multiple exposures, including to chemical mixtures; the emergence and re-emergence of infections originating in birds and animals; increased physical inactivity associated with new technology for work and leisure; and other challenges including some whose effects on human health are as yet unclear (e.g. the presence of microplastics in fish and marine biological resources). {4.2.1} Some endocrine-disrupting chemicals are of particular concern because of their potential multigenerational effects on human health (with most

**Table 3.3: Ranking the impact of system components on human health (2018-2050)**

	Key issues	Evaluation	Rank
Atmosphere	Climate change, including temperature rise	Displacement high globally; death globally; loss of homes and livelihoods; more premature deaths of older people and children	1
	Indoor air pollution	Non-infectious disease; very high mortality/morbidity in poor households, especially for women and children; locally occurring in the global South	
	Outdoor pollution	Non-infectious disease; very high mortality/morbidity in urban areas, especially for children and older people; occurring worldwide	
Land	Land degradation	Displacement occurring regionally worldwide; loss of homes and livelihoods, especially by poorer people	5
	Wildland transformation	Displacement occurring regionally in the global South; loss of homes and livelihoods	
	Waste and chemical soil pollution	Non-infectious disease; mortality, morbidity especially in rural areas; occurring worldwide	
Freshwater	Slow-onset disasters (water scarcity, drought)	Affects health, hygiene, food security, displacement and conflict; very high regionally, especially for children, occurring in the global South; loss of homes and livelihoods	2
	Changing precipitation patterns	Affects food security, displacement, conflict, high regionally; loss of homes and livelihoods	
	Waste and chemical water pollution (including antibiotics and endocrine disruptors)	Infectious and non-infectious disease; mortality, morbidity; anti-microbial resistance; endocrine disruptors affect fertility of many species, as well as human male fertility	
	Fossil water abstraction beyond recharge	Affects food security, displacement, conflict	
Oceans	Ocean warming and sea ice melting	Death from extreme weather events, death and displacement as a result of sea level rise	4
	Coral bleaching	Affects food security (protein intake of the poor), livelihoods of small fishers, tourism	
	Plastics	Could potentially lead to health risks	
	Fish stocks	Affects food security (main source of protein intake for many people, including the planet's poorest)	
Biodiversity	Genes, species, ecosystems	Affects food security and income; psychological health and cultural identity; zoonotic infectious diseases affecting more vulnerable people; species affected by endocrine disruptors	3
	Invasive species	Spread of pathogens/infectious disease; food insecurity; cultural impacts of key species lost; very high locally, high globally	

Source: Adapted from Gupta *et al.* (2019a).





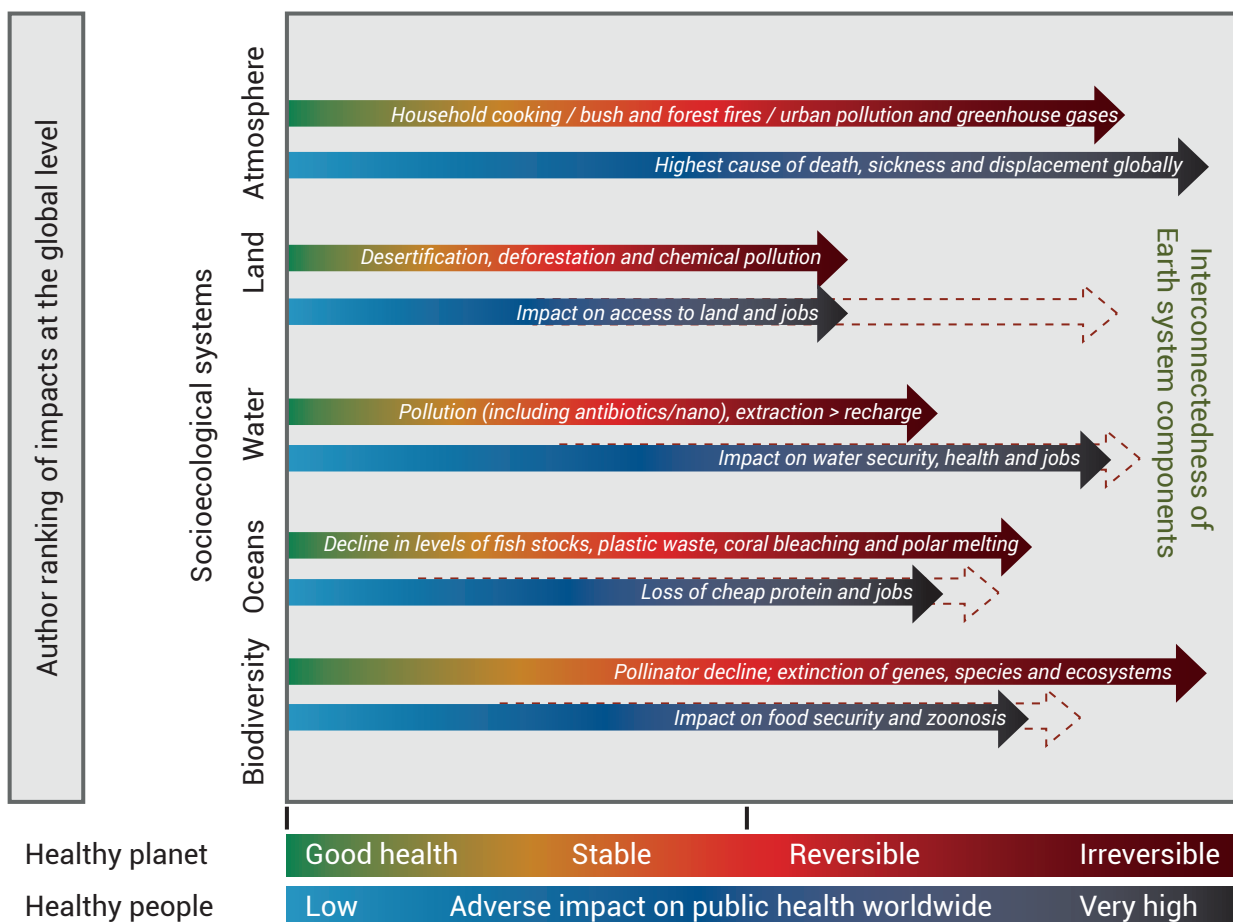
of those effects being gender-differentiated) and on wildlife. {4.3.3} Many products used in everyday life, including cosmetics, plastic containers, household cleaners and pesticides, contain compounds that may affect human health and the environment. {4.3.3}

**There is a growing risk of land use change, loss of biodiversity, and increased agricultural activity changing infectious disease distributions in flora, fauna and humans {4.3.1}. (well established)** This results in greater exposure of humans to emerging infectious disease {Chapter 6, 6.4.1}, often spread by invasive insect vectors {6.4.2}. For example, oil palm plantations in South America may have increased the risk of Chagas disease and forest burning to make place for oil palm may have contributed to the migration of bats, known to carry Nipah virus {6.6.4}. Zoonosis accounts for

about 60% of all infectious disease and while there are some projects to study zoonosis hotspots {**Box 6.1**}, the negative impacts of policies on health have typically focused on natural hazards or infectious disease, and little has been done to capitalize on the potential co-benefits on human health or ecosystems {16.4}

**Figure 3.20** is a “burning embers” figure in which the rankings of environmental disruptions are translated into bars. The length of each bar represents the impact: the worse affected, the longer the bar; the darker the colours, the less reversible an impact in the period to 2050. Dotted lines represent impacts on the most vulnerable and disadvantaged (but it should be noted that this is only a first attempt to capture these impacts).

Figure 3.20: Impacts on the health of the planet and people



Note: Rows reflect the system components. Green to brown arrows show the impact on the system components; blue to black arrows show impacts on human health. Dotted lines reflect the fact that, if the cumulative nature of a locally occurring problem and its impacts on the most vulnerable is considered, these impacts are even more serious than if the problem is simply averaged out.

Source: Gupta et al. (2019b).



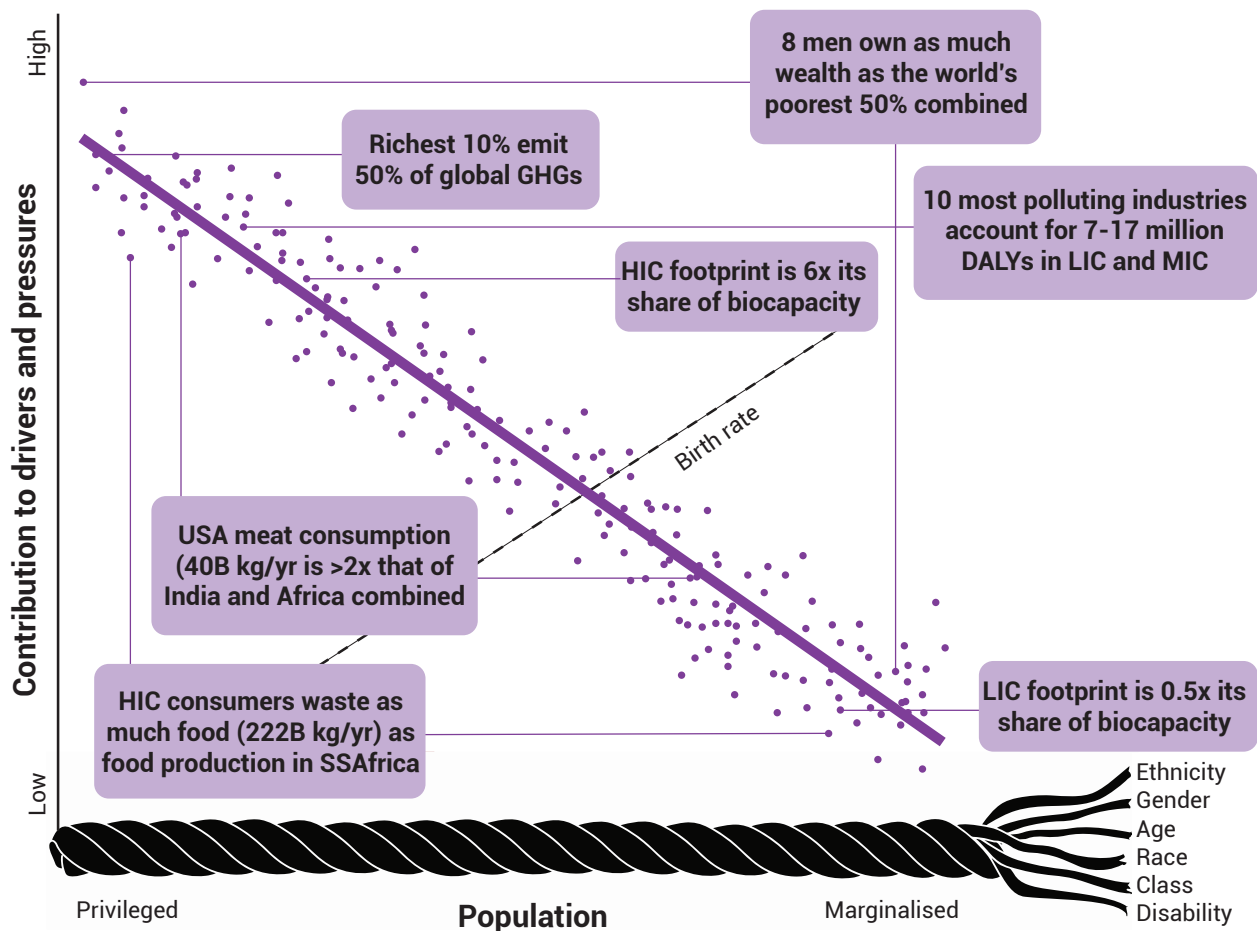
### 3.3.2 Cross-cutting equity, gender and economic issues

The drivers of environmental damage and pressures on earth systems reflect prevailing priorities in socioeconomic investments, and production and employment approaches. They disproportionately affect the most vulnerable populations (*established but incomplete*). The pursuit of growth using the current economic model and related investment, production and employment patterns leads to continuous resource extraction and externalizes pollution and related social costs. It is also characterized by unequal consumption patterns, with a relatively small percentage of the global population and industry being responsible for a higher proportion of the environmental impact. The environmental footprint of richer people is significantly higher than that of poorer people (Figure 3.21). {Co-chairs' Message, 17.3.1}

Drivers and pressures are differentiated globally, reflecting regional, social and gender inequalities (*established but incomplete*). The largest share of global wealth and resources is controlled by richer people in industrialized countries. *Monthly* emissions per capita among the richest 10 per cent of the world's equal annual emissions per capita of the bottom 50 per cent of the world population (Hubacek *et al.* 2017). The richest countries consume 10 times as much material per capita as the poorest countries. The top 10 per cent of emitters emit 45 per cent of world emissions of CO<sub>2</sub> {Cochairs' Message, Figure 2.10}

Ecosystems provide direct and indirect opportunities for employment and livelihoods (*well established*) and these opportunities are unevenly distributed. Opportunities exist in the agriculture, energy, fisheries, extractive and services sectors, among others. Ecosystems *directly* support the resource base, lives and livelihoods of

Figure 3.21: Contribution to drivers and pressures of privileged and marginalized people



Source: Gupta *et al.* (2019b).



70 per cent of the Earth's population living in poverty {Chapter 6, 6.3.4, 6.6.3, Box 6.5; Box 13.2; 2.2.2; SPM}, particularly those who are very poor.

**Social disparities in the custodianship and stewardship of air, freshwater, land and soil, oceans and coasts, and biodiversity are often overlooked** (*established but incomplete*). Approximately 80 per cent of global biodiversity is on the land of indigenous peoples, who live on and use at least 25 per cent of the world's total land surface (IPBES 2019). Indigenous peoples and local communities are credited with having looked after the bulk of global ecosystems including the seeds. {6.1}

**Exposure to environmental risks is often regionally differentiated. Such exposure is increasing in low- and middle-income countries. The risks associated with environmental degradation and climate change are generally more profound for people who are already socially vulnerable** (*established but incomplete*). Climate change exacerbates risks to human societies through its indirect impacts on food and water security (*established but incomplete*) and on human security, health, livelihoods and infrastructure. These risks are greatest for people living, for example, in coastal, agricultural, pastoral and forest communities and members of social groups who already suffer from multiple forms of inequality, marginalization and poverty and are therefore likely to be most exposed to the impacts. {Chapter 2, ExecSum, 2.7.3} There is robust evidence that climate change and greater climate variability worsen existing poverty, exacerbate inequalities and contribute to new vulnerabilities. More severe impacts can be expected as climate change worsens. {Chapter 5, ExecSum, 5.3.4}

**Human health and well-being cannot be sustained on an unhealthy planet.** Air pollution is the greatest environmental contributor to the global burden of disease and is responsible for high economic losses (*established but incomplete*). Around 3 billion people still cook using open fires and inefficient stoves with solid fuels (e.g. wood, crop wastes, charcoal, coal and dung) and kerosene. Most of them are poor and live in low- and middle-income countries. Every year close to 4 million people die prematurely from illness attributable to the household air pollution caused by inefficient use of solid fuels and kerosene for cooking (WHO 2018b). A further 3.2 to 3.5 million premature deaths have been attributed to other sources of ambient air pollution at high welfare costs. {Chapter 5, ExecSum, 5.3.1}

**Climate change alters weather patterns, which has a broad and deep impact on the environment, economies and society, threatening livelihoods, health, water resources, and food and energy security**

(*well established*). In turn, this increases poverty (*well established*), migration, forced displacement and conflict (*established but incomplete*), with particular impacts on populations in vulnerable situations (*well established*). {4.2.2}

**The estimated annual cost to the global economy of biodiversity loss and loss of ecosystem functions will be up to €14 trillion by 2050; this is equivalent to 7 per cent of projected global GDP** (*established but incomplete*). Another estimate places the global cost of loss of ecosystem services only from land-use change at US\$ 4.3 to US\$ 20.2 trillion per year (in 2007 valuation) between 1997 and 2011. In particular, the value to the commercial sector of pollinators, which provide crucial services for commercial and non-commercial food production, has been estimated at US\$ 351 billion per year. {Co-chairs' Message; 13.1; Box 6.6}

**While it is impossible to be precise, the estimated costs of inaction underscore the need for policy action** (*well established*). Moreover, the importance of biodiversity to health in all its dimensions has emerged in initiatives such as ecosystem approaches to health such as Ecohealth, One Health and Planetary Health. There is a growing focus on the relationship between the health of humans, domesticated and wild animals, and other species in the context of complex social-ecological systems. {4.2.1; Co-Chairs' Message}

**In arid and semi-arid regions, lack of adequate drainage in irrigated areas is a reason for salt accumulation in the root zone, negatively affecting crop productivity and soil properties.** In some countries soil salinization affects around half of irrigated land. It has been suggested that the productivity of about 33 per cent of the globally irrigated area is declining due to inadequate irrigation, causing waterlogging and salinization. Several studies of grain yield losses due to salinization indicate average losses of 32-48 per cent. Annual global losses of irrigated crops due to salt-induced land degradation could be about US\$ 27.3 billion as a result of lost crop production. Total crop losses on this land could represent 15-69 per cent of revenues, depending on the type and intensity of land degradation, crop variety, and irrigation water quality and management. Additional losses not included in these estimates are related to a wide range of issues, from deterioration of animal health to a decline in the property values of affected farms, among others. {8.4.2}

**Environmental pressures and their impacts on health and well-being are not equitably distributed. They fall, in particular, on groups who are already vulnerable or disadvantaged such as young people, women,**

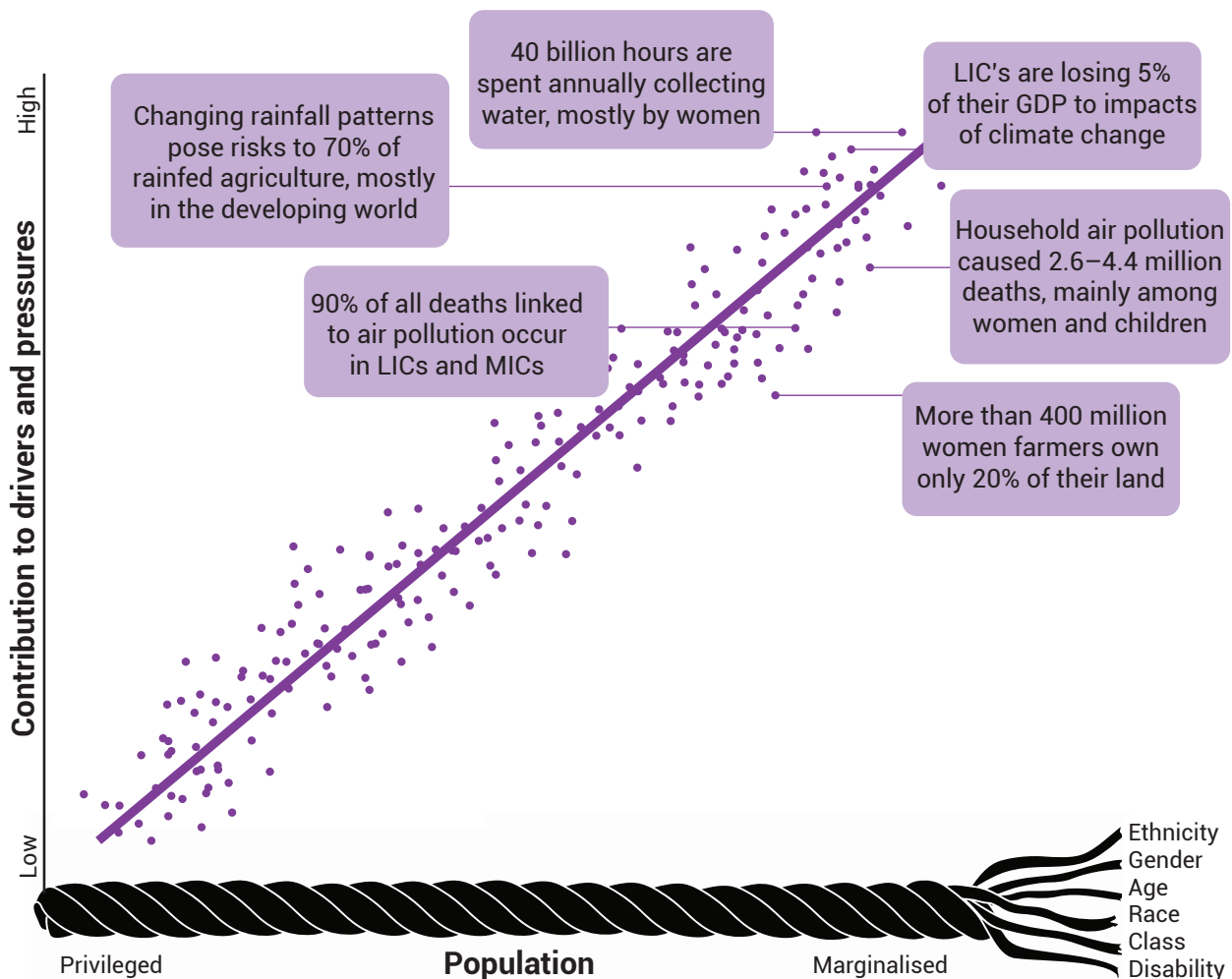


**older people, poor people, those with chronic health conditions, those targeted by racism, and indigenous peoples** (*established but incomplete*). For example, in 2015 exposure to indoor/outdoor air and water pollution was responsible for the loss of at least 9 million lives {4.2.1; Co-Chairs' Message} including 300,000 in the G7 countries. The economic losses for which ambient air pollution is responsible include medical expenditures (estimated at US\$ 21 billion globally in 2015), lost economic productivity due to pollution-related disease and premature death, and the cost of environmental degradation. Pollution-related welfare costs have been estimated at US\$ 4.6 trillion per year globally. {1.3.1} An estimated 29 per cent of land is degraded, affecting the lives and livelihoods of 1.3 to 3.2 billion people {8.3.2}, while slow-onset disasters are triggering migration. {9.3.4; 9.7.3} In 2016, 24.2 million people were internally displaced in 118 countries as a consequence of sudden-

onset disasters. {4.2.2; Co-chairs' Message} Many of the impacts listed above are serious or irreversible. They may lead to loss of livelihoods, increased morbidity and mortality, and economic slowdown, as well as having the potential to contribute to decreasing social resilience, mass migration and violent conflict. More effective adaptation measures are urgently required, especially for populations and regions in a vulnerable situation. {2.7.3; SPM} Children are particularly susceptible to the negative health impacts of chemicals because of their rapid growth and development and greater exposure relative to body weight. {1.3.2} Environmental refugees, displaced by environmental degradation, may suffer from health problems and difficulties in maintaining their livelihoods. {1.3.3}

**The societal impact of disaster-related damage to ecosystems differs from region to region** (*established*

Figure 3.22: Vulnerability to risks and impacts



Note: LIC is Low-Income Countries ; MIC is Middle-Income Countries ; HH is household

Source: Gupta et al. (2019b).

3





*but incomplete*). The extent, distribution and acute nature of impacts differ among countries. SIDS and coastal areas are experiencing rising sea levels, dying coral reefs, and the increasing frequency and severity of natural disasters. Several SIDS have experienced multiple natural disasters in one year (Haiti in 2004, for example) or close together during several years (Dominica experienced hurricanes Erika in 2015 and Maria in 2017). Such disasters affect poor countries, but also rich ones like Japan and the United States. Between 1995 and 2015 worldwide, an estimated 700,000 people died and 1.7 billion were affected by extreme weather events costing US\$ 1.4 trillion. {4.2.2; Figure 2.10, Figure 2.11} Between 2010 and 2016, an average of around 700 extreme events every year cost about US\$ 127 billion annually. While 90 per cent of these losses were recorded in high- and upper-middle income countries, less than 1 per cent of the losses in low-income countries amounted to some 1.5 per cent of their GDP, a much higher proportion than in high-income countries. The damage of climate variability and change to some small island regions is on the order of 1-8 per cent of GDP, averaged over 1970-2010. {Co-chairs' Message}

**Failure to mitigate these negative drivers and pressures results from failure to internalize the socioeconomic costs of action** (*well established*). **There has also been failure to account for differentiated livelihood/employment, regional, societal and gender aspects of the state of the environment** (*established but incomplete*). Negative drivers and pressures are the result of the

continuing failure to internalize environmental and health impacts in economic development processes, technologies and urban design. While ideas about a green, healthy and inclusive economy aim to address such challenges, these ideas have yet to be systematically reflected in national policies. The IPCC 1.5°C report emphasizes the very short time we have left in which to reduce GHG emissions enough to limit average global average temperature to that level, thus avoiding the potentially very expensive adaptation costs that will otherwise be required. {Co-Chairs' Message}

**For environmental assessments to be useful to decision makers, they need to account for the interactions, interdependencies and co-evolutionary pathways of human-earth systems in proposed policy options and scientific and technological solutions – including direct effects, co-benefits and/or trade-offs** (*established but incomplete*). Global environmental assessments generally rely on model-based quantitative scenarios of geophysical environments and processes. While many important linkages may be captured, the social dimension is not well represented. Moreover, it is difficult in conventional geophysically based global assessments to capture important details that are pertinent to local-level decision-making. A systemic and integrated approach is needed in scientifically based environmental assessments and future outlooks, in support of policy and investment decisions, to account for the highly complex, interdependent and continuously changing factors in assessing human-earth system changes. {19.1}

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# 4

## Despite Some Success Stories, Policy Measures Lag Behind

### 4.1 Introduction: some policy success stories exist, but they are not enough

**Examples of effective environmental policies and improvements exist, from the global to local levels – especially where problems have been well identified and are manageable, and where regulatory and technological solutions are readily available** (*well established, but incomplete*). All stakeholders (global institutions, local and national governments, businesses, communities and individuals) have roles to play in addressing environmental challenges. This section concentrates on responses at the international level and by national governments, but also acknowledges the important role of the private sector and local initiatives. New policies will be required if challenges are to be met effectively. However, much can also be achieved through more effective implementation and enforcement of existing policies and standards. {Chapters 12 to 17; SPM Section 2}

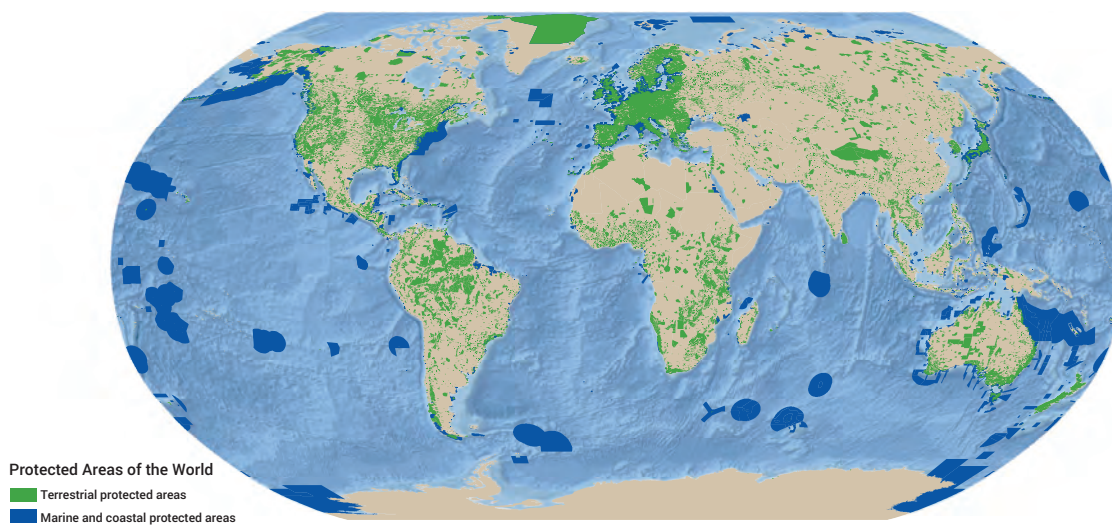
**A growing framework of international agreements and initiatives covers various aspects of issues related to air, freshwater, land and soil, oceans and coasts, and biodiversity which are linked in an integrated manner**

**through the SDGs.** However, while individual agreements can address relatively simple issues, more societally and ecologically complex problems face major political opposition, resulting in reduced clarity regarding goals, targets, indicators, instruments, concomitant funding, monitoring and enforcement measures. Furthermore, these instruments are mostly reactive and have not yet targeted emerging issues such as sand mining, plastic in the oceans, antibiotic resistance, international land grabbing and many others. {18.1}

**Among the examples of effective policies is the Montreal Protocol, which led to the decrease of emissions of ozone-depleting substances** (*well established*). The ozone hole over Antarctica in September and October 2019 was the smallest observed at any time since 1982.

**Many regulatory measures, including local and global environmental treaties and laws, have been qualified successes** (*established but incomplete*). Many countries are using local or national regulatory measures to begin to reduce (if not yet control) plastic pollution. In many countries the coverage of terrestrial and marine protected areas has increased (**Figure 4.1**).

Figure 4.1: Protected Areas of the World



Source: United Nations Environment Programme-World Conservation Monitoring Centre, International Union for Conservation of Nature and National Geographic Society (2018).



Transnational agreements on trade in waste and hazardous waste dumping have had measurable positive effects. {14.2.2}

**With regard to the effectiveness of goal-setting, the Millennium Development Goals (MDGs) mobilized action at the local and global levels** (*established but incomplete*). For example, the MDG mandates are credited with 1.5 billion people gaining access to basic drinking water services between 2000 and 2015 (*well established*). The MDGs coincided with accelerated progress on poverty eradication, health and education, but there was less progress on nutrition and on access to water and sanitation services. {2.5.2} MDG implementation efforts also resulted in the increased capacity of countries to produce and use statistics on poverty, education, health, gender, environment and governance. {3.3}

**International agreements have successfully addressed a number of specific chemicals, but new chemical risks are emerging** (*established but incomplete*). Environmental concentrations of POPs have been reduced in Europe, North America, Asia and the Pacific, and the Arctic. There are two legally binding international treaties on POPs: the Stockholm Convention on POPs and the Protocol to the regional United Nations Economic Commission for Europe [UNECE] Convention on Long-Range Transboundary Air Pollution [CLRTAP] on POPs. {5.2.2}

**Among economic measures, green bonds and other environmentally beneficial financial instruments are increasingly used to promote green investment** (*established, but incomplete*). New financial instruments, both State-regulated and privately initiated (or hybrid), can provide a platform for successful investment in green technologies or biodiversity conservation. Developed countries and countries in the global South (e.g. China and Nigeria) are using green bonds. Norway has successfully used subsidies and tolls to encourage use of electric vehicles. Creative state-subsidized projects such as the “Working for Water” programme in South Africa (which employs low-skilled people, women, youth and people with disabilities to remove invasive plants) can have both environmental and social benefits. {13.2.4, 13.2.3}

**Environmental sustainability may also be promoted through cultural practices or the creation of new institutions** (*established but incomplete*). For example, in many places women farmers have traditionally played a crucial role in protecting seeds. Seeds may also be conserved in gene banks. There were 1,750 gene banks in the world in 2010, which maintained an estimated

7.4 million accessions (both plants and animals). The Svalbard Global Seed Vault in Norway, established in 2008, plays a significant global role in protecting seeds and plant genetic diversity. As of 2018, it held over 1 million duplicate seed samples deposited by gene banks worldwide. {13.2.4, Table 13.5}

**Significant progress has been made around the world in implementing education for sustainable development (ESD) in all educational sectors** (*well established*). However, upscaling ESD is still needed if it is to be integrated into educational systems globally. Education will contribute to achieving the SDGs and mainstreaming environmental sustainability as a shared social value, but robust policy action is needed to eliminate economic and gender barriers to accessing education. {4.2.4}

**Many of the achievements in environmental policies and protection are generating economic and social co-benefits.** Although evidence is mixed on the extent to which economic trade-offs from a transition to a low-carbon and green economy will emerge, overall it is likely that the net effects would at least not be negative. {Chapter 22, ExecSum, Figure 22.9}

**Investing in environmentally sound sectors can generate substantial returns** (*established but incomplete*). For example, depending on the scenario used, at the global level the health benefits of reduced air pollution have been estimated to be 1.4 to 2.5 times greater than the costs of mitigation. The highest benefit-to-cost ratio is for the emissions reduction strategy to reach the 2°C target of the Paris Agreement: global health savings are estimated at US\$ 54.1 trillion, more than twice the global policy costs of US\$ 22.1 trillion. Under all the scenarios examined, the countries likely to see the highest health savings from improved emission reduction measures are China and India. The costs of implementing climate mitigation policies in these two countries would be fully compensated by health savings under most scenarios. The added costs of pursuing a 1.5°C instead of a 2°C target could generate substantial benefits (about US\$ 0.3-2.3 trillion and about US\$ 3.3-8.4 for China and India, respectively). In the EU and the United States, modelling suggests that the health savings would be high but would not fully compensate for the costs. {Chapter 24, ExecSum, Box 24.1}

**Gender equality has a multiplier effect in advancing sustainable development, including 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. Bringing gender perspectives to bear on environmental policies and governance, especially through 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 that public resources are more likely to be directed towards human development priorities and investments. {4.2.3}

**Achieving the SDGs will require the benefits of sustainable economic development to be used predominantly to increase the capabilities and opportunities of those with the least advantages** (*well established*). For example, educating girls, improving the status and opportunities of women, and enabling poor people to achieve full participation in society would strengthen sustainable economic growth and development, as well as reducing alienation and conflicts. {Chapter 2, ExecSum, 2.5.2, 2.5.3}

**While environmental protection policies may threaten jobs in polluting sectors, they can also generate more**

**and cleaner jobs in other sectors** (*established but incomplete*). Phasing out polluting sectors (e.g. fossil fuel production and fossil-fuelled transport) leads to loss of employment and livelihoods in those sectors, but there will be new job opportunities in sectors that replace them such as renewable energy and waste management/recycling. {1.3.1} Furthermore, while 1.2 billion jobs in agriculture, fisheries and forestry depend on a stable and healthy environment, that is also true of many jobs in tourism, pharmaceuticals and other industries which depend on natural environmental processes. {17.6} The overall health of the planet has profound implications for employment and livelihoods (see Table 4.1)

**A global shift to a circular economy based on increased resource efficiency could contribute to economic growth and human well-being, with reduced environmental pressures and impacts.** (*established but incomplete*) Key considerations in implementing a circular economy are reducing and rethinking resource use, and the pursuit of longevity, renewability, reusability, reparability, replaceability and upgradability for resources and products that are used. This would have

**Table 4.1: A healthy or unhealthy planet: employment and livelihoods (E&L)**

	Healthy Planet provides E&L (+)	Unhealthy planet affects E&L (+/-)	Policy: E&L lost (-)	Policy: E&L gained (+)	Ref.
Air	Good health to enable work	Air pollution is the No. 1 environmental cause of ill-health (25% of disease) affecting E&L	Jobs lost in fossil fuel/polluting industries	Jobs gained: 8.1 million jobs in renewables globally in 2016 and could grow to 20 million by 2030	1
Biodiversity	Supports life including agriculture	Affects agriculture/life	Could affect farmers	Managing Natura 2000 sites creates 180,000 jobs	2
Oceans	Small-scale fisheries provide 80 per cent of jobs (58-120 million livelihoods) with 10 million jobs in larger-scale fishing; jobs in marine-based tourism	Affects fisheries and tourism	Marine parks' policies could affect fishing jobs	Policies based on involving local communities could create jobs	3
Land	Agriculture employs >30 per cent of the workforce, mostly in developing countries where 40 per cent of smallholders are women; 2.5 billion people directly depend on land, including 1-1.5 billion on forests; 13 million people are employed in the formal forest sector plus 40-60 million in informal small and medium-sized forest operations	Land degradation affects 3.2 billion people	Land grabbing affects smallholders	Community-based agriculture and forest policy and recognition of tenure rights could protect jobs and the environment	4
Water	Those employed in agriculture/industry and the service sector depend on water for their livelihoods	Water pollution affects health and the ability to work; water scarcity affects agricultural income	-	Recycling water can create jobs	5

References: FAO 2005; Wei, Patadia and Kammen 2010; Agrawal *et al.* 2013; Bourguignon 2015; FAO 2015; FAO 2016a; FAO 2016b; ILO 2016; Garrett-Peltier 2017; IRENA 2017; OECD 2017; United States Department of Energy 2017; Yihdego, Salem and Pudza 2017; FAO 2018; Renewable Energy Policy Network for the 21st Century [REN21] 2018; {GEO-6, Table 7.1}.



substantial co-benefits for greenhouse gas abatement and waste and pollution minimization. {17.6}

**Participatory approaches can help decision makers identify and pursue innovative solutions to achieve sustainability** (*established, but incomplete*). Participatory and grassroots approaches provide a useful landscape of initiatives and aspirational visions, pathways and solutions from stakeholders to achieve the SDGs. This includes inclusive innovation, in which power and decision-making are relatively decentralized and externalities are internalized. These approaches also highlight gaps and blind spots in distributional equity and in responsibilities for (and capabilities to) address global environmental problems and their solutions. Participatory approaches can help deliver context-relevant solutions. For example, decentralized renewable energy generation and microgrids fit well in many bottom-up sustainable visions that challenge traditionally modelled large-scale, centralized energy transitions. {Chapter 23, ExecSum, 23.6}

**Effective environmental policies require diverse policy instruments and governance approaches as part of well-designed policy mixes** (*well established, but incomplete*). Too often the policy mix contains misaligned or conflicting policies that undermine policy effectiveness, especially where economic and sectoral policies are not aligned with environmental goals. Formulating effective environmental policy would benefit from new forms of data collection, including social disaggregation of data and information, and integrating citizen science and indigenous knowledge pathways into formal environmental assessments and policies. {Chapter 21, ExecSum}

**Despite success stories, policy actions overall are not adequate to address the severity of environmental problems** (*well established*). Urgent action on an unprecedented scale is needed to protect human health and the environment, maintain the current and future integrity of global ecosystems, and reverse some of the most significant environmental damage that has already taken place. Key actions will include reducing air, land and water pollution, land degradation, and biodiversity loss; improving management of water and other resources; climate change mitigation and adaptation; implementing greater resource efficiency; adopting decarbonization, decoupling and detoxification approaches; and preventing and managing acute risk and disasters. All these actions require more ambitious and effective policies, including for sustainable consumption and production, greater resource efficiency and improved resource management, integrated ecosystem management, and integrated

waste management and prevention. {Chapter 22; SPM Section 2}

## 4.2 Addressing specific drivers through policy innovation

**Mainstreaming environmental considerations into the drivers of environmental problems, including social and economic decisions at all levels and in all sectors, is of vital importance. In line with the SDGs, GEO-6 demonstrates that environmental issues are best addressed along with related economic and social issues, taking into consideration synergies and trade-offs among different goals and targets, especially equity and gender dimensions** (*well established*). The integration of environmental concerns needs to be improved at the local, national, regional and global levels, including broad coordination among policy areas. More ambitious and effectively implemented environmental policies are necessary, but are not sufficient in themselves 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, institutional capacities need to be strengthened and scientific information taken into account in order to improve environmental management. Strong commitment by all stakeholders and partnerships, and international cooperation, would greatly facilitate the realization of environmental goals. {Chapters 22, 23, 24; SPM Section 2}

**Current policies that address the underlying drivers of environmental unsustainability are unevenly developed; climate change and urbanization appear to receive more policy attention currently than other drivers** (*uncertain*). Policies that address mutually interdependent drivers and their cumulative effects on the environment are difficult to design, implement and assess. Climate change is being addressed through United Nations Framework Convention on Climate Change (UNFCCC) activities. The environmental impacts of urbanization are receiving increasing attention in local and national policies. However, in all cases effective policy implementation lags far behind. Global policymakers increasingly understand the nature of the drivers of large-scale environmental change, but local and national policies for effective intervention are weakly developed and enforced. {11.3, 21.3.1}

**There is considerable expert disagreement (and contradictory evidence) concerning the extent to which population growth places pressure on the environment.** (*well established*) If efforts to reduce population growth are integrated into environmental and social policies,

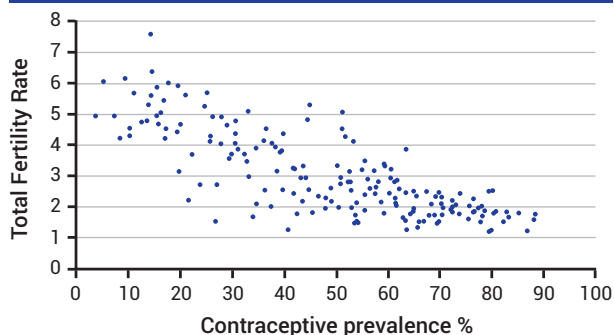


they should be based on respect for the rights of women and for their choices. A rights-based approach that places reproductive control in the hands of women may reduce rates of population growth. Most importantly, however, this approach will enhance gender equality and women’s empowerment. Government-supported population policies could consider providing access to modern contraceptive methods (Figure 4.2); enhancing access to voluntary family planning and other reproductive health services; investing in women’s education; removing barriers to women’s participation in the labour force; creating legal regimes to dismantle discriminatory practices associated with traditional patriarchal practices of male control over women, including male violence against women; and enabling women’s full participation in national and local-level decision-making and policy-setting positions. {2.3.4}

**Inequality (North-South, international, rich-poor, or rural-urban) and increasing climate vulnerability are major drivers of migratory patterns (unresolved).** Closing international welfare gaps, and promoting economic growth in the least developed countries, will moderate migratory flows. Migration within countries is driven by inequalities, especially between rural and urban areas, leading to rapid and sometimes environmentally unmanageable urbanization. While adequate developmental support for rural areas helps moderate such pressures, this support should be designed and carried out in environmentally sustainable forms. “Business as usual” growth programmes for rural and poor regions may solve one set of social problems while exacerbating existing environmental problems and creating new ones. Innovative support for climate-related adaptation and resilience is urgently needed. {2.3.6}

**Coupled with efficiency improvements, the transition to low-carbon energy sources has been accelerating globally in the last decade although it remains insufficient to achieve the 2°C global average**

**Figure 4.2: Contraceptive prevalence and total fertility**



Source: Own elaboration based on World Bank (2017).

**temperature goal of the Paris Agreement, let alone the 1.5°C aspiration (well established).** Understanding this should stimulate greater ambition and bolder action in the area of technology innovation and encouraging behaviour change. However, providing billions of poorer people with access to electricity and other modern energy sources remains a challenge. {4.4.2}

**Decoupling environmental degradation and resource use from economic growth (and its associated production and consumption patterns) will be required in order to achieve the SDGs (well established).** Partial decoupling of environmental pressures and economic growth can already be observed for some impacts and resources in certain countries. Further decoupling will require the scaling-up of existing sustainable practices and more fundamental transitions in the ways we produce, consume and dispose of goods and materials across society. These transitions are likely to be more effective if supported by long-term, comprehensive, science-based targets that provide an objective basis for future directions and actions. {2.5.1; SPM, p. 6} More fundamental changes may also be needed. This view is consistent with the intention to keep the GEO-6 theme of “Healthy Planet, Healthy People” central to our understanding of genuine progress. {4.2.1}

**What appears to be a decoupling of growth in one sector or territory can mask continuing environmental and social impacts elsewhere (established but incomplete).** Examples are the substitution of one non-renewable resource for another (e.g. the cleaner energy systems that replace fossil fuels but still require non-renewable resources) and shifting costs and environmental burdens (e.g. importing resource-intensive consumer goods from developing countries). {17.6.1}

### 4.3 Thematic responses

**GEO-6 found evidence of effective policies through the systematic assessment of a range of case studies from all world regions.** For each thematic area of GEO-6, five or six case studies were analysed for policy effectiveness against 12 or more criteria identified from the literature. In addition, the effectiveness of environmental policies was scrutinized by analysing policy-sensitive indicators. Effectiveness criteria for the case studies included goal achievement, unintended effects, baseline, coherence/synergy, co-benefits, equity, enabling/constraining factors, cost-effectiveness, timeframe, ease of implementation, acceptability, stakeholder involvement, intergenerational impacts, and transboundary impacts. GEO-6 authors participated in an expert elicitation ranking the effectiveness of 29 case studies. None of the case studies ranked





high on all effectiveness criteria, despite being selected because they represented generally accepted successful policies. The most common failings were absence of a baseline; lack of compensation for negatively impacted groups; the impacts of external factors; inadequate consideration of institutional capacity for implementation; and lack of stakeholder involvement in policy design. This suggests areas in which policymakers could make improvements in the future. The shortcomings identified in the case studies were mirrored in the indicators: throughout the thematic areas, environmental policies are not effectively addressing the drivers of environmental changes. {18.1}

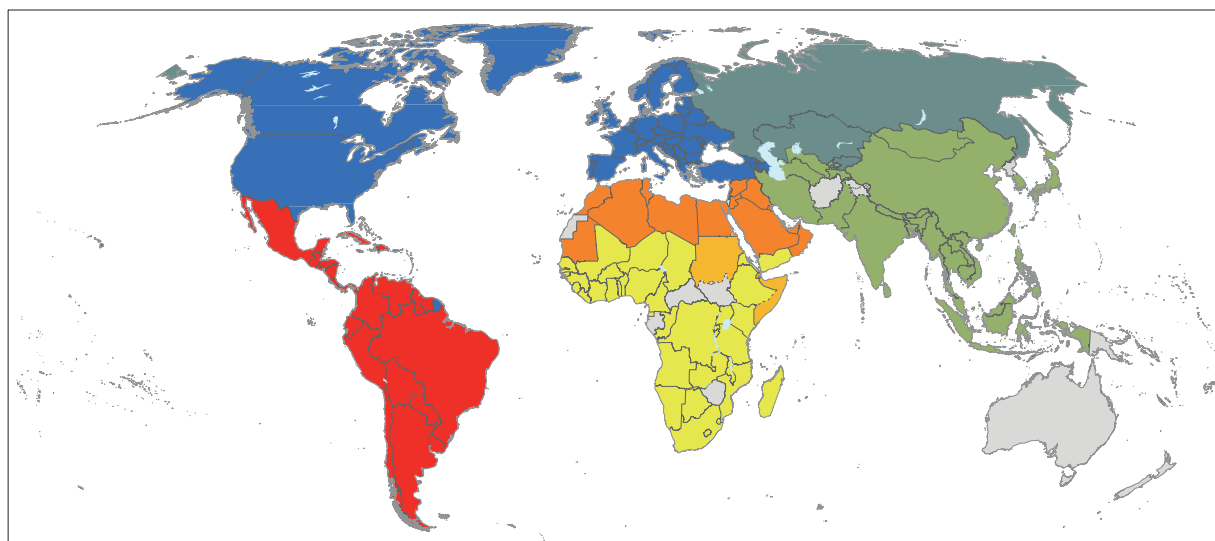
### 4.3.1 Air

**There is no single global agreement addressing air pollution, but instead a patchwork of regional intergovernmental agreements and initiatives focused on public-private partnerships (established but incomplete).** Global MEAs that have linkages to air pollution include those targeting climate change (UNFCCC), stratospheric ozone depletion (the Vienna Convention and the Montreal Protocol), mercury (the

Minamata Convention) and POPs (the Stockholm Convention). Several regional MEAs and bilateral agreements exist. One of the oldest regional MEAs is the 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) negotiated under the UNECE (Figure 4.3). Considerable progress on policy cooperation, monitoring and modelling, emissions control and reporting, and ecosystem recovery has been achieved under the eight legally binding CLRTAP Protocols. {Chapter 12}

**Under the UNFCCC, the 2015 Paris Agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global average temperature to well below 2°C. Currently the “nationally determined contributions” of emissions presented in Paris in 2015 collectively constitute only one-third of the mitigation efforts required to stay well below 2°C (well established).** {2.2, 2.7, 4.2.1, 5.2, 5.3.4} To remain well below the 2°C goal, global emissions need to drop by between 40 and 70 per cent between 2010 and 2050, falling to net zero by 2070. {2.7.4} The IPCC produces regular assessments of climate change

Figure 4.3: Groupings of selected regional multilateral air pollution agreements



- North America and Europe**  
1979 United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (Geneva)  
Overlap between North America, Europe, and Asian Agreements
- Asia and the Pacific**  
1998 Acid Deposition Monitoring Network in East Asia (EANET)  
1998 Malé Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia  
2002 Association of Southeast Asian Nations (ASEAN) Agreement on Transboundary Haze Pollution  
2006 Framework Convention on Environmental Protection for Sustainable Development in Central Asia (Ashkhabad)  
2015 Asia and the Pacific Clean Air Partnership
- Sub-Saharan Africa**  
2008 Eastern Africa Regional Framework Agreement on Air Pollution (Nairobi)  
2008 Southern African Development Community Regional Policy Framework on Air Pollution (Lusaka)  
2009 West and Central Africa Regional Framework Agreement on Air Pollution (Abidjan)  
Overlap between Sub-Saharan and Northern African Agreements
- Northern Africa**  
1986 Council of Arab Ministers Responsible for the Environment (CAMRE)
- Latin America and Caribbean**  
2008 Intergovernmental Network on Air Pollution for Latin America and the Caribbean
- No agreements**

Source: UNEP (2019a, p. 131).



and its impacts. {SPM, p. 7} The latest IPCC 1.5°C special report indicates that the scale of the required reduction in emissions is unprecedented and extremely challenging. Increasingly, there is international financial support for climate change adaptation and resilience-building measures at national and local levels (**Figure 4.4**) although the amount is considerably less than is needed.

**International banks increasingly finance air pollution related projects** (*well established*). Institutions including the World Bank, the Asian Development Bank, the African Development Bank, the Global Environment Facility and the Green Climate Fund play major roles in project funding for air pollution mitigation at national levels. Financial assistance and cooperative implementation of control measures can have clear and demonstrable effects in decreasing local emissions in the short term, although increasing long-term national and global positive impacts on planetary health requires successful control measures to be replicated and scaled up. {Chapter 12}

**Many public-private initiatives complement State action on air pollution.** They include the Partnership for Clean Fuels and Vehicles, the Global Alliance for Clean Cookstoves {Chapter 12, 12.2.3}, the Global Research Alliance on Agricultural GHGs, and the Climate and Clean Air Coalition for the Reduction of Short-Lived Climate Pollutants (CCAC). {Chapter 12}

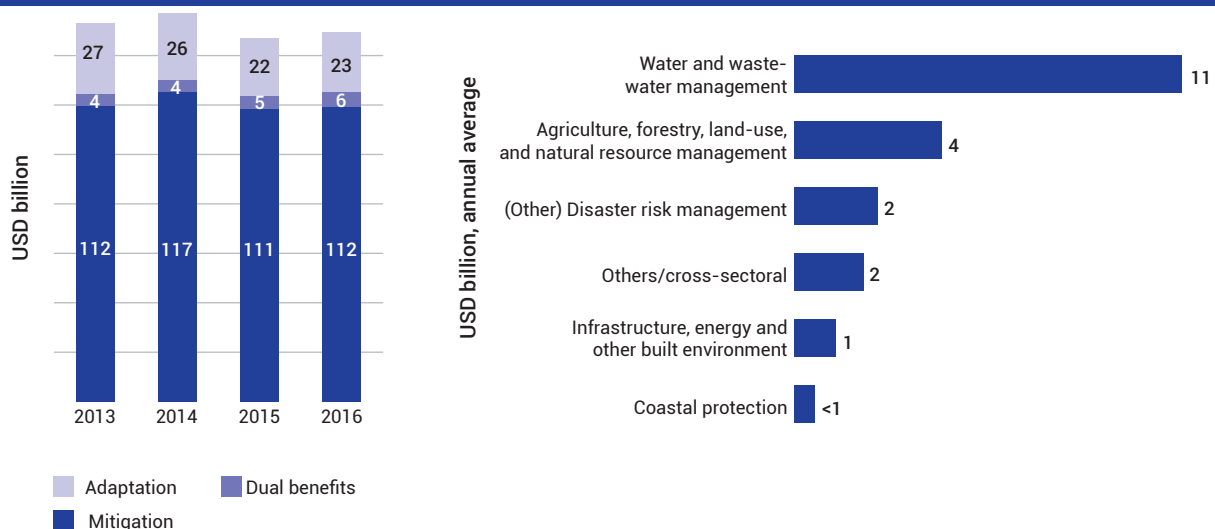
**Air pollution has been widely subject to regulatory approaches, including the use of emissions and technology standards, which have been successful**

**in addressing some pollution sources** (*established but incomplete*). Planning regimes establish ambient targets (e.g. concentration standards, total pollutant loads, or a change in global mean temperature) and emissions budgets (or ceilings). Clusters of policies are then developed and implemented to meet targets or budgets. Progress is monitored and, if necessary, additional policies are developed or existing policies are revised. {Chapter 12, ExecSum} In addition to ambient standards, emissions standards and performance standards for specific industrial processes, equipment or products are critical, especially in the transport sector. { Chapter 12, ExecSum, 12.2.1, 12.2.2}

**Air policy has also used economic incentives (e.g. subsidies, tax credits, loans or price guarantees) and disincentives (e.g. fees or taxes) in existing markets, or created new markets for rights or commodities that had previously not been traded (e.g. emissions reduction credits or renewable energy credits) in order to influence lifestyle and technology choices** (*well established*). All these types of market interventions have been used to some extent to mitigate air pollution, climate change, ODS or PBTs. While market interventions do not directly reduce emissions or ambient concentrations, they provide regulated businesses and individuals with flexibility and can create incentives to improve performance and lower costs. {Chapter 12}

**Infrastructural and technological innovation and transfer can improve energy efficiency in manufacturing sectors (including mining) and are key to reducing emissions.** Energy efficiency can be improved through

Figure 4.4: Climate finance for adaptation



Note: Climate finance comes from the public sector

Source: Buchner et al. (2017).



approaches such as cleaner brick kiln technology, piloted in Asia and Latin America; cleaner technologies to reduce or eliminate mercury use piloted in several countries; and Perform-Achieve-Trade schemes for energy intensive industry in India. {5.2.3}

**Information and behavioural/ persuasive policies have been used to promote lifestyle changes in order to reduce either emissions or exposure to harmful levels of air pollution by providing the public with better information.** (*well established*) This is in line with improved understanding of the hazards and risks of exposure to air pollution in recent years, although the importance of public education with respect to air pollution control was raised many years ago. These approaches need to reach a threshold level of awareness and recognition across their target populations before they have much effect on consumption and other emissions-generating behaviour, or on impacts (exposure-related behaviour). However, once this threshold is reached, citizens can begin to expect and demand such information. Moreover, increasing awareness of the sources and impacts of pollution may increase public demand for cleaner air, lower-emitting products and services, and more stringent policies. {Chapter 12}

#### 4.3.2 Biodiversity

**The Convention on Biological Diversity (CBD) is the key global convention on biodiversity;** this has been manifested through instruments such as the Strategic Plan for Biodiversity 2011-2020 (encompassing the Aichi targets), the Cartagena Protocol on Biosafety, and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. A new Strategic Plan for 2020-2030 is being developed. There is also a patchwork of other multilateral and bilateral intergovernmental agreements, as well as private sector biodiversity investment initiatives (*well established*). During the last 10 years, awareness about the loss of biodiversity has risen significantly in international discourse on health and economic policy. A number of internationally agreed biodiversity-related conventions, treaties and platforms have framed considerable global efforts to protect and conserve biodiversity, including areas beyond national jurisdictions (*established but incomplete*). These have been important in obtaining increased responses at the national level. {Chapter 6, ExecSum, 6.7.1, 13.1}

**The CBD is supported by scientific assessments.** In 2012 the IPBES was established to strengthen the science-policy interface for biodiversity and ecosystem services/nature's contributions to people for the conservation and sustainable use of biodiversity, long-

term human well-being and sustainable development {6.1}. IPBES released a landmark global assessment in 2019 (IPBES 2019).

**Conservation of biological diversity is mainly undertaken through management of protected areas.** (*well established*) Both the establishment and effective management of protected areas constitute an important response to the need to conserve biodiversity, as reflected in Aichi Biodiversity Target 11 of the Strategic Plan for Biodiversity 2011-2020. The International Union for the Conservation of Nature and Natural Resources [IUCN] defines a protected area as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (IUCN 2018). {6.6.3}

**In addition to State collaboration, the private sector is increasingly engaged in biodiversity protection.** (*well established*) The Natural Capital Coalition, which evolved in 2014 from The Economics of Ecosystems and Biodiversity (TEEB) global initiative, is an international collaboration that aims to mainstream natural capital approaches in the public and private sectors. {Annex 13-2} Gene banks also draw on international investment support. Tax breaks for green infrastructure, conservation agreements, carbon offsets, green fiscal policies and green bonds, and private- and third-sector investment are response tools available to policymakers to support investments in biodiversity conservation. Green bonds are one of the fastest growing fixed-income market segments, with US\$ 81 billion in 2016. Green bonds can be used strategically by governments and corporations to tap international capital in order to support investment in biodiversity conservation; they can also provide a platform for interactions between financial and investment policymaking, which are institutionally separate in some countries. {Chapter 13, ExecSum, 13.2.4; Annex 13-2}

**Biodiversity has often been addressed at national levels through policy measures regulating endangered species and national land-based and marine parks.**

While the creation of protected areas is often effective in preserving species, such zones can present issues of legitimacy, equity and sustainability for local communities. Integrating the views of local stakeholders during the decision-making and implementation phases is often key to the success of policies. {13.2.2} At the same time, the rise in trade of endangered species (including through the Internet) raises questions about the effective monitoring and implementation of such policy instruments. The CBD requires parties to submit



National Biodiversity Strategies and Action Plans (NBSAPs) that reflect national policies and articulate the challenges they face in moving forward, although these plans have been unevenly produced. {13.3}

**National biodiversity conservation efforts are reflected in the NBSAPs submitted to the CBD (*well established*).** A NBSAP is a national policy expression of globally agreed biodiversity conservation goals. Biodiversity has also been increasingly inculcated in a wider range of national policy and planning tools. Examples include assigning monetary values to nature's contributions to people; the UN System of Environmental-Economic Accounting; and the OneHealth approach, which promotes collaboration to address the drivers of human disease, biodiversity loss and ecosystem degradation. {Chapter 6, 5.6}

**Biodiversity conservation has used economic incentives and market-based instruments to shape the behaviour of people and their relationship with the environment. (*well established*)** This approach is based on the assumption that economic incentives can address market externalities through facilitating pro-conservation behaviour, disincentivizing negative behaviour, and compensating stakeholders who are negatively affected by biodiversity conservation. Economic instruments are able to address scale mismatches in biodiversity conservation, for example where the benefits of conservation are felt at a regional or national scale while the cost is borne by local communities on a smaller scale. {13.1} Such instruments include payment for ecosystem services and Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks (REDD+). {13.2.3} Market and other mechanisms have also been used to reduce over-fishing including eco-certification, individual transferable quotas in British Columbia {14.2.4} and traditional user rights in Chile. {14.2.3}

**Traditional knowledge held by indigenous peoples and local communities (IPLCs) is increasingly understood to be a valuable resource for biodiversity conservation, environmental assessment and sustainable development (*well established*).** This is demonstrated by the increase in the number of studies and discussions on traditional knowledge and its inclusion in global policy agreements. Nevertheless, the ability of poor and indigenous people to conserve biodiversity and protect associated ecosystems would be enhanced by secure tenure rights. {13.2.2, SPM, 2.2.4, 8.5.3}

**To address current and future challenges including climate change, research suggests that the best**

**approaches may be characterized by the coordination of modern science and technology with traditional knowledge.** While cooperation between local and global communities and knowledge systems has proven successful for the health of individuals and the planet, challenges remain. Traditionally based knowledge is often gender-differentiated, and successful efforts to amplify and include traditional knowledge will only be successful if both women and men are part of collaborations. {13.1; Chapter 25, 25.2.3}

**The *ex situ* conservation of genetic material in gene banks, aided by the use of new genomic tools, has become an integral part of conserving genetic diversity (*well established*).** Advances in technology allow cheaper and faster genome sequencing. This has accelerated the rate of sequencing of crops and their wild relatives, although genetic data for most wild species is lacking. The *ex situ* conservation of genetic material in gene banks (or seed banks) is practised at local and national levels. {6.4.1, 13.2.4}

**Financial resources at levels much higher than at present are needed in order to conserve biodiversity.** Sources of financing for investment in biodiversity can come from multiple sources (SCBD 2012), including core national biodiversity funding sources, national government financing, international flows of Official Development Assistance, and multilateral funding. Meeting the 2020 Aichi Biodiversity Targets would provide monetary and non-monetary gains that far outweigh the costs of achieving these goals. {Chapter 13}

**Policies and mechanisms aiming to support innovative measures can strengthen biodiversity conservation. (*well established*)** For example, arrangements such as community-based protected areas (e.g. Locally Managed Marine Areas) are needed to supplement national protected areas for conserving biodiversity in the long term. {13.1; Exec Sum, Chapter 13} During the last few decades there has been a shift away from protected areas that exclude humans towards more people-centred or community-based conservation and integrated landscape management. Communities are the major players in decision-making in indigenous and community conserved territories and areas (ICCAs). ICCAs play a key role in conserving traditional ecological knowledge, as well as cultures and languages, which are often inextricably linked to biodiversity conservation. {13.4.2}

**There is a close connection between biodiversity loss, human health, poverty, and uneven access to natural resources (*well established*).** Biodiverse systems can facilitate human health and equity. To reverse



trajectories of biodiversity loss and degradation and meet globally agreed targets, biodiversity policies need to advance equity and not place disproportionate burdens on already-vulnerable populations or on future generations. {Exec Sum Chapter 13}

**Despite unprecedented efforts to protect ecosystems and biodiversity on community, national and international scales, there has been no slowing or reversal of the decline in global biodiversity** (*well established*). While there has been significant progress towards meeting some components of the Aichi Biodiversity Targets of the Strategic Plan for Biodiversity 2011-2020, in most cases this progress has not been sufficient to achieve the targets for 2020. {13.4, 21.3.2}

### 4.3.3 Oceans and Coasts

**No single global agreement addresses all ocean issues, but there is a patchwork of regional and intergovernmental agreements and initiatives including public-private partnerships** (*well established*). Policy coherence and integration are important in addressing the cumulative impacts of local and regional threats to support the resilience of marine ecosystems (e.g. coral reefs) to climate change and land-based pollution (*inconclusive*). However, without international policies to curb carbon emissions, the effectiveness of resilience-based management is likely to be very limited given the limited capacity of marine species to adapt to warmer ocean waters (*well established*). {Chapter 14, ExecSum, 14.2.1; Exec Sum}

**Marine governance instruments include the 1982 United Nations Convention on the Law of the Sea, which sets out the legal framework regulating all activities in the oceans and the follow-up Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.** (*well established*). These overarching agreements are supported by several treaties addressing the pollution of marine areas. Increasingly, there is a policy of regional cooperation to address regional maritime problems including marine litter. The Regional Seas Programme is one of UNEP's main activities addressing coastal and marine environmental issues. This programme illustrates regional cooperation approaches to coastal and marine management. It focuses on engaging neighbouring countries in regional action plans to tackle problems in shared marine environments. {14.2.5}

**International non-governmental organizations (NGOs) are collaborating to protect coral reefs** (*well established*). There has been considerable interest in resilience-based approaches to coral reef management. For example,

the Coral Triangle Initiative (an intergovernmental and NGO activity involving Indonesia, Malaysia, Papua New Guinea, the Philippines and Timor-Leste) incorporates resilience principles and multi-issue management. The International Union for Conservation of Nature (IUCN) has adopted an agenda for action on coral reefs, climate change and resilience that urges the development of policies to support resource-based management at national and international levels. {14.2.1}

**National oceans-related policies rely on diverse regulatory measures, with varying success** (*established but incomplete*). Planning instruments such as integrated coastal zone management and marine spatial planning have often been successfully used. Territorial Use Rights for Fishing (TURF) programmes are a good fit for fisheries with relatively sedentary stocks, high exclusionary potential, and governments keen to devolve costly management and enforcement functions (*well established*). Individual transferable quotas (ITQs) work best in the case of relatively high-value stocks when supported by strong, independent, scientifically set quotas and strong monitoring, control and surveillance. The regulation of access and resource use rights may be successful when effective enforcement and compliance mechanisms are in place (*well established*). {Exec Sum Chapter 14, 14.2.3}

**Resilience-based management of coral reefs is an emerging concept in a context of very limited alternatives**, given that the basic cause of coral stress and death is the increasing level of atmospheric CO<sub>2</sub>. Resilience-based management refers to strategic policy interventions at local and regional levels that support ecological resilience (i.e. the capacity to resist disturbances and to recover from these disturbances). It is believed to help offset, to some extent, the increasing effects of climate change although individual national efforts are not proportionate to the global scale of the problem. {14.2.1}

**Problems involving numerous ocean and coastal activities, sectors and sources (e.g. marine litter) require policies involving comprehensive and coordinated measures** (*established but incomplete*). When such problems involve multiple jurisdictions, governance approaches to engage neighbouring countries (e.g. the Regional Seas Programme) may be appropriate. {14.2.2}

**Lack of standardization makes it difficult to track progress towards marine conservation** (*well established*). In the case of beach litter, used as an indicator of litter in the marine environment, the lack of standardization



and compatibility between methods used and results obtained in various bottom-up projects makes it difficult to reach an overall assessment of the status of marine litter over large geographical areas. {14.3.2}

#### 4.3.4 Land and Soil

**Land areas generally fall under national jurisdiction.** (*well established*) There is no single global agreement addressing land related pollution, but again there is a patchwork of international, regional and national intergovernmental agreements and initiatives focused on land-related issues. {Chapter 15, ExecSum}

**The 1994 United Nations Convention to Combat Desertification (UNCCD) is the principal international legally binding agreement that associates sustainable land management with environment and development.** It addresses dry sub-humid, semi-arid and arid land areas, where some of the most vulnerable ecosystems and people are found. {15.2.2}

**Other treaties regulate various aspects of land-related challenges.** For example, the Stockholm Convention regulates production and use of POPs, while the Basel and Rotterdam Conventions regulate hazardous waste movements between countries and imports of hazardous chemicals. {15.2.3}

**Sustainable land management is a major instrument for climate change mitigation because it increases carbon sequestration in the soil** (*well established*). This is why land and soil policy gained increasing international recognition during climate change negotiations at the 21st Conference of the Parties to the UNFCCC (COP 21) in Paris in 2015, when the “4 per 1000 Initiative” was launched by the Government of France. This initiative promotes enhancement of soil quality, carbon sequestration and soil conservation through improved agricultural practices that mitigate climate change. {Chapter 15, ExecSum, 15.3.1, 15.4}

**There is no legally binding global convention on the protection of forests.** (*well established*) Attempts to agree such a convention at the Rio Earth Summit in 1992 resulted only in the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests. This document makes several recommendations for conservation and sustainable development of forests. {Chapter 15}

**United Nations voluntary declarations are a first step towards protecting minority rights and responsibilities with respect to land.** The rights of indigenous peoples to their lands and territories are explicitly mentioned in the UN Declaration on the Rights of Indigenous People (Articles 25 and 26). FAO’s Voluntary Guidelines on the Responsible Governance of Tenure (VGGT) also seek to improve the governance of land tenure (public, private communal, indigenous, customary and informal). {25.2.3}

**Land protection policies differ among countries and regions, from barely existent to well defined** (*established but incomplete*). Often national policies and programmes that address socioeconomic development (e.g. economic incentives for agricultural, bioenergy and urban development) have overlooked land degradation side-effects. If economic growth is not decoupled from environmental degradation, local policies aimed at sustainable use and management of land will not succeed. {Chapter 15, ExecSum}

**Land protection policies have built on sustainable land management strategies and used a diversity of regulatory mechanisms, including land tenure/ownership rules, spatial planning, economic incentives, and standards for the use and disposal of pesticides and other chemicals.** The success of any strategy to combat desertification depends on the implementation of sustainable land and water management practices that are adapted to specific local geo-biophysical and socioeconomic situations. Well-managed soils slow down the process of land degradation, regulate the water cycle, safeguard biodiversity, conserve landscape multi-functionality, and improve the provision of ecosystem services. Economic incentives for sustainable land management include subsidies for farmers who plant trees or undertake other soil conservation measures. {Chapter 15}

**Tenure-secure indigenous lands generate benefits worth billions of dollars in the form of carbon sequestration, reduced pollution, clean water, erosion control and many other local, regional and global ecosystem services** (*established but incomplete*). Current tenure rules and practices present critical challenges. There is increasing evidence, however, of local indigenous communities successfully managing and conserving their lands. The benefits of tenure-secure lands are likely to outweigh the costs in most



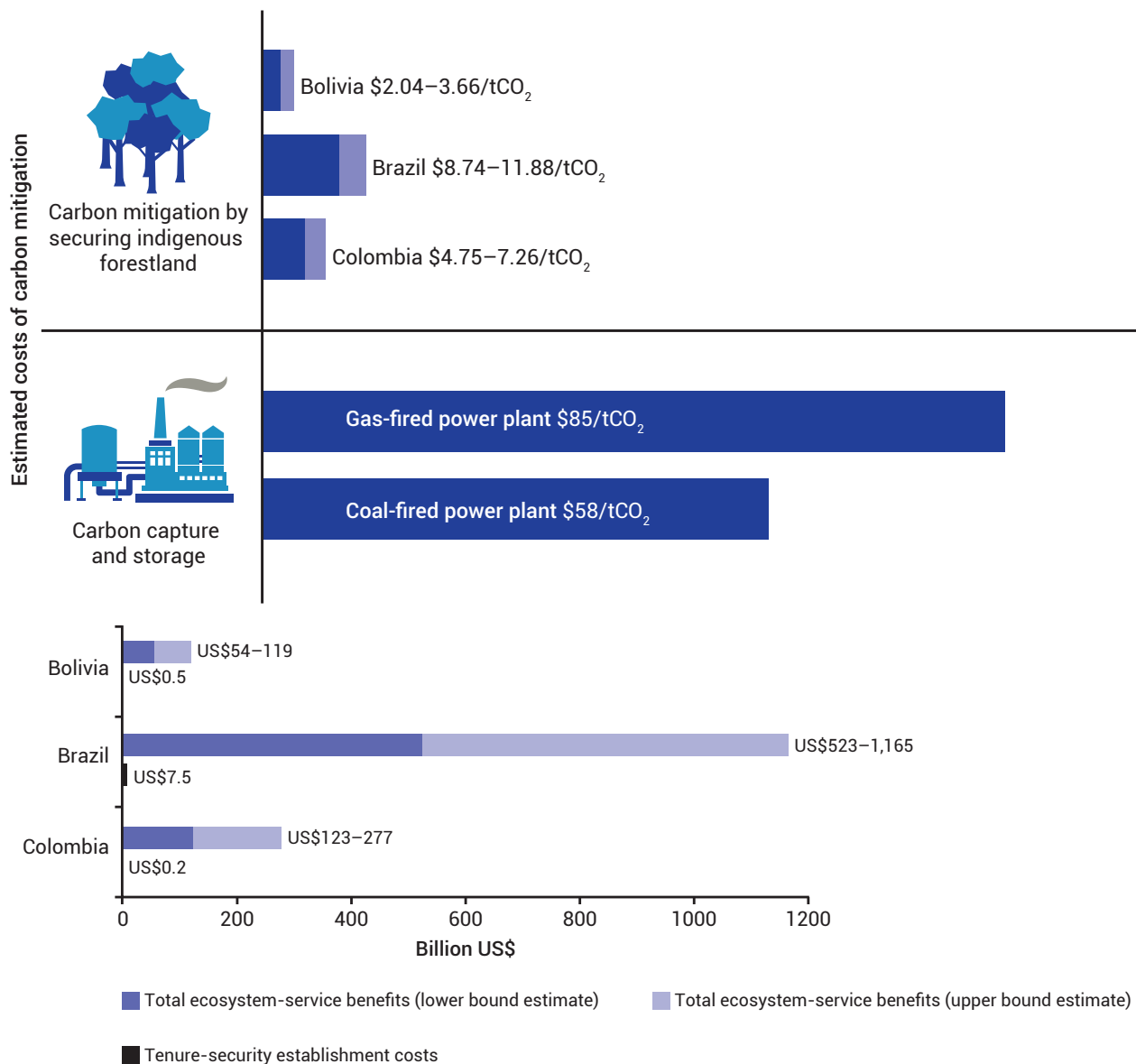
countries (Figure 4.5) (established but incomplete). {8.5.3}

**Education is critical in land policy.** (established but incomplete) The provision of education and extension services, and knowledge about the complementary approaches of no-tillage agriculture and conservation agriculture, can help combat soil erosion, optimize crop production, promote soil health by keeping soil organic matter and nutrients in place, sequester carbon, and improve water and air quality. With these practices, yields tend to be lower than with conventional

agriculture at least during the first few years. With time, this gap can narrow. {15.2.4}

**Land-use planning, sustainable use of land resources, and sustainable land management can balance production with environmental protection** (well established). Sustainable intensification practices attempt to integrate increasing crop yields with the maintenance of soil fertility and improvements in water-use efficiency. Annually, US\$ 75.6 trillion can be gained through implementing global policies that enable sustainable land management. Among many other

Figure 4.5: Benefits of tenure-secure lands outweigh the costs in three Latin American countries



Source: Ding et al. (2016).



sustainable land management practices, conservation agriculture that includes zero tillage is a good example of a practice that maintains land quality, enhances soil carbon sequestration, mitigates climate change, protects biodiversity and sustains productivity. However, policies, economic analysis, science and farming incentives are needed to support the implementation of such practices, especially by small landowners and above all those in developing countries. {Chapter 15, ExecSum, 15.2.4}

**Land management, restoration and policies need to be tailored to local conditions** (*well established*). Successful policy implementation depends on a number of factors that provide an integrated landscape approach well matched to socioeconomic and natural characteristics, supported by good governance and good levels of stakeholder engagement. { Chapter 15, ExecSum, 15.2.4, 15.2.5}

#### 4.3.5 Freshwater

**There is no single international agreement addressing all freshwater issues – many intergovernmental**

**agreements (bilateral and multilateral) and public-private initiatives address issues related to freshwater and to transboundary river basins** (*well established*). By 2007 there were 250 freshwater treaties, with 30 additional treaties being entered into every decade, mostly focusing on water quality and the environment. For transboundary rivers, more comprehensive agreements have been developed over the past few decades. Forty-three countries are Parties to the UNECE Water Convention, which entered into force in 1996. The UN Watercourses Convention, which entered into force in 2014, has 36 Parties. However, greater global attention is merited to lakes, reservoirs, wetlands and other lentic (standing) water systems, both because of the vast quantities of freshwater they contain (more than 90% of the liquid freshwater on the surface of Earth), and the wide range of life-supporting ecosystem services they provide to humanity. {16.3.3}

**Globally important wetlands are protected under the 1971 Ramsar Convention on Wetlands.** By 2019, 170 member states had designated 2,341 “Wetlands of International Importance” (known as “Ramsar sites”)





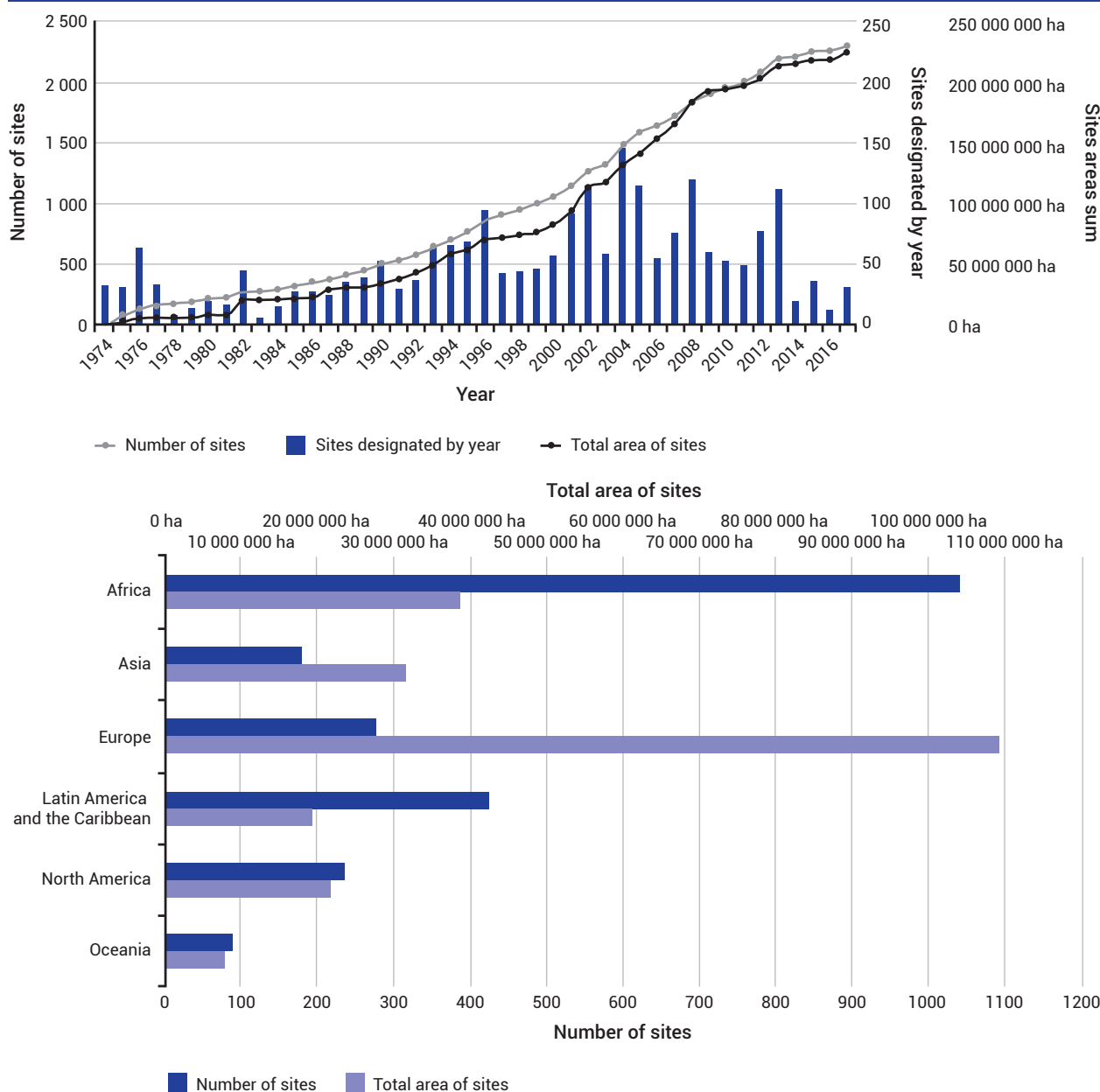


protecting 252 million hectares, an increase of 81 million hectares since 2000 (Figure 4.6). {Annex 6.1}

**There are non-legally binding agreements which recognize the human rights to water and sanitation services.** The right to water includes considerations of sufficiency, safety, acceptability, physical accessibility and affordability for personal and domestic uses. The development of the MDGs introduced a partial human rights approach to water while maintaining the notion of water as an economic good: there are clearly tensions between these approaches. A growing number of

countries now formally recognize this human right, following a General Assembly Resolution. The 2014 Global Analysis and Assessment of Sanitation and Drinking-Water reported that 70 out of 94 countries recognized the right to water. SDG 6, which has six targets with their indicators, aims to “ensure availability and sustainable management of water and sanitation for all”. National constitutions and legislation in which the right to water is recognized need to be supported by policy instruments that target financing and budgeting. Lack of financing is one of the primary obstacles to realizing the rights to water and sanitation. Water pricing,

Figure 4.6: Ramsar sites designated, by year and region



Source: Ramsar (2018).



if it is efficient, includes all the economic costs required to provide water. It underscores that the right to water does not necessarily call for free water provision. {16.2.4}

**International and transboundary river basin organizations (RBOs) are critical for transboundary treaty implementation.** *(established but incomplete)*

In general, the main functions of RBOs are (i) data gathering, monitoring and regulation; (ii) river basin planning; and (iii) development of infrastructure and facilities. {Chapter 16} Many RBOs are guided by Integrated Water Resource Management (IWRM) principles that seek to achieve efficiency, equity and ecological sustainability while addressing water quality and quantity issues. Examples of international RBOs include the International Commissions for the Protection of the Rhine and the Danube in Europe; the Mekong River Commission in Asia; the Senegal River Basin Development Organization, the Niger Basin Authority, the Zambezi Watercourse Commission, the Limpopo Watercourse Commission and the Nile Basin Initiative in Africa; the La Plata Basin Treaty in Latin America; and the Great Lakes Commission in North America. Such organizations could usefully be extended to cover international and transboundary lake and reservoir basins. {16.2.1}

**Voluntary reporting on water use and pollution in the mining sector is becoming critically important.**

Mining operations typically use vast amounts of water. Governments, companies and communities have recognized the fundamental need for efficient management of water resource-related risks by the mining industry. The main voluntary protocol for sustainability reporting is the Global Reporting Initiative (GRI), which began in 1997 as a coalition of government, community and corporate stakeholders, and aimed to make sustainability reporting as commonplace and important as corporate reporting. The current GRI standard includes a wide range of indicators across social, economic, environmental and local-community health aspects. It was designed to be used not only by the mining sector, but by any company or organization. {16.2.5}

**National water policy increasingly uses and implements integrated water resources management (IWRM) in a participatory process, based on intersectoral coordination and greater engagement of non-governmental actors.** An integrated management approach should consider both flowing rivers/streams (lotic water systems) and standing lakes/ wetlands (lentic water systems) in developing basin management plans. Managing lentic water systems also requires recognition of their unique characteristics, compared to flowing water systems (e.g., long water retention time; integrating

nature; non-linear responses). Integrated Lake Basin Management (ILBM) provides a means of addressing these unique features within basin management plans via integration of institutional responsibilities, policy directions, stakeholder participation, scientific and traditional knowledge, technical possibilities and funding prospects. Collaborative efforts are required to involve the private sector and NGOs, or local governments and citizens. Stakeholder engagement is a long-term process that requires investment in supporting stakeholder relationships. Institutions should be designed to enable inputs to decision-making from these relationships, rather than treating them on an ad hoc basis. Devolution of water governance requires supporting investments, capacity-building and sustained long-term awareness-raising efforts. Fusion of ILBM within IWRM would provide a comprehensive and effective management approach. {Chapter 16, ExecSum, 16.1, 16.2.1, 16.2.2, 16.2.5}

**While policy approaches become further integrated and complex, there is an ongoing need to address basic environmental clean-up and the reversal of damaging legacies.**

Even in developed economies regulation, technical fixes and investments are required in order to continually improve water use practices and prevent the degradation of water quality. {16.1} However, new policies may be needed to change the direction of trends in water use. {Chapter 16, ExecSum, 16.6.1}

**Efficient water use requires water-sensitive urban design of water infrastructure, including conjunctive surface and groundwater development and promotion of managed aquifer recharge** *(well established)*.

Together with investment in wastewater treatment and recycling, these approaches support water quantity and quality management. They also promote drought risk reduction and resilient urban water supplies. At the same time, the provision of drinking water supply and sanitation services to all (as well as leakage control from bulk water supplies) are still challenges in many cities of the world. {9.9}

**Promoting water-use efficiency, water recycling, water reclamation and rainwater harvesting is increasingly important to ensure more equitable water allocation for different users and uses, thereby facilitating human water security** *(well established)*.

Circular approaches such as reusing water within recycle loops help to reduce water withdrawals, as well as protecting ecosystem health. More sustainable management and better monitoring of surface and groundwater is urgently needed. {9.4.2, 9.9.5}

**For effective management, an entire watershed or river basin needs to be considered holistically as an integrated socio-ecological system** *(well established)*. This entails

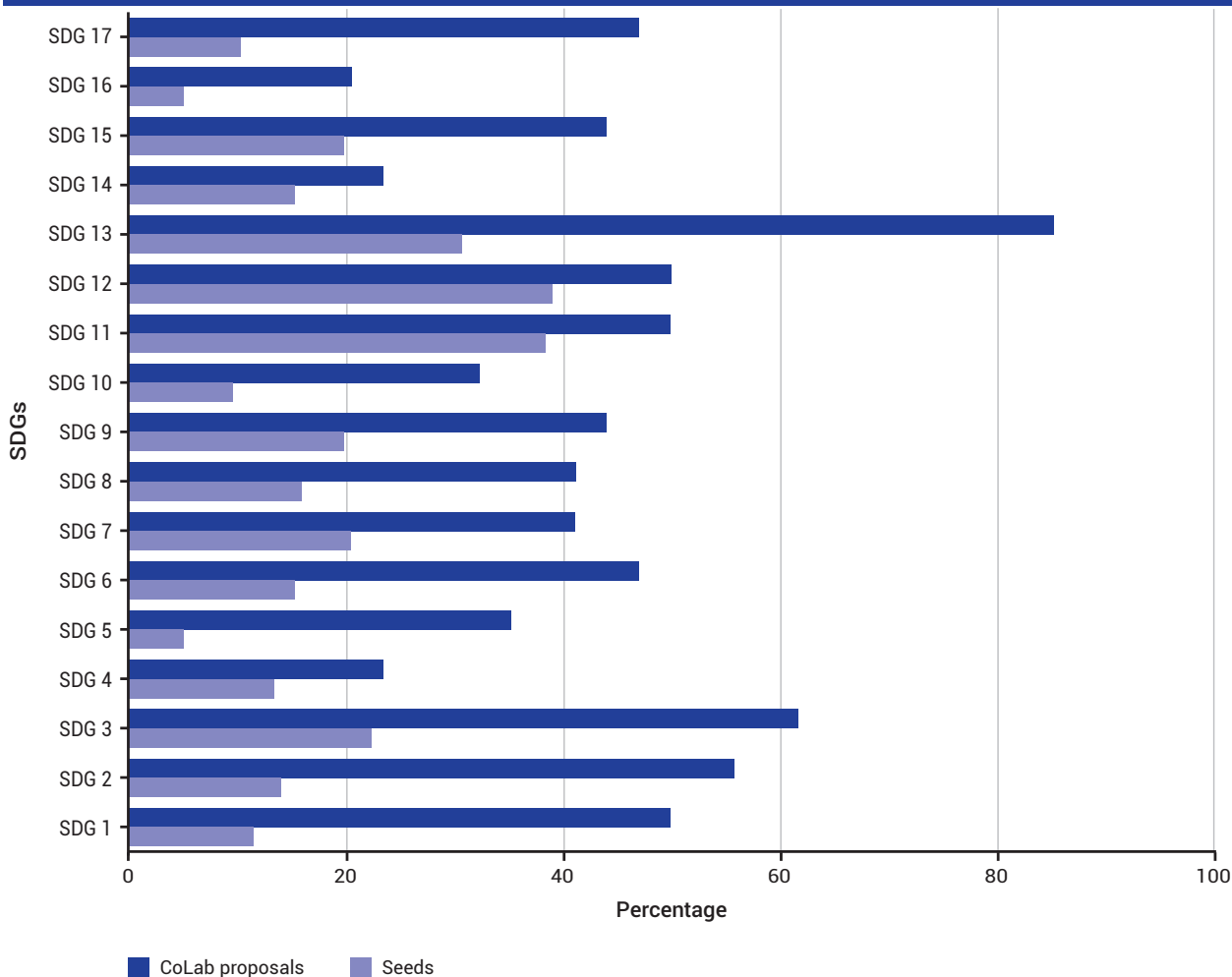


managing water resources across agriculture, forestry, cities, industry, domestic and commercial uses within the context of the ecosystems remaining in the basin. MEAs governing water resources and water-related ecosystem management and climate change support embedding IWRM in laws, including national and local legislation, regulations and institutions. However, in some regions there is limited capacity to implement IWRM at the institutional or individual level. {9.9.3}

**Monitoring, modelling and managing aquifer systems and flux exchanges with freshwater and ecosystems at local, national and transboundary scales are essential in order to implement sound aquifer and integrated water resources management** (*well established*). For example, salinization of aquifers resulting from subsidence in river deltas is a complex issue for coastal agriculture and urbanization, whereas saline intrusion into coastal aquifers can be controlled through managed aquifer recharge. {Chapter 9, ExecSum, 9.9}

**Evidence-based risk management is essential to promote cooperative water governance and build trust with and among stakeholders** (*well established*). The availability of open, transparent data is important in implementing multilateral environmental agreements and water-related conventions; supporting a bottom-up inclusive and informed stakeholder engagement; and facilitating uptake of scientific knowledge and best practice. Citizen science, and decentralization of decisions to impacted communities, are increasingly being included in good water governance, along with support for multinational cooperation in transboundary basin and aquifer management. The use of remote sensing and smart technologies to map available water resources (and abstractions and quality), combined with ground-truthing of data, mapping demographic and land-use changes, can be used for early warning of water scarcity as well as disaster risk reduction. {9.4.4}

Figure 4.7: SDGs targeted by the total workshop seeds and the total Climate CoLab proposals



Source: UNEP (2019, p. 556).

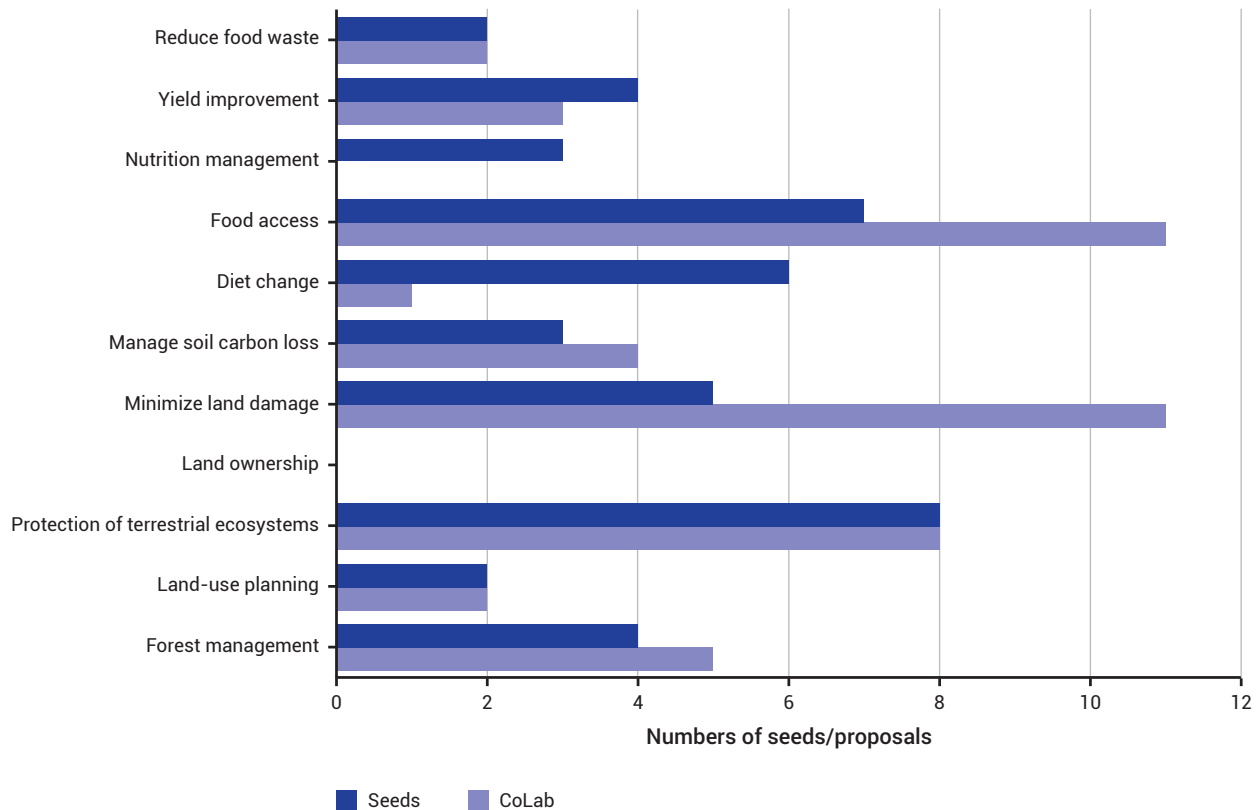


## 4.4 Bottom-up action

The need to consider the primary evidence (as opposed to scholarly publications) regarding the contributions of bottom-up initiatives is being recognized formally in global assessments (*unresolved*). This demonstrates both political commitment to bottom-up implementation and the potential to achieve environmental goals, such as decarbonization by 2050. {23.4} In the Fifth Assessment Report of the IPCC, Chapter 12 on human settlements, infrastructure and spatial planning acknowledged the role of local actors in global climate mitigation. The 2016 Emissions Gap Report included, for the first time, an assessment of multiple studies that quantified the additional contribution of local actors to mitigation. This analysis found that subnational and non-State actors could reduce emissions by as much as 10.0 Gt of CO<sub>2</sub> in 2020 compared with 2015. These cuts would help narrow the 12-14 Gt gap in 2030 between emissions cuts by national governments and the amount that global scenarios tell us is needed to avoid a 2°C increase in global average temperature – although the latest IPCC report emphasizes the need for global action to meet the 1.5°C target (IPCC 2018). {23.4}

Several approaches for bottom-up futures identify local practices and small-scale sustainability initiatives at varying geographic levels and across sectors (*unresolved*). At the global level, the Seeds of Good Anthropocenes and Climate CoLab projects are examples of such initiatives. Other “seeds” (small-scale sustainability initiatives) were identified at workshops held at the time as some of the GEO-6 authors’ meetings. The Seeds of Good Anthropocenes project is developing a collection of local, social, technological, economic, ecological and socio-ecological initiatives to help envision positive environmental futures. Climate CoLab is an online platform where anyone can submit and discuss climate change solutions. While the Seeds of Good Anthropocenes project focuses on identifying and investigating local initiatives, Climate CoLab focuses primarily on initiative identification, development and evaluation through a crowdsourcing mechanism. {23.4} The workshop seeds and Climate CoLab proposals identified for GEO-6 targeted each of the 17 SDGs to varying extents. **Figure 4.7** highlights the range of SDGs found in the analysis. **Figure 4.8** shows the types of issues addressed. In the case of the workshop seeds, SDG 12 (responsible consumption and production) and SDG 11 (sustainable cities and

**Figure 4.8: Total number of workshop seeds and Climate CoLab proposals addressing each intervention in the agriculture, food, land and biodiversity cluster (seeds and proposals are double counted when they meet multiple measures)**



Source: UNEP (2019, p. 564).



communities) were most represented. In the case of the Climate CoLab proposals, SDG 13 (climate action) was targeted by over 80 per cent of proposals, followed by SDG 3 (good health and well-being). {23.9.2}

**Participatory approaches to identify and assess transformative solutions and envision pathways towards greater sustainability can provide decision makers with a useful landscape of initiatives and concrete synergistic solutions** (*established but incomplete*). By engaging with stakeholders through global workshops and Climate CoLab, GEO-6 collected diverse solutions and visions that can complement (and potentially contribute to) quantitative information to be fed into integrated assessment models. For example, there was a strong emphasis on sustainable food systems as critical intervention points for moving towards a healthy planet and healthy people. {23.4}

**Many bottom-up visions for urban futures coalesce around building sustainable cities or communities.** Urban areas are imagined in which buildings are fitted with solar panels and/or green roofs, built with sustainable materials, and use smart technologies to minimize energy use. Pathways to sustainable futures often included setting aside spaces and providing infrastructure to enable urban agriculture, the products of which could be used for food and sustainable consumer goods. One initiative focused specifically on an international cities platform allowing environmental data and actions to be aggregated internationally, and to be used by citizens to learn and to take part in sustainable community actions. {23.13}

**Many solutions provide an opportunity for developing countries to leapfrog to more sustainable and equitable development trajectories.** The use of information and communications technology (ICT) plays a major role in driving change in the bottom-up pathways towards sustainability: this is a result of a stronger focus on theories of change and on *how* change processes are facilitated. There are already many good examples of the way ICT is being leveraged for change in the global South. The roles of different societal actors and diverse knowledge systems are made explicit in bottom-up pathways. For example, in many proposals there is an important role for city-level government actors. The proposals also include a role for global networks of, for example, sustainable cities or energy cooperatives. Diverse higher-level enabling conditions such as international agreements, again tied to specific actors, are discussed as part of the bottom-up pathways and their seed initiatives. {23.13}

## 4.5 Lessons learned

**Mainstreaming social and ecological dimensions into environmental and climate policies is critical for their success** (*well established*). New policies should explicitly target women, indigenous peoples, family farmers, pastoralists and fishers, among other groups, so that they can have secure and equal access to land, resources, inputs, knowledge, financial services markets, and opportunities for adding value and non-farm employment (*established but incomplete*). Closing the gender gap regarding access to and control over resources such as land and production inputs (and access to information and technology) would increase agricultural productivity and reduce poverty and hunger. {1.5.1}

**Policy design is at least as important as the choice of policy instruments for policy effectiveness** (*well established*). Common elements of good policy design include: (i) establishing 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 for optimal efficiency and effectiveness, and ensuring that social aspects are 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 in order to close the loop for future policy design improvement. {11.2.3}

**Multilevel governance is a source of policy innovation** (*well established*). MEAs 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 of advancing policies at other levels. {11.4}

**An integrated approach is key for effective policies** (*well established*). The integration of environmental concerns into various sectors at all levels (including agriculture, fisheries, tourism, forestry, industry, manufacturing and processing, energy and mining, transport, infrastructure and health) is key to effective protection of the environment. Social and economic



aspects require careful consideration when environmental policy is being developed. Similarly, a gender-integrative approach could support more effective and transformative environmental policies and interventions. {11.3}

**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 and natural capital accounting systems to ensure that external costs are addressed and that processes are incorporated that will identify possible future risks, opportunities and conflicts. {18.3}

**Greater application of the precautionary approach, in accordance with international agreements (where applicable), can reduce environmental and climate risk.** (*established but incomplete*) Coalitions between government institutions, businesses and civil society to agree on pathways for tackling societal risks can achieve progress, even under conditions of great uncertainty. Multilevel coordination between local and national policy levels will be instrumental in accelerating the transition towards sustainable development models. {24.3.4}

**Environmental policies struggle with conceptual and empirical challenges, so that a good starting point for analysis is to determine what constitutes “good” policy design.** Within the definition of good policy design, ecosystem properties and problems, and the performance of existing policies, practices and actors, should be considered as common elements. Analysts and policymakers need to better understand the temporal dynamics of policy change, how and why specific policies work (or do not work), and how policy choices interact in increasingly complex policy mixes. {Chapter 11, ExecSum}

**Policy innovation can be regarded as a mix of invention (new or novel approaches), diffusion (transfer and adoption) and monitoring of effects (outcomes, impacts and possibly disruption).** Good practice suggests that multiple innovative policies should be implemented as a form of quasi-experiment, with best practices emerging from the monitored effects. {Chapter 11, ExecSum}

**Policy instruments working in silos are insufficient to stem environmental problems** (*well established*). A key lesson learned is to carefully craft a mix of policies that are well aligned with an overall policy objective, followed by monitoring of the actual effects to determine best practice and the likely contributions of different policies. For example, climate change mitigation policy objectives need a comprehensive mix of carbon pricing, support for energy efficiency and renewable energy, phasing out of fossil fuel subsidies, innovation policies, prevention of the lock-in of certain technologies, and changes in consumer behaviour, among others. {Chapter 11, ExecSum}

**Environmental objectives cannot be realized through environmental policies alone. They need to be incorporated in non-environmental policy sectors.** Environmental ambitions often clash with other sectoral goals. Environmental policy integration should therefore be used to address conflicts between environmental and other policy objectives. A corollary to policy integration is policy coherence: the promotion of mutually reinforcing policy actions that create synergies towards achieving objectives in multiple sectors. {Chapter 11, ExecSum}

**Different investments are needed to improve management capacity in different regions.** For example, the GEO-6 regional assessments identified improving air quality monitoring infrastructure as a priority for Africa and Latin America and improving the use of benefit-cost analyses of climate change and air pollution mitigation measures as a priority for Asia and the Pacific. {Chapter 23, ExecSum}

**Education for sustainable development is essential to achieve the SDGs, promote a more sustainable society, and accommodate unavoidable environmental changes** (*well established*). Significant progress has been made around the world in implementing education for sustainable development in all educational sectors. However, scaling it up is essential so that it can be included as a core element of education system structures globally. Policies that eliminate economic and gender barriers will improve access to education. Education for sustainable development can be scaled up through 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}

**Even achieving the SDGs and meeting other internationally agreed goals related to climate change,**



**pollution control, clean-up and improved efficiency 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. This requires

a paradigm shift in thinking and approaches. 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. {18.2}

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



















## A Healthy Planet and Healthy People are Synergetic: Achieving Transformative Change

### 5.1 Future developments without further policy interventions

Based on an assessment of the scenario literature, it can be concluded that a continuation of current trends will not lead to fulfilment of selected environmental targets of the SDGs (*established but incomplete*). While business-as-usual scenarios project some improvement for indicators related to human development, indicators related to the natural resource base are projected to move further in the opposite direction (**Figure 5.1**). Ongoing population growth and economic development imply that global demand for food, water and energy will strongly increase towards 2050. At the same

time, clear improvements are projected in reducing hunger, increasing access to safe drinking water and adequate sanitation, and increasing access to modern energy services, although not fast enough to meet the corresponding SDG targets by 2030. Furthermore, although resource efficiency in production and consumption (in agricultural yields, nutrient use efficiency, water use efficiency and energy efficiency) is projected to improve, mostly in line with historical trends, climate change, biodiversity loss, water scarcity, land degradation, nutrient pollution and ocean acidification are projected to continue at a rapid rate so that the corresponding SDG targets will not be met. {21.4}

Figure 5.1: 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
	2.1 End hunger			6.3 Improve water quality 6.4 Reduce water scarcity	
	3.2 End preventable deaths of children under 5			11.6 Improve air quality in cities	
	6.1 Achieve universal access to safe drinking water 6.2 Universal access to adequate sanitation			13 Limit global warming	
	7.1 Achieve universal access to modern energy services			14.1 Reduce marine nutrient pollution 14.3 Minimize ocean acidification 14.4 Sustainably manage ocean resources	
<b>Legend</b>				15.2 Achieve land degradation neutrality 15.5 Halt biodiversity loss	
	On track to achieve target (under business-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}

Source: United Nations Environment Programme [UNEP] (2019a, p. 19).



**Table 5.1: Historic and business-as-usual trends in resource use efficiency in production and consumption**

Selected target for GEO-6	Indicator	Historic development	Trend in business-as-usual scenarios
<b>Increase agricultural productivity (Section 21.3.2)</b>	Yield improvement over time (cereals)	1.9 per cent/yr (1970-2010)	0.4-0.9 per cent/yr (2010-2050)
<b>Increase nutrient-use efficiency (Section 21.3.2)</b>	Total N inputs to the crop N yields	0.42 in 2010	0.55 in 2050
<b>Increase water-use efficiency (Section 21.3.4)</b>	Change in water-use efficiency over time	0.2-1 per cent/yr (1970-2010)	0.3-1 per cent/yr (2010-2050)
<b>Increase the share of renewable energy (Section 21.3.3)</b>	Renewable energy share in total final energy consumption	15 per cent in 2010	20-30 per cent in 2050
<b>Increase energy efficiency (Section 21.3.3)</b>	Reduction in energy intensity over time (measured in terms of primary energy and GDP)	1-2 per cent/yr (1970-2010)	1-2.5 per cent/yr (2010-2050)

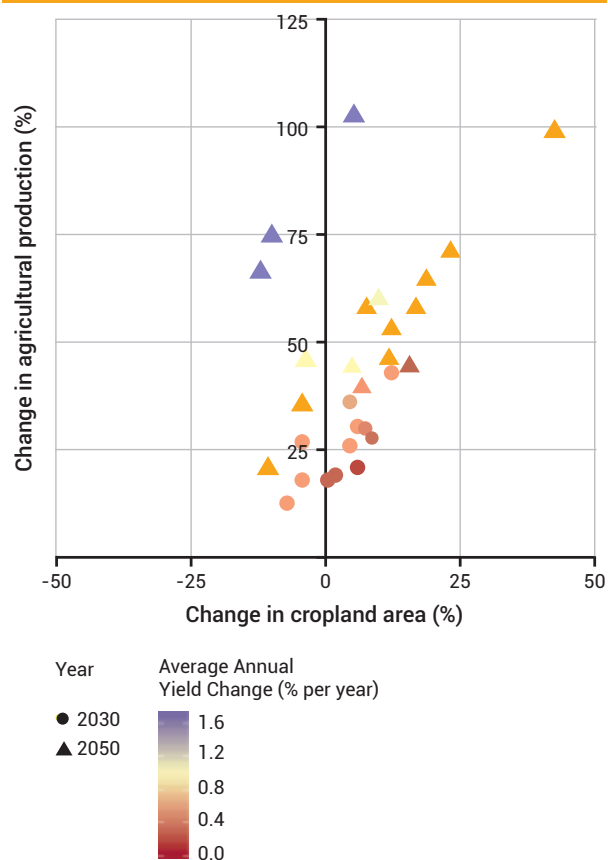
Source: UNEP (2019b, p. 505).

**Under current trends, environmental problems related to global food production will further increase and energy systems will continue to be largely responsible for climate change and air pollution (well established).** Global demand for food and primary energy sources is projected to increase by more than 50 per cent between 2015 and 2050. The number of undernourished people is projected to decline and access to modern and clean energy sources is projected to increase, but far from enough to eradicate hunger or to achieve universal access by 2030. Over the last decades, around four-fifths of the increase in food demand has been met by agricultural intensification and one-fifth by an increase in agricultural area. This trend is projected to more or less continue (Figure 5.2). {21.4}

**Fossil fuels are projected to remain prominent in the world energy system.** Overall, global food production will continue to contribute to environmental problems, including increased GHG emissions, land conversion, water demand, nutrient run-off, biodiversity loss and land degradation. Furthermore, energy use is projected to continue to be the most important cause of GHG emissions and air pollutants. {21.3.2; 21.3.3}

**Without the adoption and implementation of new climate policies, the Paris Agreement goal of limiting global average temperature to well below 2°C will not be achieved (well established).** Current and planned climate policies, as formulated by different countries under the Paris Agreement, are projected to lead, at best, to a stabilization of emissions. This is considerably less than what is needed to achieve the Paris Agreement objectives. Achieving these objectives would require an almost complete decarbonization of the energy system by 2050. {21.3.3}

**Figure 5.2: Percentage change in non-energy crop production vs. the percentage change in non-energy cropland area from 2010 to 2030 and 2050**

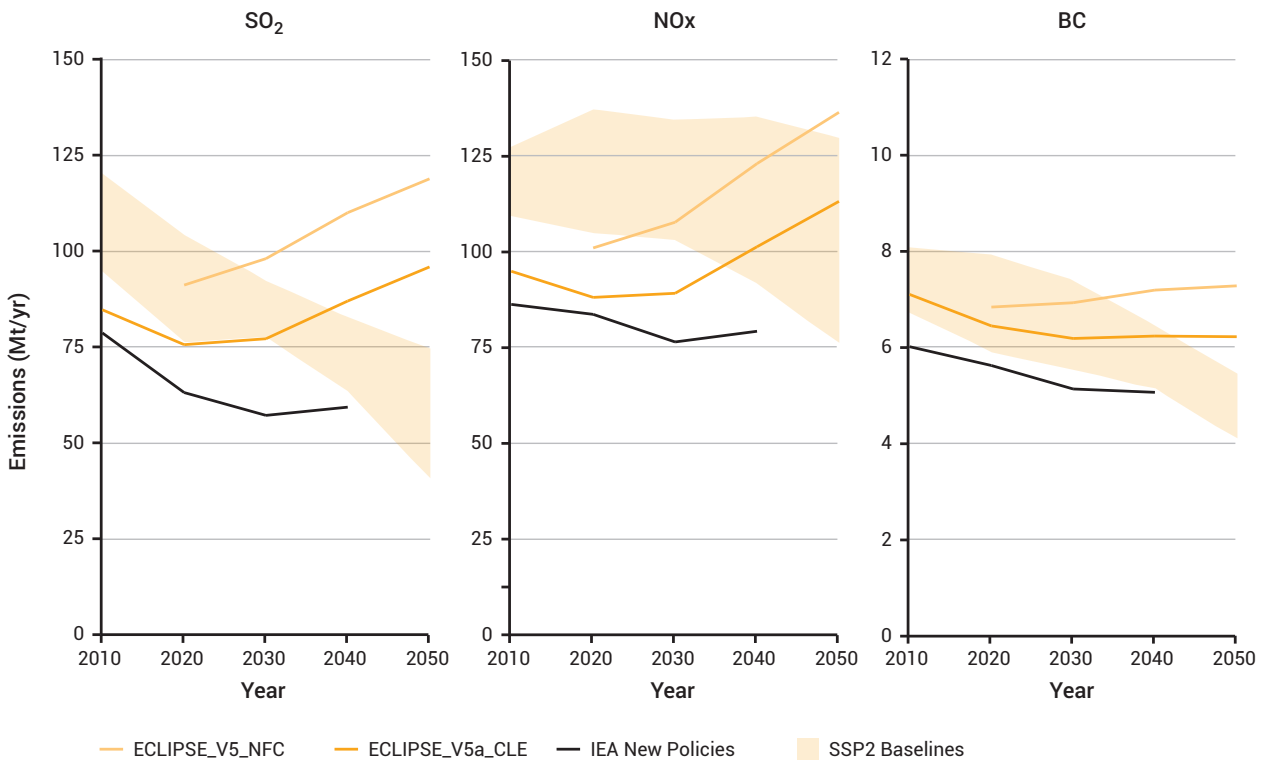


Each marker is a model-scenario-year combination. Colour indicates the annual percentage change in yield over the same time period. Yellow is close to historical trends (about 1 per cent per year between 1960 and today from Alexandratos and Bruinsma 2012); blue indicates yield growth faster than historical trends; red indicates yield growth slower than historical trends. For the SSPs, yield is the global average yield for cereal crops. For the Bajželj *et al.* (2014) scenarios, yield is the global average yield for wheat and data are referenced with respect to 2009.

Sources: SSPs (Popp *et al.* 2017) and Bajželj *et al.* (2014).



Figure 5.3: Future projections of emissions for air pollutants SO<sub>2</sub>, NO<sub>x</sub> and BC



Source: ECLIPSE\_V5\_NFC and ECLIPSE\_V5a\_CLE represent ECLIPSE's "no further control" and "current legislation" scenarios (Stohl *et al.* 2015; Klimont *et al.* 2017). IEA New Policies represent IEA's new policy scenario that includes nationally determined contributions (NDCs) of the Paris Agreement (International Energy Agency [IEA] 2016). For the SSP2 scenario, the shading represents the range for all models (Rao *et al.* 2017).

**Ambient air pollution is projected to continue contributing to millions of premature deaths in the coming decades (Figure 5.4).** (*established but incomplete*). Without stringent policies to control air pollution, ambient PM<sub>2.5</sub> concentrations are projected to increase. Most trend scenarios assume that more stringent air pollution policies will be applied in developing countries as their incomes increase, bringing about a slow decrease in emissions of PM<sub>2.5</sub> and its precursors. However, this trend would not be sufficient to reduce PM<sub>2.5</sub> concentrations below the least stringent WHO air quality target in large parts of Asia, the Middle East and Africa, thus projecting 4.5 to 7 million premature deaths globally by mid-century. {21.3.3}

**Biodiversity will continue to decline under business-as-usual scenarios** (*well established*). Loss of natural habitat has been, and still is, the single most important factor in biodiversity loss. However, trends in water scarcity, climate change, pollution and disturbance are driving a further decline in biodiversity. Scenario studies show that many of these factors are likely to worsen in the future. As a result, model projections show changes in different dimensions of biodiversity. {21.3.2}

**Oceans are expected to continue to be polluted and overexploited** (*established but incomplete*). Increased fertilizer use in agricultural production and developments in wastewater treatment that are lagging behind improvements in access to sanitation are projected to increase nutrient (nitrogen and phosphorus) flows from land run-off and freshwater transport into oceans, exceeding sustainable levels. As a result, dead zones and algal blooms in coastal areas will increase. Furthermore, because of increasing CO<sub>2</sub> concentrations, oceans are projected to further acidify, negatively affecting marine organisms' ability to create shells and skeletons or even resulting in shell dissolution. Acidification is expected to increase most rapidly in the polar regions. Finally, if current strategies for improving fishing performance fail to be effective or more widely deployed, the projected increase in demand for fish is expected to reduce the proportion of fish stocks that remain at biologically sustainable levels. {21.3.5}

**Further land degradation is expected to occur, based on trends in land use, climate change and increasing pressure on land and water resources.** (*well established*) As a consequence of continuing land conversion and



unsustainable land management, an additional 27 Gt of soil organic carbon is projected to be lost between 2010 and 2050, affecting agricultural yields through reduced water-holding capacity and loss of nutrients. Furthermore, losses of soil organic carbon will have wider effects on biodiversity, hydrology and carbon emissions. {21.3.2}

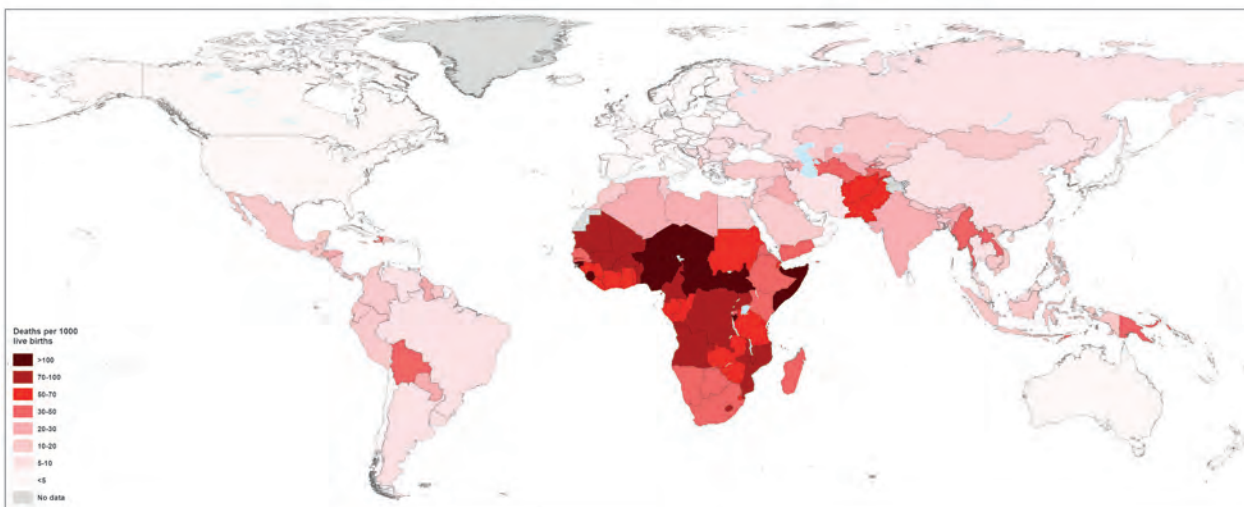
**Despite technological development and improved seeds, machinery and fertilizers, based on current trends we are unlikely to meet future demands for food, energy, timber and other provisioning ecosystem services, or the SDG targets for terrestrial and marine biodiversity (well established).** International trade is increasingly important to meet global food demand. However, as seen during the 2008 food price crisis, it is not a “silver bullet solution” to sudden shocks or crises, which is what will be needed as climate change exacerbates environmental problems in vulnerable agricultural systems. {8.5.1}

**Both global water scarcity and the population affected by it are expected to increase (established but incomplete).** Human water demand is projected to increase by around 25 to 40 per cent by the end of this century. This increase will primarily be driven by rapid population growth and increased industrial activity (with, for example, higher electricity and energy use) in developing countries. Expansion of irrigated area and higher irrigation intensity are also projected, although

their effect could be compensated by improvements in irrigation efficiency in regions where there is strong economic development. Changing rainfall patterns will exert additional pressure on regional water availability. By 2050 the Asian population living in areas exposed to severe water stress is projected to increase by around 50 per cent compared with 2010 levels, putting severe pressure on non-renewable groundwater reserves. {21.3.4}

**Preventable environmental health risks are projected to remain prominent in 2030, with related negative impacts particularly on child mortality (established, but incomplete).** Nearly one-quarter of all deaths globally in 2012 can be attributed to environmental factors, with a greater portion – differentiated by gender, age and class – occurring in vulnerable populations and in developing countries. Preventable environmental risk factors (e.g. exposure to ambient air pollution or not having access to clean water, adequate sanitation and modern energy services), together with global hunger, are projected to improve towards 2030 although not fast enough to achieve the corresponding targets in all countries. Related global child mortality is projected to decline, but not enough to achieve the SDG targets in many developing countries (**Figure 5.4**). Especially in sub-Saharan Africa, child mortality rates remain high, with a continued (although smaller) share related to preventable environmental risk factors. {21.3.6}

Figure 5.4: Projected under-five mortality rate in 2030



Source: Moyer and Hedden (2020).



## 5.2 Pathways to Sustainable Development

**Based on an assessment of the scenario literature, it can be concluded that different pathways exist to achieve selected environment-related SDG targets, but that these pathways require transformative change (*established but incomplete*).** The rates of change in the pathways imply more than incremental environmental policies: significant improvements in resource efficiency with respect to land, water and energy are required. This would include large productivity gains in agriculture; significant improvements in nutrient-use and water-use efficiency; almost a doubling of the energy efficiency improvement rate; and more rapid introduction of “carbon-free” energy options. Achieving full access to food, water and energy resources will also require systemic change. {22.3; 22.4.1}

**Achieving the targets of the environment-related SDGs will require a broad portfolio of measures based on technological improvements, lifestyle changes and localized solutions (*established but incomplete*).** The pathways emphasize a number of key transitions associated with achieving sustainable consumption and production patterns for energy, food and water, in order to provide universal access to these resources, while preventing climate change, air pollution, land degradation, loss of biodiversity, water scarcity, over-exploitation and pollution of the oceans. These transitions include, on one hand, changes in consumer behaviour and, on the other, cleaner production processes, resource efficiency and decoupling, and corporate responsibility. {22.3}

**Concurrently eliminating hunger and preventing biodiversity loss is possible through combining measures related to consumption, production and access to food, including food from the sea, with nature conservation policies (*well established*).** Scenarios for achieving the targets are typically characterized by a 50 per cent faster improvement in agricultural yields than business-as-usual scenarios, but they 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. Reducing land degradation is linked to developments in land use, but scenario studies are lacking in the literature. {22.3.1}

**Resource efficiency contributes to economic resilience (*well established*)** by increasing the supply security of primary materials and closing resource

loops through remanufacturing and recycling, thereby reducing the pressures of resource exploitation, climate change, accumulation of toxic substances in ecosystems, and biodiversity loss. {17.6.2}

**Increasing resource efficiency to the required extent will not happen spontaneously through the market but requires well-designed policies (*established but incomplete*)** that facilitate a change to sustainable systems of production and consumption and sustainable and resilient infrastructure. {17.6.4}

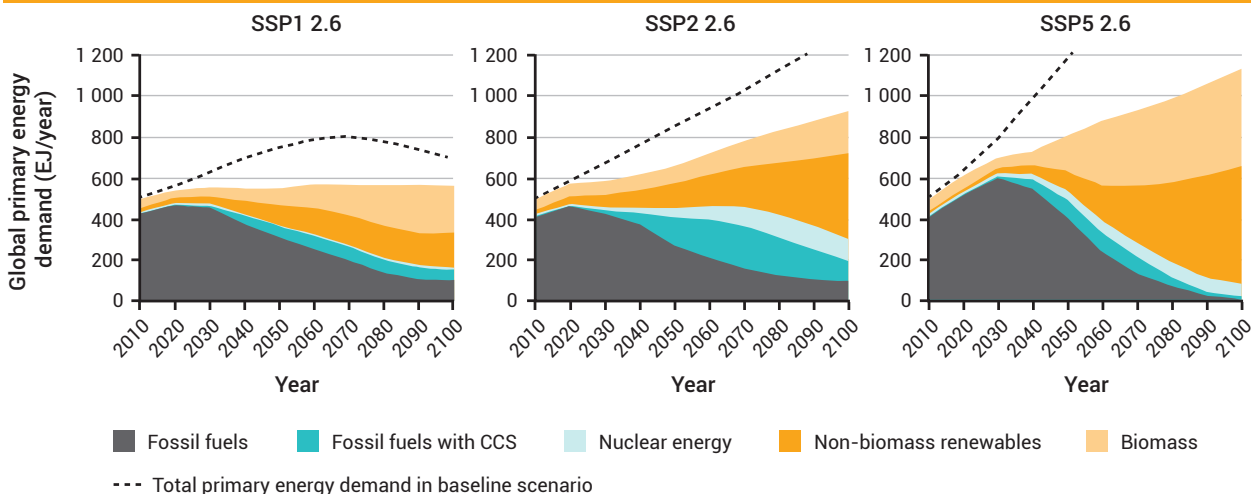
**The strong links between biodiversity loss and land use mean that more coordinated international action is needed (*established but incomplete*).** The scenario literature clearly shows that meeting targets to halt biodiversity loss would not be feasible if land use followed business-as-usual trajectories into the future. Moreover, other policies outside the realm of traditional nature conservation policies, such as those related to infrastructure development and climate change, are urgently needed in order to conserve biodiversity. Ensuring more coordinated policy action is therefore important at all levels – within national governments, but also internationally – particularly between land-use planning and biodiversity protection. {22.3.1}

**Measures to achieve targets related to climate change, air pollution and access to energy can be combined in different ways but need to be implemented rapidly and at an unprecedented scale (*well established*).** This involves investment in energy access, doubling of energy efficiency improvement, lifestyle changes (e.g. a shift to low-meat diets and a move to more public modes of transport), more rapid introduction of low- and zero-carbon technologies (including hydropower, solar and wind, and carbon capture and storage), air pollution control, reduction of non-CO<sub>2</sub> GHG emissions, and use of land-based mitigation options (e.g. forestation measures and the use of bioenergy). Emission reduction measures need to be implemented rapidly, as the carbon budgets for achieving the Paris Agreement are very tight. {22.3.2}

**Pathways consistent with meeting the objectives of the Paris Agreement are characterized by a combination of energy intensity reduction and an increase in the share of low-GHG emission technologies that is significantly larger than historical values. (*well established*)** The energy efficiency increase would need to be at least 2-3.5 per cent per year, while the level of low- and zero-carbon technologies would need to increase from around 15 per cent today to at least 40-60 per cent by 2050



Figure 5.5: Different pathways leading to a global mean temperature increase well below 2°C



Source: Bauer et al. (2017); Riahi et al. (2017).

(Figure 5.5). The low-range value of 40 per cent is only sufficient if combined with a rapid decline in energy demand. All in all, the reduction in the carbon intensity of the global economy (rate of change of the ratio of CO<sub>2</sub> over GDP) needs to increase from around 1-2 per cent per year historically to around 4-6 per cent per year towards 2050. {23.3.2}

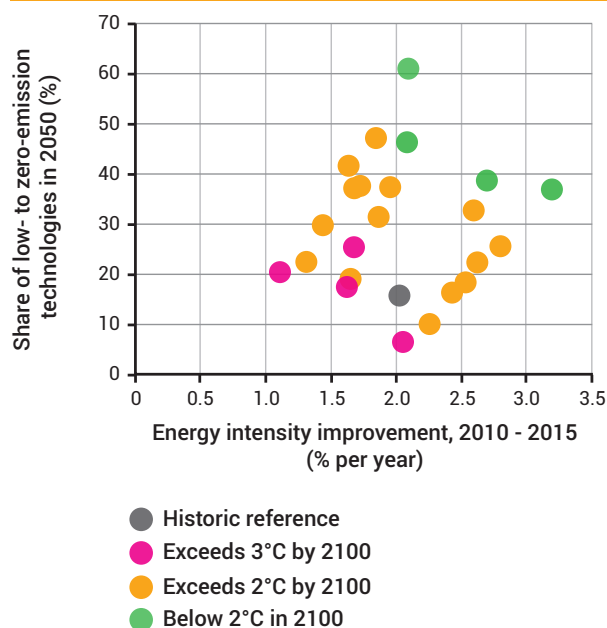
**There are numerous policy mechanisms available to address these challenges.** These include carbon pricing (cap and trade systems, carbon taxes, and other economic instruments such as fuel taxes and different subsidies to renewable energy), regulatory approaches (energy efficiency standards, command-and-control, mandatory decommissioning of old plants), information programmes (targeting behaviour, lifestyles and culture), and addressing administrative or political barriers (including through international cooperation) (*established but incomplete*). {24.3}

**Decarbonizing supply and improving demand efficiency are two key policy elements that have been applied successfully (*well established*).** Nevertheless, they need to be scaled up rapidly, together with phasing in new policies, reducing energy intensity, and increasing the share of low- or zero-carbon technologies. While demand-side measures mostly reduce energy intensity, supply-side measures would increase the share of low-carbon options (Figure 5.6). {17.5.4; 22.3.2} Major areas of policy intervention in energy systems related to the SDGs (especially SDG 7) are decarbonization measures that aim to substitute fossil fuels with clean(er) or renewable alternatives and implementation of efficiency measures that can provide the same service while using fewer resources. {17.5.2} Rapid advances are occurring in

the market development of cleaner and energy-efficient technologies, including renewables (e.g. solar, wind, advanced biomass), storage (e.g. batteries, pumped hydro), energy efficiency (e.g. demand-side management and dematerialization) and decarbonized transport options (e.g. electric vehicles). In the case of renewable energy, for example, diffusion and scale-up are becoming both feasible and affordable worldwide. {2.6.2}

#### The economics of transition to low-carbon energy

Figure 5.6: 2010-2050 energy intensity reduction rate and the 2050 share of low GHG technologies in the total energy mix of the scenarios included in the SSP database



Source: Riahi et al. (2017); Rogelj et al. (2018).



**sources have been greatly assisted by a dramatic reduction in the cost of renewables** (*established but incomplete*), especially wind and solar photovoltaic systems. Solar power experienced a price decline of 23 per cent for each cumulative doubling of production during the last 35 years. In many cases these costs are now lower than those of conventional fossil fuel electricity generation technologies. By 2040, it is estimated that renewables will constitute two-thirds of the global investment in power generation while solar energy will become the largest source of global low-carbon capacity. {2.6.2, 4.4.2}

**Air pollution emissions can be reduced significantly, but pathways towards meeting the most stringent air quality guidelines are currently not available** (*established but incomplete*). Introducing air pollution policies alone is often not enough to achieve stringent air quality standards. However, climate change mitigation (e.g. through phasing out fossil fuels) also significantly reduces air pollutant emissions (**Figure 5.7**). As a result, scenarios that combine climate policies with stringent air pollution policies show strong reductions in emissions of particulate matter with diameter less than 2.5 micrometres ( $\mu\text{m}$ ) (or  $\text{PM}_{2.5}$ ), leading to a significant improvement in air quality in all regions. Under the best-case scenarios, less than 5 per cent of the population is projected to be exposed to  $\text{PM}_{2.5}$  levels above the WHO's most lenient interim target of  $35 \mu\text{g}/\text{m}^3$ , although more than half the population is still projected to be exposed to levels above the guideline of  $10 \mu\text{g}/\text{m}^3$ . {22.3.2}

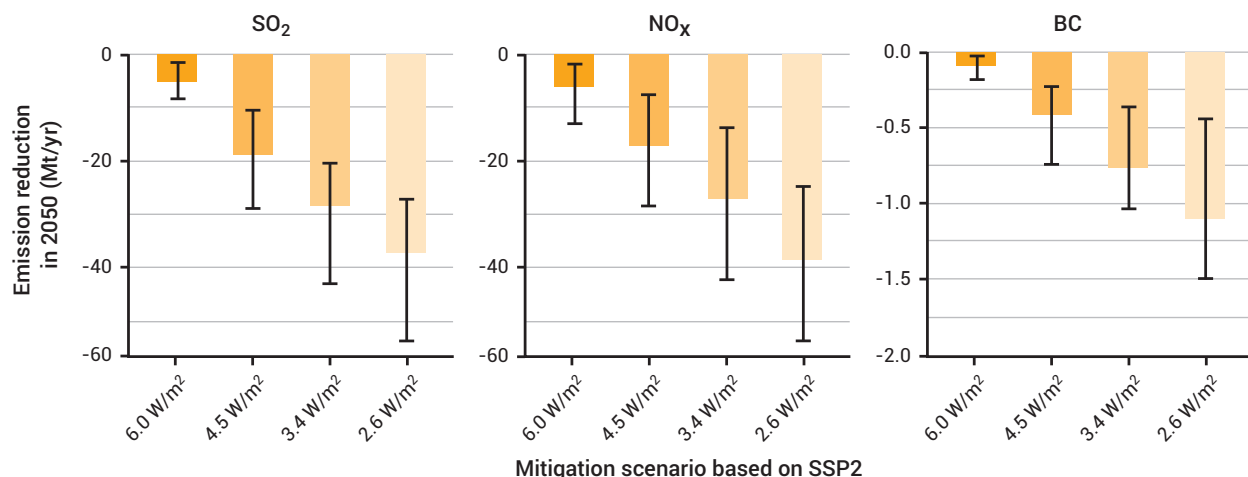
**Achieving environmental targets related to oceans requires consistent policies in other sectors** (*well established*). Preventing ocean acidification is highly

dependent on climate change mitigation (i.e. reduced  $\text{CO}_2$  emissions). Reducing marine nutrient pollution, and related hypoxia and algal blooms, will require a significant reduction in nutrient run-off, primarily from fertilizer use and untreated wastewater. {22.3.4}

**Reducing global water stress, including groundwater depletion, will require more efficient and circular water use, as well as increasing water storage above and below ground and investing in wastewater treatment, recycling and reuse** (*established but incomplete*). To reduce the total global population suffering from water scarcity by 2050 and beyond, water-use efficiency needs to improve by more than 20-50 per cent globally. This includes increasing agricultural water productivity, improving irrigation efficiency, and making water use more efficient in both domestic and industrial sectors. Rainwater harvesting and aquifer storage and recharge require modest investments which are urgently needed. Wastewater treatment and reuse need a large amount of economic investment and modernization of existing infrastructure, which might not be feasible for some developing countries. Desalination technologies are highly capital- and energy-intensive. However, nature-based solutions can increase and/or regulate water supply by mitigating water pollution while complementing economic investments. {22.3.3}

**Land-based climate change mitigation and agricultural intensification are key measures for achieving climate and biodiversity targets, respectively, but they could have significant detrimental effects on other targets if not managed carefully** (*well established*). While nearly all scenarios consistent with achieving the Paris Agreement rely on land-based mitigation measures (i.e.

**Figure 5.7: Differences in the air pollution emissions between various climate mitigation scenarios, and the SSP2 baseline**



Source: Rao et al. (2017).





bioenergy crop production and afforestation projects), their use increases demand for land, with related biodiversity impacts, and potentially leading to higher food prices. Increasing agricultural yields can improve overall food availability and reduce pressure on land, but could also (through greater water, pesticide and fertilizer use and mechanization) lead to land degradation, water scarcity, hypoxia and algal blooms, biodiversity loss and increased GHG emissions. {22.4.2}

**Changes in diet are considered an effective measure to reduce the land-use impacts of agriculture.** (*established but incomplete*) Diet changes resulting in lower consumption of meat, particularly beef, would reduce crop use as animal feed, in turn reducing demand for land since direct human consumption of crops requires less land, as well as reducing greenhouse gas emissions (most notably methane). Vegan and vegetarian diets are widely understood to demand less land, water and energy, and produce less methane emissions, than meat-based ones, although regionally appropriate livestock rearing on pasture and well managed fisheries can be sustainable. {22.3}

**Reducing food waste would help meet future demand for food.** (*established but incomplete*) If food wastage were a country, it would be the third largest GHG emitting country in the world. In the global South, losses are mainly due to the absence of food-chain infrastructure and lack of knowledge about (or investment in) storage techniques. In the global North pre-retail losses are lower, but those arising from retail, food service and households are higher. {8.5.1}

**Reducing global hunger and staying within the limits of available land and water Meeting requirements for food will require transformative practices in agriculture and fisheries and across the entire food system.** (*established but incomplete*) Better agricultural and fishing practices also play a role in maintaining a sustainable balance between reducing global hunger and staying within the limits of available land, and water and fish stocks. Some agricultural technologies and practices (e.g. crop protection, drip irrigation, improved drought and heat tolerance, integrated soil fertility management, no-till farming, nutrient use efficiency, organic agriculture, precision agriculture, sprinkler irrigation, water harvesting, and land conservation measures) might be scaled up to achieve the dual goal of improving food security while reducing environmental pressure. International Food Policy Research Institute has identified 11 agricultural innovations which, in aggregate, might help to improve global crop yields by up to 67 per cent by 2050 while reducing food prices by nearly half. {2.6.3} Agricultural productivity could

also be increased (and hunger and poverty reduced) by closing the gender gap in regard to access to information and technology, as well as access to and control over production inputs and land. {5.4}

**Meeting demand for resources while reducing waste generation will require more efficient resource use and a shift to the circular economy, combined with changes in production, distribution, and consumption habits.**

The circular economy entails a systems approach to industrial processes and economic activity that makes it possible for resources to maintain their highest value as long as possible (*well established*). Key conditions for implementing the circular economy are reducing and rethinking resource use, and the pursuit of longevity, renewability, reusability, reparability, replaceability and upgradability for resources and products. It also involves end-products (wastes) being reduced, reused, recycled for as long as possible. This also requires the redesign of products, e.g. through green (or sustainable) chemistry and developing obsolescence prevention pathways in product and urban system designs through sustainable materials management (UNEP 2019c, pp. 515-543). {8.5.2, 17.6.3}

**Creating and expanding markets for products for circular and sharing economies requires innovation.**

It may also require market-supporting policies that make niche innovations more affordable for consumers (e.g. in reusing waste). Support for learning and experimentation, research and development, deployment and demonstration, and policies that stimulate entrepreneurship, incubators, low-interest loans, venture capital and supportive regulatory conditions are interventions that can create an enabling environment for sustainable innovations to be developed. Cross-sector and cross-disciplinary collaboration that empowers consumers as citizens is also key. {17.6.4, 23.12}

**Understanding interlinkages between measures and targets is crucial for synergistic implementation and policy coherence** (*well established*). Where measures generally aim at achieving specific targets, or clusters of targets, they can also affect other targets. Integrated approaches are needed to grasp synergies and address potential trade-offs to achieve the environmental targets simultaneously. {22.3, 22.4.2}

**Ending the preventable deaths of children under five requires continued efforts to reduce environmental risk factors, but also an increased emphasis on poverty eradication, the education of women and girls, and child and maternal health care** (*established but incomplete*). Ending hunger and achieving universal



and equitable access to safe drinking water, adequate sanitation and modern energy services would improve health significantly, especially for young children. Nevertheless, even if all the environment-related SDG targets were achieved by 2030, the under-five mortality target would not be met. A healthy planet alone is not enough to ensure that there are healthy people. Working solely on environmental problems will not solve the human rights or quality of life problems that are implicated in inequitable social systems. For example, achieving the SDG target for child mortality also requires addressing non-environmental risk factors including poverty alleviation, better education of women and girls, and improvements in child and maternal health care. Environmental problems and social problems are inextricably linked and must be addressed both separately and synergistically. {22.3.5}

**Overall, the literature reveals that there are more synergies than trade-offs within and among the SDGs and their targets** (*established but incomplete*). Synergies exist between specific measures and a broad range of sustainability targets, including measures related to education, reducing agricultural demand and reducing air pollution. Improved education, especially for women and girls, has particularly strong synergies with health outcomes, economic growth, reduced poverty and better environmental management. Reducing agricultural demand through changing dietary patterns towards less meat consumption (and less food loss and waste) reduces pressures on land and water, creating synergies with reducing biodiversity loss and mitigating climate change. Phasing out the use of fossil fuels and moving to low- and zero-carbon technologies will contribute to achieving both climate and air pollution targets,

the latter having synergies with improving human health, increasing agricultural production and reducing biodiversity loss. {22.4.2}

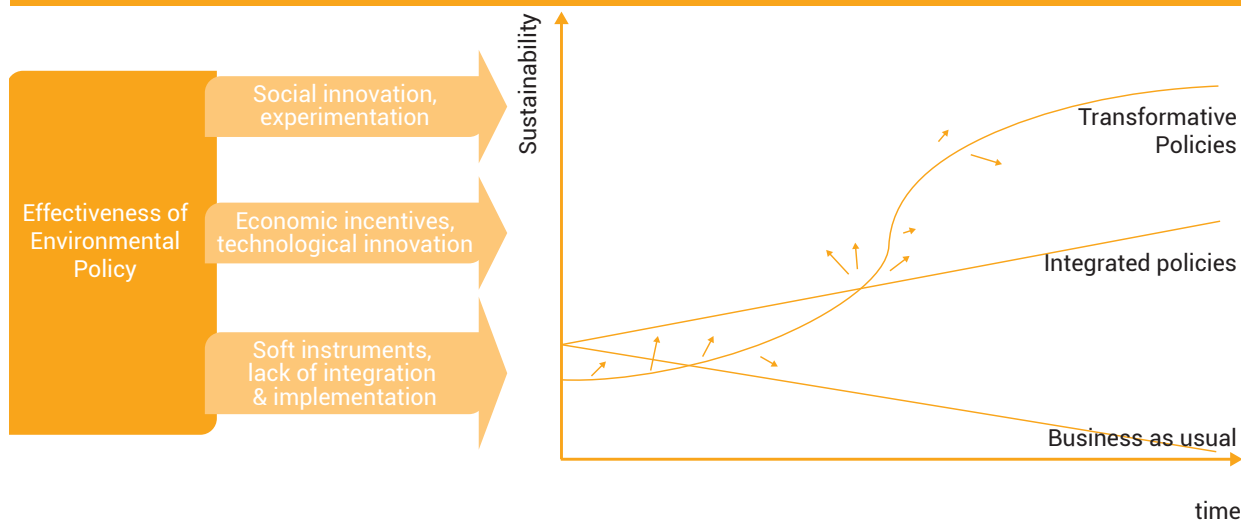
### 5.3 Transformative Change

**Business-as-usual and the implementation of existing policies will be inadequate to address key environmental challenges.** (*established but incomplete*) Integrated approaches may help resolve some of these challenges, but they will not be sufficient to put the global community on the path to sustainability. Instead, transformative approaches are necessary (**Figure 5.8**). {24.1}

**Following transformative pathways to sustainable development requires (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 with and enabling actors and stakeholders** (*established but incomplete*). Innovative solutions could link policies to the SDGs, promote viable business models, finance support for and management of investment risks, support international cooperation, and address the concerns of citizens and stakeholders and ensure their active participation. {24.3}

**Transformative change cannot occur without adaptive policies, the creation of an enabling environment for niche innovations, and the removal of barriers to change.** The physical, social, economic and health impacts of climate change, especially on the most vulnerable communities, call for urgent adaptation approaches that are systemic, multidimensional and transformative (*established but incomplete*). Adapting to

Figure 5.8: Different policy approaches



Source: UNEP (2019b, p. 583).



climate change, biodiversity loss and land degradation is a complex process that requires clear environmental governance and needs to occur in all regions and sectors and at numerous temporal and geographical scales. The initiatives taken to adapt to climate change should consider the complex and interacting elements and feedback mechanisms of the human-environment system. Political, institutional and behavioural changes can help make possible transformative change. Local-scale policy experiments can provide space for policy tailoring and innovation that are closely monitored. They can also allow inclusion of indigenous and local knowledge systems for improved environmental management. Redress for environmental degradation through legal procedures is another important mechanism that can help ensure a cleaner, healthier environment for all. {17.3.1}

**There are many existing projects and initiatives promoting change that could collectively help to achieve the SDGs, MEAs and other relevant internationally agreed goals** (*well established*). Social, policy and technological innovations are needed. At the local scale, numerous transformative projects and innovative solutions could be scaled appropriately. Reviewing bottom-up initiatives reveals ideas, actions, and programmes that seek to achieve the SDGs and involve a wide range of different public and private stakeholders. Among them are (i) nature-based solutions, including those that draw on indigenous knowledge such as that pertaining to 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 people in environmental monitoring, and natural capital accounting that integrates economic, social and environmental components; (iii) circular and sharing economy innovations based on increased efficiency of resource use, for example through new business models that better engage with the 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 reduce plastics, toxic substances and solid waste; (v) building of awareness and skills through sustainability and environmental education to improve public awareness and build relevant skills; (vi) an emphasis on gender equity and equality, women's empowerment, and solutions that promote the fair treatment of all from local to global; (vii) decentralization of technologies to educate and engage citizens (e.g. web applications that allow citizens to monitor water quality and report problems to relevant government agencies); and (viii) smart, sustainable cities that, for example, use modern digital technologies to engage and connect citizens in addressing key urban sustainability challenges

such as transportation, consumption patterns, energy, nutrition, water and waste management. {23.11; 24.3; SPM 4.3}

**Sustainability transformations are often broken down into multiple phases** (*established but incomplete*), with a preparation phase in which innovations begin to develop, a navigation/acceleration phase in which innovations grow and become part of the new system, and an institutionalization phase in which a more desirable system is made sustainable in the long term. For transformations to occur successfully, each phase requires governance conditions that are strongly enabling, both supporting appropriate innovations and weakening existing, problematic structures. {23.12}

**A transformative approach to adapting to climate and other environmental change needs to address uncertainties and complexities** arising from climate change impacts, as well as the drivers of risks and the underlying factors of vulnerability (*established but incomplete*). It should also reduce inequality, promote gender empowerment, and build resilience and adaptive capacity. {17.3.3}

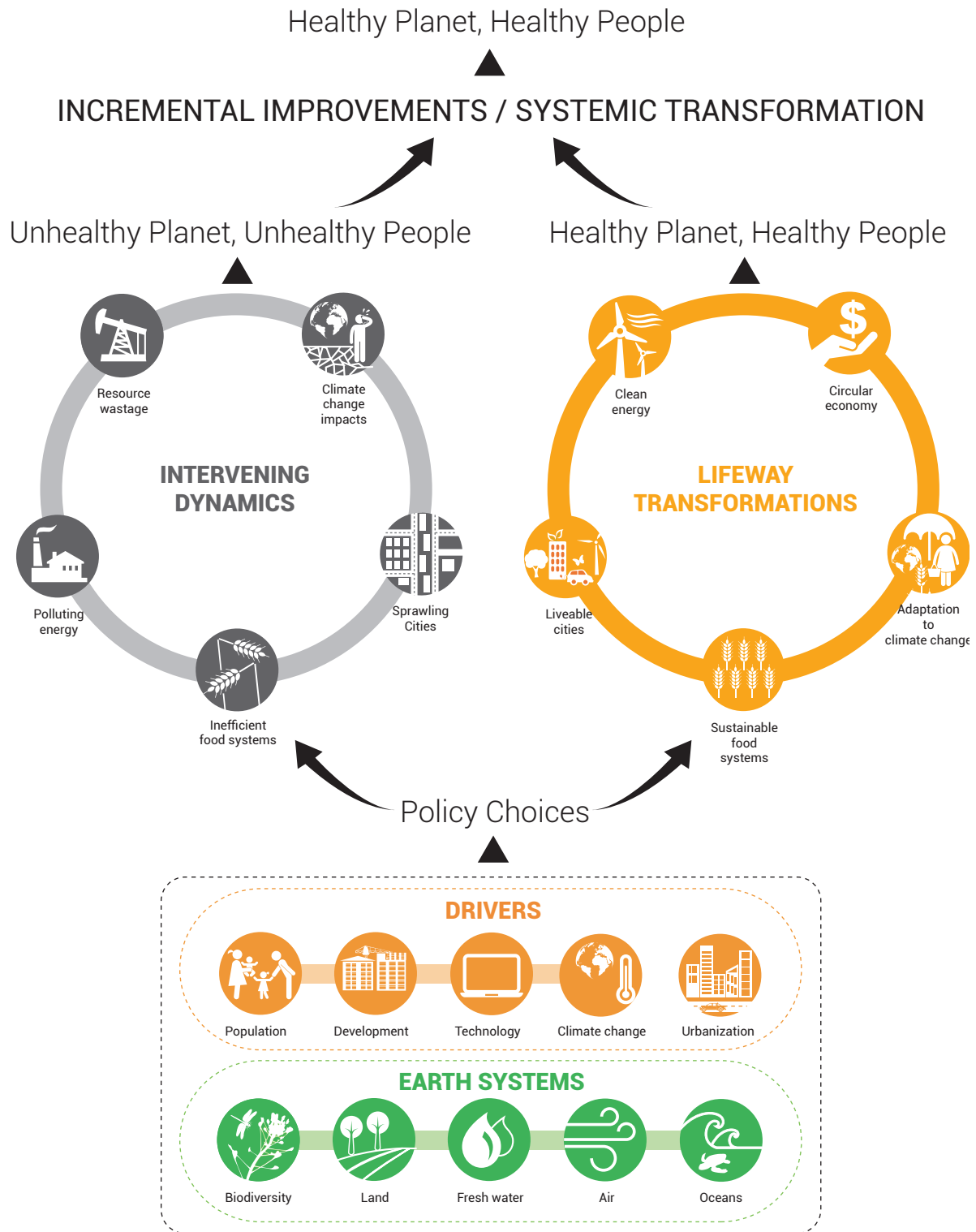
**Incorporating principles of distributive justice can help construct a development agenda based on principles of equity and equality.** (*established but incomplete*) Normative principles designed to guide the allocation of the benefits and burdens of economic activity based on fair distribution can help account for the disparate developmental conditions of the global South and global North. This process can provide more equitable options for where and how to implement solutions with the most transformative potential to achieve sustainable development, for example in reforming consumption and production patterns or in instituting market mechanisms such as caps in emission-trading schemes, carbon taxes and offsetting schemes. Addressing these global inequities is a means of achieving the global goal of equity. {23.14}

## 5.4 A Healthy Planet and Healthy People are Synergetic

**GEO-6 underlines the importance of maintaining the integrity of ecosystems and recognizes their interlinkages with socioeconomic systems.** It emphasizes that a healthy planet is a necessary foundation for human physical, psychological, social, economic and emotional health and well-being and is therefore critical for achieving all the SDGs. {1.1} **Figure 5.9** illustrates how policy choices may contribute to transformations that lead to a healthy planet for healthy people. {1.1}

**Education promotes a healthier environment, and**

Figure 5.9: Choices to be made to achieve a healthy planet for healthy people



Source: UNEP (2019b, p. 6).



**vice versa** (*established but incomplete*). Environmental pollution, biodiversity loss and climate change are important causes of health problems and environmental diseases, which in turn may negatively affect education and learning, especially among children; they can also restrict employment among adults. {1.3.2}

**Although some degree of environmental ill-health may be seen as having been inevitable during the economic growth process, the Earth is reaching tipping points beyond which human health and well-being will be irreversibly threatened.** A healthy planet requires protection and sustainable management of natural capital (nature's contributions to people) and human capital. {1.1} Throughout GEO-6, evidence is presented showing how nature's contributions fundamentally underpin human health and well-being. Cleaning up the environment, avoiding pollution, and protecting and restoring habitats are major opportunities to improve health which, in turn, help people lead fuller and more productive lives. {1.3.2} The social environment has a strong influence on health and well-being, as clearly shown in socioeconomic studies where social disadvantage is associated with poor health and well-being across a wide range of diseases and behaviours that pose health risks. {3.6.2} Rigorous incorporation and integration of human health considerations in health-determining sectoral plans (e.g. for agriculture, water, disaster management, urban design, climate mitigation and adaptation) can support responses that address human health impacts with a focus on prevention activities. {4.2.1} The health sector must

rapidly strengthen the way it articulates messages on human health and emphasize that most environmental pressures ultimately have human health impacts. {4.2.1}

**Furthermore, healthy lifestyles can have beneficial impacts on the environment.** (*established but incomplete*) Activities like walking and bicycling have many benefits for health and well-being. However, these benefits vary with, for example, the climate and pollution levels. Reducing red meat intake per capita where there is high consumption (especially of processed meats) will improve human health. The benefits to human health and well-being of access to safe and biodiverse natural environments, both green and blue spaces, are being recognized. {4.2.1}

**Enhancing synergies between the health of the planet and people's health may require more fundamental changes.** (*established but incomplete*) Solutions to the degradation of natural systems, including management of environmental pollution at its sources, should take account of the complex interactions between the planet and human health, consider "environment-health" as a complex system, seeking co-benefits and, where practicable, avoid trade-offs, win-lose situations and unintended adverse consequences. Rigorous incorporation and integration of human health considerations within health-determining sectoral plans (e.g. agriculture, water, disaster management, urban design) can support responses that address human health impacts, with a focus on prevention activities. {4.2.1}

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# 6

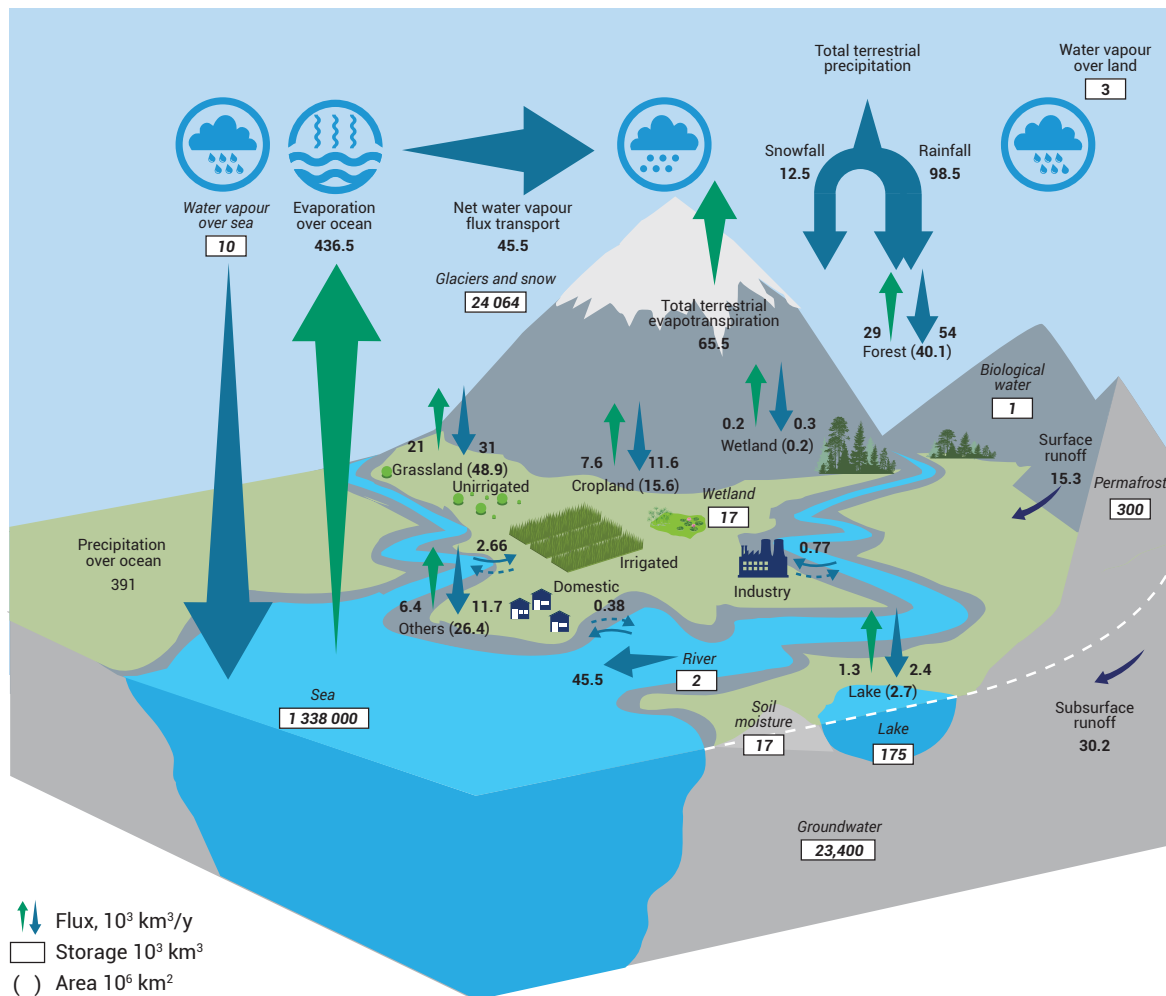
## Data and Knowledge for a Healthy Planet

### 6.1 Data and Knowledge: State and Future

**Current science justifies policy action now, but more detailed knowledge can enable more refined and preemptive policy.** Existing knowledge is already sufficient to mobilize action today. New knowledge, including disaggregated data from Earth Observation, *in situ* data, citizen science, socially-disaggregated data, ground-truthing and indigenous and local knowledge, needs to be brought into national policy and accounting

more broadly. There are major benefits in accounting systems that register the details about who causes damage to the environment, how and why; what is the extent of nature's contributions to humans and the loss of ecosystem goods and services; and who is affected. Statistics and accounting systems also need to recognize the realities of predominantly poor people in the informal economy, who are often particularly dependent on nature's contributions to people and hence more vulnerable to environmental degradation. {Co-Chairs' Message}

Figure 6.1: Global hydrological fluxes and storages (expressed in 1,000 km<sup>3</sup> per year), illustrating natural and anthropogenic cycles



Source: Oki and Kanae (2006).

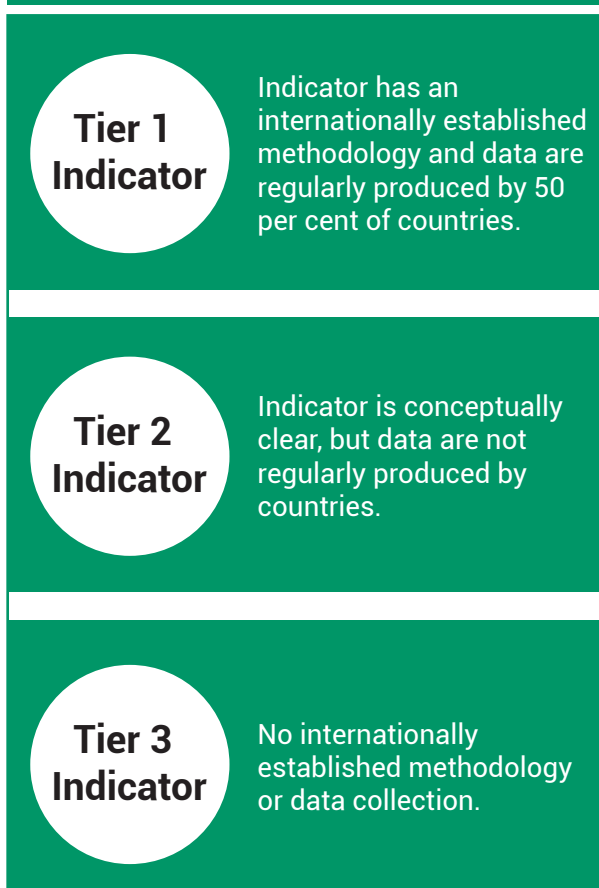




Meeting environmental challenges will require advances in environmental indicators and analysis, particularly analysis that addresses interlinkages across different environmental domains and among the environment, society and the economy (*well established*). Recent advances in collecting official statistics related to the environment, including geospatial ones, contribute to environmental monitoring and permit representations of environmental flows (Figure 6.1). However, there are still methodological gaps in measuring many aspects of the environment; there is very limited information linking social and environmental processes; and there are significant capacity gaps in countries attempting to build their environmental information and natural capital accounting systems. {Chapter 3, ExecSum}

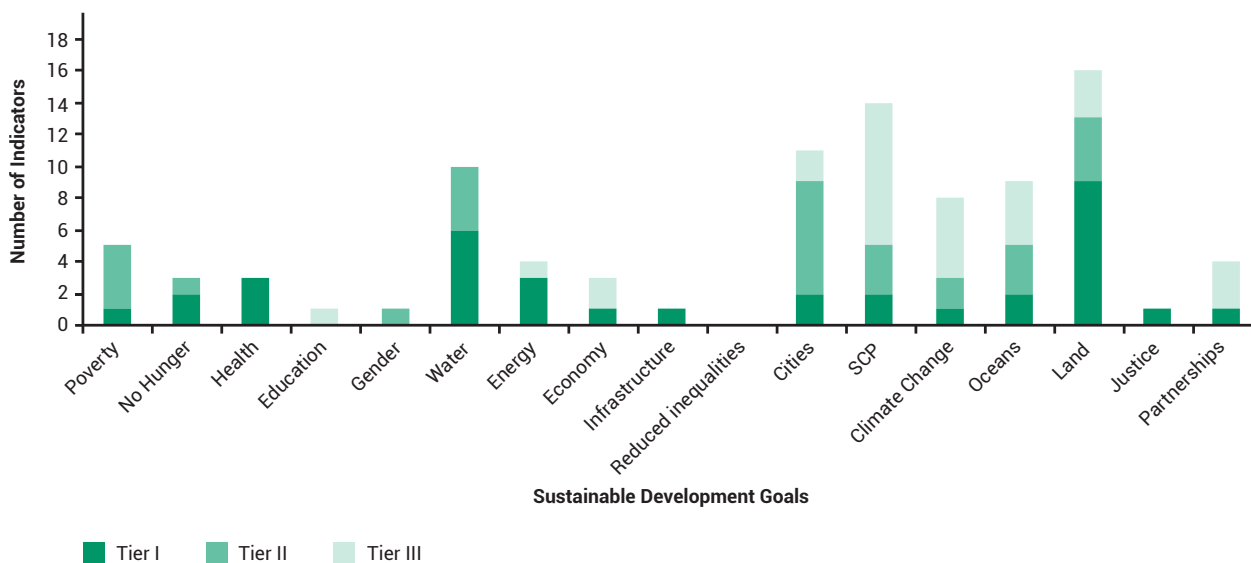
Meeting the SDGs will require a new commitment to environmental data collection. (*established but incomplete*) Global commitments to the SDGs increase global recognition that monitoring the environmental dimension of development requires regular, standardized data collection, including time series statistics and indicators. Monitoring progress on the SDGs requires shifts in data collection, analysis and dissemination, including the use of environmental statistics, geospatial data, earth observation and new data sources (i.e. citizen science, big data, traditional knowledge). The number of Tier 2 and Tier 3 environmental indicators relating to the SDGs (Figure 6.2 and Figure 6.3) shows that implementing the SDGs calls for a data revolution, incorporating

Figure 6.2: SDG indicator status



Source: United Nations (2018a).

Figure 6.3: Environment-related SDG indicators by goal and tier



Source: United Nations (2018a).



disaggregated data, to ensure that no one is left behind, and for reporting at all levels of the 17 goals. New and innovative approaches to data and knowledge systems, with an aligned focus on evidence-based information gathering, are essential for achieving the ambitious SDG framework. {25.4.8}

**However, monitoring the entire SDG framework over the 2016-2030 period is estimated to cost as much as a quarter of a trillion dollars.** So, in addition to improving data systems, there is also a need for priority setting to target data collection and improve efficiencies. {3.8}

**Currently, most environmental indicators capture the geophysical characteristics of environmental states and processes** (*well established*). Environmental processes are crucially influenced, however, by the interactions between physical and social systems. Without information – and data – on both domains and their interactions, the picture of the current situation and direction of travel will be incomplete. A combination of conventional methods with emerging forms of data and knowledge, including social data, provides a holistic view of the environment, encompassing social, physical and economic perspectives. {25.4.8} Environmental change is difficult to measure and its effects are even more complicated to measure, especially in relation to identifying causes. A shift from focusing solely on physical dimensions to including social orientation, economic value and impacts on health and well-being is crucial, although it is a challenge for even well-developed statistical systems {3.8}

**The usefulness of knowledge and data depends on what the data represents and the issues it addresses** (*well established*). The ability to fund data ensures that data serves the needs of different communities, and assesses whose knowledge counts in critical in defining good quality policies. As highlighted in GEO-6, Chapter 3, the nexus between society and the environment can only be assessed if there is disaggregated information on different populations since not everybody has the same level of dependence on the environment, nor does everybody have the same impact on it. Therefore, there is a need for information that can be disaggregated by income, gender, age, ethnicity, migratory status, disability, geographical location and other characteristics relevant in national contexts. Unfortunately, there is currently a dearth of environment-related information that can be disaggregated; data from household surveys on access to water, energy and other natural resources is available only at the household level, which makes understanding differences at other levels difficult. {25.4.1} Moreover, the question of which available data should be acted on, or what kind of

information, based on which assumptions, and which reality counts, is almost entirely a problem that must be resolved in the social realm. {25.4.8}

**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. Time series data are vitally important in this regard, as they form 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 capture information by gender, ethnicity, race, income, age and geographic region can identify critical differences and promote effective policy design. {3.5, 3.7; SPM}

## 6.2 The Primary Domains of Data and Needs in those Domains

**There are growing amounts of data on the health impacts of environmental challenges, but these data are not always adequate for some world regions and are often not disaggregated by gender, class or social status** (*well established*). Combined physical and social environments have strong influences, both direct and indirect, on human health and well-being. Measuring linkages between “exposure” and “outcome” and assessing causal relationships and the exposure of populations to environmental changes, requires strong statistical bases and large sample sizes. Effective large-scale epidemiological studies require the development of data systems with high degrees of security and reliability. Many governments and institutions do not have the capacity to enact or even to effectively use the findings of such systems. Recent developments in big data may allow the assessment of long-term environmental exposures. However, establishing causal relationships between human exposure to environmental damage and subsequent health outcomes is complicated and contested. It is necessary to explore the use of multiple forms and sources of information, such as citizen science and traditional knowledge, to establish and validate the long-term effects of human activities and natural disturbance such as climate change on health. {3.8}

**Measuring the nexus between gender and the environment has been identified as a high priority; women and men, in many contexts, have differing rights over and access to the environment** (*well established*). Furthermore, women and men often have



different perceptions of environmental problems; have different vulnerabilities to environmental degradation and hazards; and often play different roles in environmental management decision-making. Currently, only very limited time series data and statistics are available on the gender-environment nexus. {Chapter 3, ExecSum, 3.5} Producing gender statistics entails disaggregating data by sex (and other intersectional characteristics) to reveal differences or inequalities in environmental relationships. Collecting effective gender statistics also requires rethinking data collection norms and techniques in order to ensure that the diversity of various groups of women and men, and their specific activities and challenges, are captured; for example, data collected at “household” level masks intra-household gender differences in access to and use of resources. Gender-specific data inadequacies (e.g. persistent underreporting of women’s economic activity, underreporting of violence against women, and undercounting of girls, their births and their death) must be addressed in order to develop a realistic understanding of social-environmental relations. {Box 3.2}

**Citizen science is providing unprecedented opportunities to engage the public in collecting and analyzing vast amounts of environmental data** (*well established*). The potential of widely dispersed teams of observers, together with new technologies such as smart sensors, mobile telephony, the Internet and computing capabilities, is offering new approaches for research and for engaging the public on environmental issues. In addition to the collection of large amounts of data, the advancement of new technologies has enhanced the quality and veracity of the data collected. Key opportunities presented by citizen science include greater frequency of data from dispersed sources; the ability to address large knowledge and funding deficits; the ability to educate the public about environmental policy issues; and use of local knowledge. However, combining citizen science-derived information with other data systems (especially earth observation systems) presents significant data compatibility and comparability challenges. {Chapter 25, ExecSum, 25.2.1}

**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 peoples to document, revive and strengthen their knowledge. However, 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 among traditional knowledge holders, academia and governments has led to innovative processes, procedures and tools for data generation, and for knowledge production and enrichment, which can help in understanding and caring for the environment. {25.1.3; SPM}

**Many environmental data do not systematically assess the economic costs of action and inaction** (*well established*). Existing economic-environmental data are scattered and fragmented; data on inactions are growing but inadequate. The economic evaluation of environmental impacts will need to include overall assessment of nature’s contributions to people’s lives; an accounting of the impacts of global economic activities, investment and trade on people and the environment; and the comprehensive institutional issues affecting equity and market operations. Specific findings on sustainability can only be obtained through robust analysis covering ecological, social and cultural factors and their interactions over time. Economic analysis of the environment should be oriented towards the wider scope of the SDGs, including peace, equity and security. Monetary and non-monetary values in relation to the environment and resources (as well as models reflecting the economics of nature) can only be generated through the use of timely and reliable knowledge and data from statistical surveys and other new sources such as big data, gender-disaggregated data, and information drawn from citizen science and indigenous knowledge. {3.8}

**Earth Observation is the primary contributor to remotely sensed big data** (*well established*). When coupled with emerging technologies such as smart sensors, mobile devices and web applications, citizen science and other forms of localized data collection, Earth Observation 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 {25.4.1}.

**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 which cannot. For example, deforestation and land use change can be measured with increasing accuracy using satellites, but satellites cannot monitor all aspects of subsurface ocean environments. Data are particularly sparse for biodiversity, which is measured mostly by *in situ*

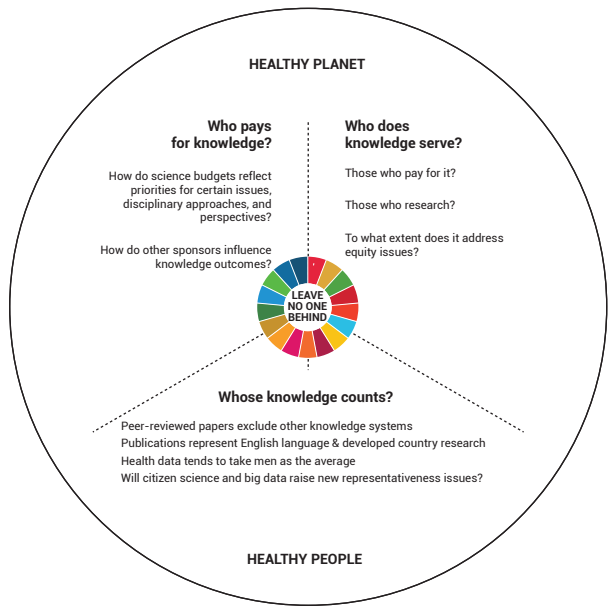


observation and genetic analysis. Some freshwater components, such as groundwater and water use, are also data-deficient due to measurement challenges. The dichotomy in the volume of remotely sensed data versus *in situ* data will inevitably grow as Earth Observation technologies improve. This should not lead to a bias in understanding, and should be compensated by resources for adequate ground-truthing and *in situ* data. {3.4; SPM}

**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 monitor developments and impacts 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; SPM}

**There are inadequate data on indicators for equity and on human-environment interactions** (*well established*). Collection, disaggregation and analysis of data for the most vulnerable communities and for indigenous communities remain a challenge. More work in this area would better capture issues of inequality. It is important to promote data and knowledge on how to overcome barriers to political and social participation that perpetuate discrimination and exclusion. In terms of the geographic distribution of environmental research, most is concentrated in the United States of America, China, Japan and Germany, which together account for 63 per cent of the global research and development expenditures, mostly funded by the business sector. Businesses as funders of research have overtaken government-led funding, which has moved the balance towards more applied research than basic research. This issue raises the question of who is reaping the benefits of research and if a “greater good” is achieved by it (**Figure 6.4**). {3.8} For many measures there is a strong imbalance in data access between developed and developing countries, which contributes to global differences in countries’ ability to understand the environment, the implications of this understanding for human health, and the use of environmental data for socioeconomic benefits {25.2.2; SPM}

**Figure 6.4: Equity questions in data and knowledge**



Source: UNEP (2019a, p. 66).

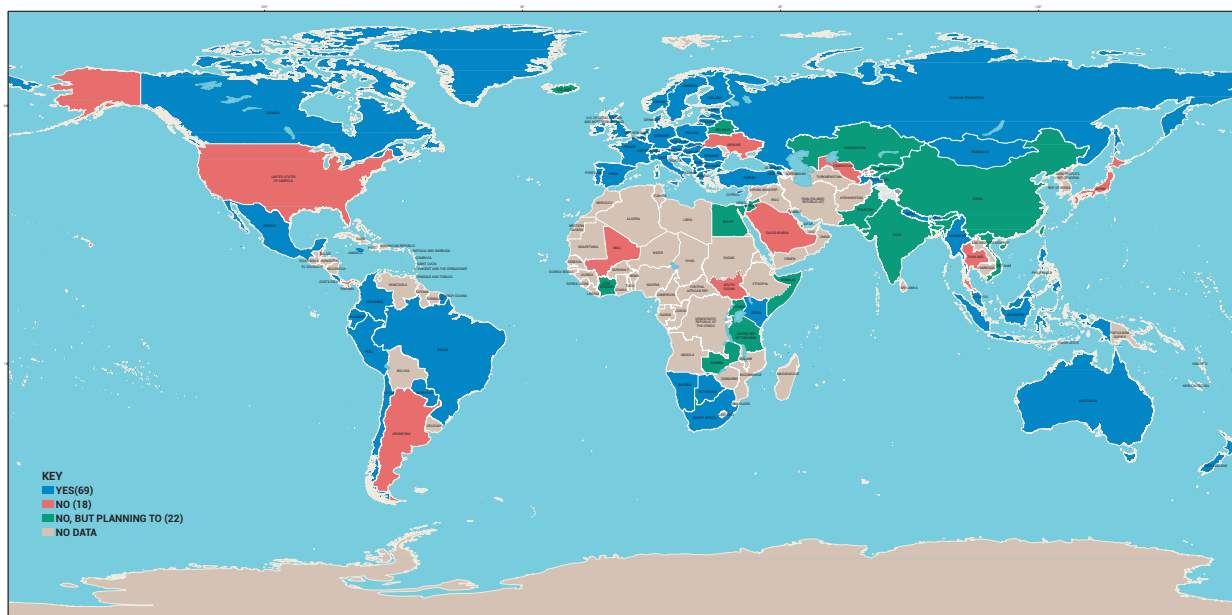
### 6.3 The Need for Open Data and International Cooperation

**Currently much environmental data are collected as part of one-off studies or projects, limiting their usefulness** (*well established*). In addition to filling knowledge gaps with new data, enormous gains can be made through consolidating, curating, harmonizing and increasing open access to existing data which might otherwise be widely dispersed and not easily be 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, and to adequately compensate for spatial differences in the ability to generate and assess data – as well as to undertake disaggregated information collection that reflects economic, health and equity issues. In this context, the Framework for the Development of Environment Statistics, the System of Environmental-Economic Accounting, and the System of National Accounts are robust consensus-based statistical frameworks and methodological approaches that could be broadly adopted (**Figure 6.5**). Rationalizing both existing and newly collected data is essential for the development of indicators. {3.3; SPM}





Figure 6.5: Extent of adoption of the System of Environmental-Economic Accounting



Source: United Nations (2018b).

**Actions need to be taken on the basis of the knowledge already at hand, but the world needs openly accessible data, information, analysis, knowledge and science to better inform and guide what must be done to achieve sustainability across all environmental dimensions** (*established but incomplete*). Achieving the SDGs, MEAs and other internationally agreed environmental goals and science-based targets will require an integrated approach that considers linkages across different environmental and non-environmental components, building upon disaggregated data generation and incorporating traditional knowledge and citizen science. The achievement of the SDGs and their targets needs to be followed up on and reviewed, using their global indicators and complemented by indicators at the national and regional levels. Work is also needed to develop the baselines for 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; SPM, p. 23}

**More inclusive and open access to data will assist in achieving equity, transparency, and the best data use 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. Countries should be forward-thinking in building the capacity to analyse and interpret environmental data. {25.4.2}

**International cooperation and sharing of data and information are key to success** (*well established*).

Continued investment in the education and training of the next generation of experts and decision makers is essential to maintain the pace of progress on the multigenerational challenges associated with the “Healthy Planet, Healthy People” theme. {25.3; SPM}. Sustainable capacity is achieved when the entire value chain works: when data from collation and analysis through to use are dealt with competently, in order to deliver the value of the information, disseminate it through the most effective and efficient channels, and ensure that those for whom its value is intended are able to use it. To reach this stage of competency, environmental education should be implemented at all levels. Indigenous knowledge systems, including emerging opportunities offered by technological advances to democratize the participation of citizens in the exercise of science and scientific discovery, should be facilitated. {25.4.6}

**Data gaps will be an ongoing reality in the foreseeable future and should not delay urgent action** (*well established*). Decision makers at all levels cannot wait for new data before acting. Instead, they should implement evidence-based management based on current knowledge and 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; SPM, p. 24}

**Transforming human-environment interactions (and related human-human interactions) towards sustainability, especially in the case of consumption and production patterns and lifestyles, requires a**

**better information base** as well as new, diversified knowledge of planetary systems and transformative processes within globalized social and economic systems. This includes the cultural dynamics and ethical foundation of human perceptions and understanding of “nature and environmental sustainability” and the need to incorporate people’s health and well-being. {1.1}





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# Annex 1. Examples of other global environmental assessments and their links to GEO-6



Organisation	Assessment	Objective: To support policymaking by assessing ...	GEO-6 used results in ...
UNEP, WMO	Intergovernmental Panel on Climate Change Reports	The scientific basis for climate change, its impacts and future risks, and options for adaptation and mitigation.	Drivers, cross-cutting issues, air, policy and outlooks chapters
UNEP, UNESCO, FAO, UNDP, IPBES	Intergovernmental Platform Biodiversity and Ecosystem Services (IPBES) Reports	The state and trends of biodiversity and of the ecosystem services it provides to society, long-term human well-being and sustainable development.	Biodiversity chapters
CBD	Global Biodiversity Outlook (GBO) IV (2014)	The latest data on the state of biodiversity and draw conclusions relevant to the further implementation of the Convention.	Biodiversity chapters
UNESCO, UN-Inter-agency (UN-Water)	World Water Assessment Programme (WWAP) (2018)	The world's freshwater resources, tools for implementing sustainable use of water resources, tracking progress towards achieving targets, particularly those of the MDGs/SDGs.	Water, policy and outlooks chapters
Experts of the Regular Process/ UN	World Ocean Assessment I (2015)	The state of the marine environment, including socioeconomic aspects.	Oceans, cross-cutting and policy chapters
FAO, UNEP	Global Land Degradation Assessment/Global Soil Health Assessment (2015)	The current and projected soil conditions built on regional data analysis and expertise and implications for food security, climate change, water quality and quantity, biodiversity, and human health and wellbeing.	Land, cross-cutting policy and outlooks chapters
FAO	The State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals (2018)	The state of world fisheries and aquaculture and their link to meeting the Sustainable Development Goals.	Oceans chapters
UNCCD	Global Land Outlook (GLO) (2017)	The status of land and response strategies to reduce land degradation and desertification.	Land, cross-cutting policy and outlooks chapters
UNEP International Association of Solid Waste Management	Global Waste Management Outlook (2015)	The state of waste management and response strategies.	Land, cross-cutting policy and outlooks chapters
UNEP	Global Chemicals Outlook I (2013) and Global Chemicals Outlook II (2019)	The use of chemicals and their health and environmental effects, economic implications, and policy options throughout their life cycle.	Cross-cutting policy, outlooks chapters
UNEP	Global Mercury Assessment (2002/2008/2013/2018)	The state of mercury use and impacts on the environment and response strategies.	Cross-cutting policy, outlooks chapters
UNEP	Global Gender and Environment Outlook (GGEO) (2016)	A global synthesis of the state of knowledge on the gender-environment nexus.	Cross-cutting policy and outlooks chapters
UNEP International Resource Panel	Global Resources Outlook 2019	An assessment of current global resource use and its environmental impacts, with a projection of different resource use scenarios to 2060.	Published at the same time as GEO-6, so not included in GEO-6





## Acronyms and Abbreviations

<b>BC</b>	Black Carbon	<b>IPBES</b>	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
<b>CCAC</b>	Climate and Clean Air Coalition for the Reduction of Short-Lived Climate Pollutants	<b>IGOs</b>	Intergovernmental Organizations
<b>CBD</b>	Convention on Biological Diversity	<b>ILO</b>	International Labour Organization
<b>CLRTAP</b>	Convention on Long-Range Transboundary Air Pollution	<b>IMO</b>	International Maritime Organisation
<b>CO<sub>2</sub></b>	Carbon Dioxide	<b>IPES-Food</b>	International Panel of Experts on Sustainable Food Systems
<b>COP</b>	Conference of Parties	<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>DPSIR</b>	Drivers, Pressures, State, Impact, Responses Framework	<b>IPLC</b>	Indigenous People and Local Communities
<b>EDCs</b>	Endocrine-Disrupting Chemicals	<b>IRENA</b>	International Renewable Energy Agency
<b>ESD</b>	Education for Sustainable Development	<b>IRP</b>	International Resource Panel
<b>FAO</b>	Food and Agriculture Organization of the United Nations	<b>ISA</b>	International Seabed Authority
<b>GDP</b>	Gross Domestic Product	<b>ITQs</b>	Individual Transferable Quotas
<b>GEO</b>	Global Environment Outlook	<b>IUCN</b>	International Union for the Conservation of Nature and Natural Resources
<b>GEO-6</b>	Sixth edition of the Global Environment Outlook	<b>IWRM</b>	Integrated Water Resource Management
<b>GEO-ES</b>	GEO-6 Executive Summary	<b>LIC</b>	Low Income Countries
<b>GHG</b>	Green House Gas	<b>LMIC</b>	Low- and Middle-Income Countries
<b>GPS</b>	Global Positioning System	<b>MARPOL</b>	International Convention for the Prevention of Pollution from Ships
<b>GRI</b>	Global Reporting Initiative	<b>MDGs</b>	Millennium Development Goals
<b>Gt</b>	Giga tonnes	<b>MEA</b>	Multilateral Environmental Agreement
<b>GWP</b>	Global Water Partnership	<b>MW</b>	Megawatts
<b>ELD</b>	The Economics of Land Degradation Initiative	<b>NBSAPS</b>	National Biodiversity Strategies and Action Plans
<b>ICCAs</b>	Indigenous Peoples' and Community-Conserved Territories and Areas	<b>NOx</b>	Nitrous Oxides
<b>ICTs</b>	Information and Communication Technologies	<b>OCPs</b>	Organochlorine Pesticides
<b>IAEA</b>	International Atomic Energy Agency	<b>ODSs</b>	Ozone Depleting Substances
<b>IEA</b>	International Energy Agency or Integrated Environmental Assessment	<b>OECD</b>	Organisation for Economic Co-operation and Development
<b>IFPRI</b>	International Food Policy Research Institute	<b>OHCHR</b>	United Nations Office of the United Nations High Commissioner for Human Rights



<b>PAHs</b>	Polycyclic Aromatic Hydrocarbons	<b>UN Habitat</b>	United Nations Human Settlements Programme
<b>PBDEs</b>	Polybrominated Diphenylethers	<b>UMIC</b>	Upper Middle-Income Countries
<b>PBTs</b>	Persistent, Bioaccumulative and Toxic Substances	<b>UNCCD</b>	United Nations Convention to Combat Desertification
<b>PCBs</b>	Polychlorinated Biphenyls	<b>UNDP</b>	United Nations Development Programme
<b>PCNs</b>	Polychlorinated Naphthalene	<b>UNECE</b>	United Nations Economic Commission for Europe
<b>PFCs</b>	Perfluorinated Chemicals	<b>UNEP</b>	United Nations Environment Programme
<b>PM<sub>2.5</sub></b>	Particulate Matter diameter of less than 2.5micrometers	<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>POPs</b>	Persistent Organic Pollutants	<b>UNFPA</b>	United Nations Population Fund
<b>RBM</b>	Results Based Management	<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>RBOs</b>	International and Transboundary River Basin Organizations	<b>UNGA</b>	United Nations General Assembly
<b>REDD</b>	Reducing Emissions from Deforestation and forest Degradation	<b>US EPA</b>	United States Environmental Protection Agency
<b>RFMOs</b>	Regional Fisheries Management Organizations	<b>USA</b>	United States of America
<b>SAICM</b>	Strategic Approach to International Chemicals Management	<b>UV Ray</b>	Ultraviolet Rays
<b>SDG</b>	Sustainable Development Goals	<b>VGGT</b>	FAO Voluntary Guidelines on the Responsible Governance of Tenure
<b>SO<sub>2</sub></b>	Sulphur Dioxide	<b>WESO</b>	World Employment and Social Outlook
<b>SPM</b>	Summary for Policy Makers	<b>WHO</b>	World Health Organization
<b>TURFs</b>	Territorial Use Rights for Fishing programmes	<b>WRI</b>	World Resources Institute
<b>USD</b>	United States Dollars	<b>WTO</b>	World Trade Organisation
<b>SIDs</b>	Small Island Developing States	<b>WWF</b>	World Wildlife Fund
<b>SSP</b>	Shared Socio-economic Pathway		
<b>TEEB</b>	The Economics of Ecosystems and Biodiversity		
<b>UNDESA</b>	United Nations Department of Economic and Social Affairs		



## GLOSSARY

This glossary is compiled from citations in different chapter of the GEO-6 and draws from glossaries and other resource available of the websites of the following organizations, networks and projects:

American Academy of Ophthalmology; American Meteorological Society; Asian Development Bank ; Biodiversity Journal; Business Dictionary; Business Dictionary ; Cambridge Dictionary; Center for Transportation Excellence (United States); Centers for Disease Control and Prevention; Charles Darwin University(Australia); Collins Dictionary; Consultative Group on International Agricultural Research; Convention on Biological Diversity; Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar); Department of Agriculture (United States); Department of the Interior (United States); Department of Transportation (United States); Deutsche Gesellschaft für Internationale Zusammenarbeit, GmbH, GiZ; Edwards Aquifer Website (United States); Encyclopaedia Britannica; Encyclopedia of Earth; Energy Information Administration (United States); Environmental Protection Agency (United States); Environmental Science and Pollution Research; Europe's Information Society; European Commission; European Environmental Agency; European Nuclear Society; Farlex Free; Food and Agriculture Organization of the United Nations, Foundation for Research; Gender GEO; Global Earth Observation System of Systems; Global Environment Outlook Sixth Edition; Global Footprint Network ; Global Land Outlook; Glossary of Environment Statistics; GreenFacts Glossary; Hayes' Handbook of Pesticide Toxicology; Healthline; IGI Global; Illinois Clean Coal Institute (United States); Illuminating Engineering Society of North America; Industrial Organisation Economics and Competition Law; Intellectual Property Organization; Intergovernmental Panel on Climate Change; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; International Centre for Research in Agroforestry; International Comparison Program; International; Federation of Organic Agriculture Movements; International Research Institute for Climate and Society at Columbia University (United States); International Strategy for Disaster Reduction; International Union for Conservation of Nature; Journal of Pharmaceutical Microbiology; Journal of the Association for Information Science and Technology; Lyme Disease Foundation (United States); Manual Práctico de Ecodiseño; Medical Dictionary; Merriam-Webster Dictionary; Millennium Ecosystem Assessment; Ministerial Conference on the Protection of Forests in Europe; Ministry of Environment New Zealand; Ministry of Rural Development (Malaysia); MIT Press; National Aeronautics Space Administration (United States); National Bureau of Economic Research; National Cancer Institute (United States); National Center for Biotechnology Information (United States); National Geographic; National Heart, Lung and Blood Institute (United States); National Oceanic and Atmospheric Administration (United States); National Safety Council (United States); National Snow and Ice Data Centre (United States); Natsource (United States); Organisation for Economic Co-operation and Development; Organisation for Economic Co-operation and Development; Oxford Dictionary; PPP Knowledge Lab; Professional Development for Livelihoods (United Kingdom of Great Britain and Northern Ireland); RadioPaedia; Redefining Progress (United States); SafariX eTextbooks Online; Science and Technology (New Zealand); Science Dictionary; SDG Knowledge platform; Semantic Scholar.org; SER Primer; The IUP Journal of Applied Economics; TheFreeDictionary.com; Tirana Declaration; UN Environment; UN-Habitat; United Nations Convention to Combat Desertification; United Nations Development Group; United Nations Development Programme; United Nations Development Programme; United Nations Economic and Social Commission for Asia and the Pacific; United Nations Educational, Scientific and Cultural Organization; United Nations Framework Convention on Climate Change ; United Nations Industrial Development Organization; United Nations International Strategy for Disaster Reduction; United Nations Statistics Division; United Nations Water; United Nations Women; United State Geological Survey; University of Sydney; USLegal.com; Water Footprint Network, (Netherlands); Water Quality Association (United States); Wikipedia; World Bank; World Health Organization; World Health Organization; World Meteorological Organization; World Wide Fund for Nature



### **Agrifood system**

This is the combination of activities and institutions around the production and consumption of a particular food item in crops, livestock, forestry, aquaculture and fisheries.

### **Antimicrobial**

Agents that prevent the spread of bacteria, fungi, and some viruses

### **Decarbonization**

Removal of carbon or carbonaceous deposits from

### **Adaptation**

Adjustment in natural or human systems to a new or changing environment, including anticipatory and reactive adaptation private and public adaptation and autonomous and planned adaptation

### **Biodiversity**

The variety of life on Earth, including diversity at the genetic level, among species and among ecosystems and habitats. It includes diversity in abundance, distribution and behaviour, as well as interaction with socio-ecological systems. Biodiversity also incorporates human cultural diversity, which can both be affected by the same drivers as biodiversity, and itself has impacts on the diversity of genes, other species and ecosystems.

### **Biofuels**

Fuels produced from dry organic matter or combustible oils from plants, such as alcohol from fermented sugar or maize, and oils derived from oil palm, rapeseed or soybeans

### **Business as usual**

An ongoing and unchanging state of affairs despite difficulties or disturbances

### **Citizen science**

The collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists.

### **Climate change**

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

### **Climate finance**

Refers to local, national or transnational financing that seeks to support mitigation and adaptation actions that will address climate change.

### **Drivers**

The overarching socioeconomic forces that exert pressures on the state of the environment

### **Energy intensity**

Ratio of energy consumption to economic or physical output. At the national level, energy intensity is the ratio of total domestic primary energy consumption or final energy consumption to GDP or physical output. Lower energy intensity shows greater efficiency in energy use.

### **Equity**

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

### **Food waste**

Any food that is discarded or lost uneaten

### **Fossil fuel**

Coal, natural gas and petroleum products (e.g. oil) formed from the decayed bodies of animals and plants that died

### **Gender**

Gender refers to the roles, behaviours, activities, and attributes that a given society at a given time considers appropriate for men and women. In addition to the social attributes and opportunities associated with being male and female and the relationships between women and men and girls and boys, gender also refers to the relations between women and those between men. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. They are context/ time-specific and changeable. Gender determines what is expected, allowed and valued in a woman or a man in a given context. Gender is part of the broader socio-cultural context, as are other important criteria for socio-cultural analysis including class, race, poverty level, ethnic group, sexual orientation, age, etc. Circular economy – a circular economy is a systems approach to industrial processes and economic activity that enables resource users to maintain their highest value for as long as possible.



### **Groundwater**

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

### **Human health**

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

### **Impacts**

Changes to the environment or social systems that are caused directly or indirectly by humans

### **Invasive species**

Introduced species that have spread beyond their area of introduction, (and rarely, native species that have recently expanded their populations) and which are frequently associated with negative impacts on the environment, human economy or human health

### **Paris Agreement**

An agreement within the United Nations Framework Convention on Climate Change (UNFCCC) that sets out an action plan to put the world on track to avoid dangerous climate change by limiting global average temperature to well below 2°C, while pursuing efforts to limit warming to 1.5°C. Adopted by 195 countries at the Paris climate conference (COP21) in December 2015, the Paris Agreement is the first-ever universal, legally binding global climate deal.

### **Poverty**

The state of one who lacks a defined amount of material possessions or money. Absolute poverty refers to a state of lacking basic human needs which commonly include clean and freshwater, nutrition, health care, education, clothing and shelter.

### **Pressures**

The stresses that human activities place on the environment

### **Protected areas**

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

### **Resilience**

The capacity of a system (social or ecological) to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.

### **Response**

The responses by society to the environmental situation

### **Scenario**

A description of how the future may unfold based on if-then propositions, typically consisting of a representation of an initial situation, a description of the key drivers and changes that lead to a particular future state. For example, "given that we are on holiday at the coast, if it is 30°C tomorrow, we will go to the beach."

### **State**

Condition of the environment/ human

### **Urbanization**

An increase in the proportion of the population living in urban areas

### **Vulnerability**

An intrinsic feature of people at risk. It is a function of exposure, sensitivity to impacts of the specific unit exposed (such as a watershed, island, household, village, city or country), and the ability or inability to cope or adapt. It is multidimensional, multi-disciplinary, multi-sectoral and dynamic. The exposure is to hazards such as drought, conflict or extreme price fluctuations, and also to underlying socio-economic, institutional and environmental conditions.

Please consult the following link for a more extensive glossary: [https://wedocs.unep.org/bitstream/handle/20.500.11822/33925/GEO-6\\_Glossary.pdf?sequence=1&isAllowed=y](https://wedocs.unep.org/bitstream/handle/20.500.11822/33925/GEO-6_Glossary.pdf?sequence=1&isAllowed=y)



Published to coincide with the Fourth United Nations Environmental Assembly, UN Environment’s sixth Global Environment Outlook (2019) calls on decision makers to take bold and urgent action to address pressing environmental issues to achieve the Sustainable Development Goals as well as other Internationally Agreed Environment Goals, such as the Paris Agreement.

GEO-6 builds on the findings of previous GEO reports, including the six regional assessments (2016), and outlines the current state of the environment, illustrates possible future environmental trends and analyses the effectiveness of policies. This flagship report shows how governments can put the world on the path to a truly sustainable future. It emphasizes that urgent and inclusive action is needed by decision makers at all levels to achieve a healthy planet with healthy people.

This Technical Summary distills the science and data in the GEO-6 report to make it more accessible to students and scientists, and more useful for teaching and learning at the university level. The Technical Summary is useful for academics and their students in universities – and others – who would like to have more specific knowledge about sustainable approaches to health and environmental problems related to air, freshwater, land and soil, oceans and coasts, and biodiversity, as described in GEO-6.



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