Convention on
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Measuring Progress

Environment and the SDGs

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Acronyms

10YFP	The 10 Year Framework of Programmes on Sustainable Consumption and Production Patterns
AFD	*Agence Française de Développement* [French International Development Agency]
BRI	biodiversity risk index
CES	Conference of European Statisticians
CFC	chlorofluorocarbons
CHP	combined heat and power
CIDP	County Integrated Development Plan
CITES	Convention on International Trade in Endangered Species
CO_2	carbon dioxide
CSA	climate-smart agriculture
DMC	domestic material consumption
DPSIR	driver, pressure, state, impact and response
Eco-DRR	ecosystem-based disaster risk reduction
EEA	European Economic Area
EECA	Eastern Europe and Central Asia
EECCA	Eastern Europe, Caucasus and Central Asia
EGRLCR	economic growth rate to land consumption rate
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ESCWA	United Nations Economic and Social Commission for Western Asia
ESGAP	environmental sustainability gap
ETC/CME	European Topic Centre on Climate Change Mitigation and Energy
ETS	Emissions Trading System
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDES	United Nations Framework for the Development of Environment Statistics
GBF	Global Biodiversity Framework
GBIF	Global Biodiversity Information Facility
GCC	Gulf Cooperation Council
GDP	gross domestic product
GIS	geographic information system
GMBA	Global Mountain Biodiversity Assessment
HLPF	High-level Political Forum on Sustainable Development
IAEG-SDGs	Inter-agency and Expert Group on SDG Indicators
IAS	invasive alien species
ICSU	International Council for Science
IFAD	International Fund for Agricultural Development
IIASA	International Institute for Applied Systems Analysis
IOC-UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
ISPONRE	Institute of Strategy and Policy on Natural Resources and Environment of Viet Nam
IUCN	International Union for Conservation of Nature
IUU	illegal, unreported or unregulated
KEPI	Kenyan Environmental Performance Index
KMFRI	Kenya Marine and Fisheries Research Institute
LAC	Latin American and the Caribbean
LCRPGR	land consumption rate to population growth rate
LDN	land degradation neutrality
LMICs	low- and middle-income countries
MONRE	Ministry of Natural Resources and Environment
MPI	Ministry of Planning and Investment
MRI	Mountain Research Initiative
MST	Measuring the Sustainability of Tourism
MTP	Medium Term Plan

NDPES	National Development Plan of the Energy Sector
NEI	National Environmental Indicators
NEMA	National Environment Management Authority
NESC	National Economic and Social Council
NSO	national statistical office
NSS	National Statistics System
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
PM	particulate matter
POPs	persistent organic pollutants
RES	renewable energy sources
RLI	Red List Index
SAICM	Strategic Approach to International Chemicals Management
SANBI	South African National Biodiversity Institute
SCP	sustainable consumption and production
SDG	Sustainable Development Goal
SEEA	United Nations System of Environmental–Economic Accounting
SEIS	Shared Environmental Information System
SES index	Strong Environmental Sustainability index
SOE	State of the Environment report
SPONRE	Strategy and Policy on Natural Resources
UAV	unmanned aerial vehicles
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNECE	United Nations Economic Commission for Europe
UNECE JTFESI	UNECE Joint Task Force on Environmental Statistics and Indicators
UNEP	United Nations Environment Programme
UNEP-CBD	UNEP Convention on Biological Diversity
UNEP-WCMC	UNEP World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children’s Emergency Fund
UNSD	United Nations Statistics Division
UNWTO	United Nations World Tourism Organization
VNR	Voluntary National Review
VSDG	Viet Nam Sustainable Development Goals
WFP	World Food Programme
WHO	World Health Organization
WWF	World Wildlife Fund

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Foreword

The 2030 Agenda for Sustainable Development was launched in 2015 with an international commitment of governments to transform our world. The 17 Sustainable Development Goals (SDGs) were constructed in a way to ensure interlinkages between the environmental, economic and social aspects of development. This report addresses the need for implementation of the 2030 Agenda for Sustainable Development in a more integrated and holistic way.

Leaving no one behind, including nature, is an essential and integral ingredient of the 2030 Agenda. Our footprint on the planet is unsustainable. If the current COVID-19 pandemic has a lesson to teach us, it would be to respect nature and better understand how our actions are impacting the environment, and how we in turn are affected by a changing environment.

Unfortunately, this report shows that our comprehension of the environmental dimension of the SDGs is lagging. Our limited capacities to collect, disseminate and effectively use environmental data have hindered our holistic understanding of the environment and the effect on it of socio-economic factors. Living in the era of proliferation of big data and new data science techniques, we need to pair these new sources and techniques with traditional data compilation. Improved data and indicators, coupled with science-based tools and methodologies for using that information, will give more insights to policy makers to enable them to develop more robust policy responses.

Since the adoption of the SDGs, progress has been achieved in understanding interlinkages across goals and targets, allowing for the implementation of more integrated interventions that translate such understanding into concrete results on the ground.

Measuring Progress: Towards Achieving the Environmental Dimension of the SDGs, the first report in this series, measured progress toward achieving the SDGs, as reflected by all of the environment-related SDG indicators. This 2nd Measuring Progress report analyses the progress made in 92 environment related SDG indicators, and explores the potential and limitations of using statistical correlation analyses to show the interlinkages between state of environment indicators and direct drivers of change and state of society indicators, using the driver-pressure-state-impact-response (DPSIR) framework. While conceptualizing interlinkages in abstract terms is useful, the statistical correlation analysis which has been explored in this report may contribute to further exploration of interlinkages between the environmental and socio-economic SDG indicators through statistical methods. The report also discusses how filling data gaps could enable even more robust statistical analyses of interlinkages.

We hope that this report will encourage governments to strengthen their statistical capacity in relation to the environment and encourage discussion on the use of new techniques to address environmental data gaps and analyses.

Executive Summary

This Measuring Progress report serves two purposes. It explores the potential and limitations of using a statistical correlation analysis between indicator pairs (“state of the environment” and “drivers of change” indicators; “state of the environment” and “state of society” indicators) to improve the understanding of the interlinkages between SDG indicators. It also informs on progress being made for those SDG indicators UNEP identified as environment-related since December 2018, based on data from the SDG Global Indicators Database.

Statistical Correlation Analysis and Methodology

Actions taken in achieving one SDG target may impact other SDG targets. The interlinked nature of the SDGs means that achieving one goal or target may contribute to achieving other goals or targets, or the pursuit of one objective may conflict with the achievement of another. The analysis in the report aims to contribute to the growing research on SDG Interlinkages Analysis.

The report uses an analytical approach driven by data, whereby the relationship between the indicators of the SDG framework and their underlying data identify topics to be explored. The analytical approach is broken into five stages. The first stage is based on classifying the 231 unique indicators of the SDG framework as “drivers of change”, “state of the environment” or “state of society” indicators. Stage 2 identifies potential synergies between pairs of these indicator classifications to investigate the relationship between direct drivers of change and the state of the environment, and secondary relationships between the state of the environment and the state of society indicators. Stage 3 selects the indicators to investigate based on the availability of their underlying data, while Stage 4 consists of performing a correlation analysis between the pairs of indicators. The last stage identifies the positive outlier countries that represent an opportunity to further investigate based on their environmental improvements.

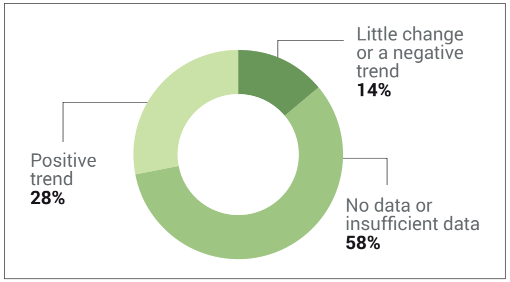
The analysis revealed examples where correlations are significant and are consistent with intuition or published evidence. In line with published evidence and intuition, water stress and water ecosystem extent are negatively correlated; Domestic Material Consumption (DMC) related to biomass extraction is negatively correlated with the Red List Index; and the proportion of Key Biodiversity Areas and certified forest area are correlated with both water ecosystem extent and forest area.

Monitoring Progress

The report also gives a general analysis of progress made based on the 92 SDG indicators which are most relevant to the environmental dimension of the SDGs and a regional analysis of the progress in each region.

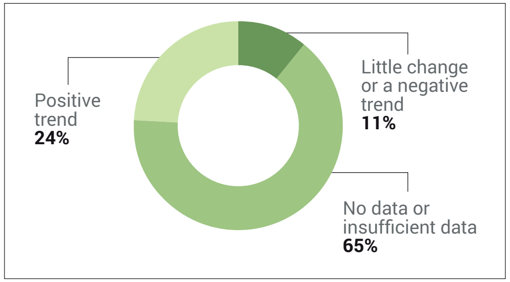
In July 2020, of 92 SDG indicators relevant to the environment, 42 per cent had sufficient data to assess progress made in achieving the SDG targets. This is an increase of 10 per cent compared with data from the Measuring Progress report I (MP I) (UNEP 2019a). However, with the addition of indicators with sufficient data to be assessed, the percentage of indicators now showing a positive trend toward meeting the relevant SDG has declined from 74 per cent in December 2018 to 67 per cent as of this report, and 33 per cent show little change or a negative trend, up from 26 per cent.

Global



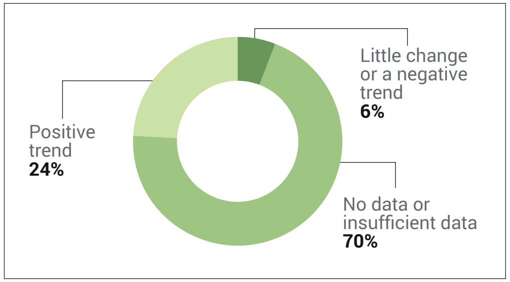
Sub-Saharan Africa saw an increase in the number of environmental indicators showing a positive trend toward the achievement of the relevant SDG (47 per cent more indicators), and a decrease of 17 per cent and 9 per cent for indicators with little or negative change and insufficient or no data, respectively, in comparison with data from MP I. Although 65 per cent of indicators lack data to assess for Sub-Saharan Africa, data availability for a number of environmental indicators improved from no data or one data point to more data points, which is an indication that the data gap for SDG indicators is reducing - albeit very slowly.

Sub-Saharan Africa

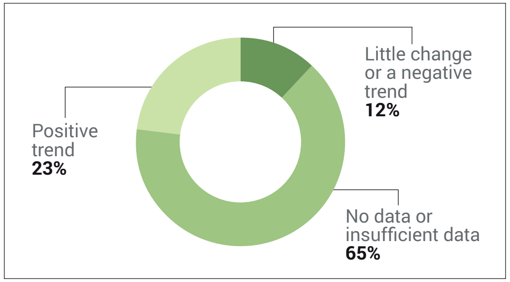


In comparison with data from MP I, Asia and the Pacific had an overall increase in the positive trend indicators (92 per cent more in Oceania, 40 per cent more in Eastern and South-Eastern Asia and 29 per cent more in Central and Southern Asia), a decrease in the number of environmental indicators with little change or negative trend (50 per cent less in Central and Southern Asia, 41 per cent less in Oceania and 21 per cent less in Eastern and South-Eastern Asia), while the insufficient or no data indicators showed no change in Central and Southern Asia, and a 6 and 8 per cent fewer indicators in Eastern and South-Eastern Asia and Oceania, respectively (UNEP 2019a).

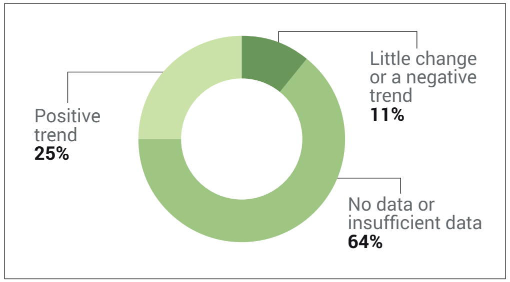
Central and Southern Asia



Eastern and South-eastern Asia

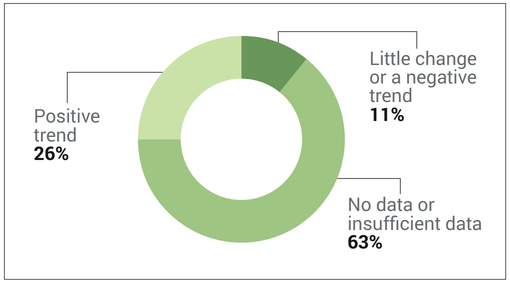


Oceania



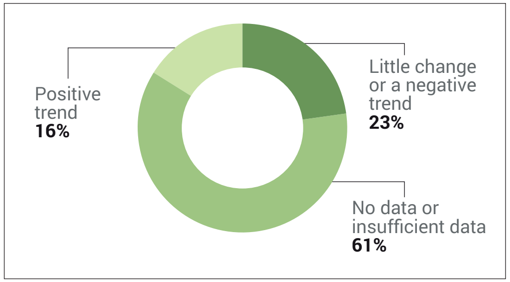
In Europe, although indicators with insufficient or no data to analyse progress decreased by 18 per cent, over half (63 per cent) of the indicators still lack sufficient data for assessment. Environmental indicators showing positive trends increased significantly (167 per cent more indicators), and indicators with little change or negative trends decreased (23 per cent) in comparison with data from MP I (UNEP 2019a).

Europe



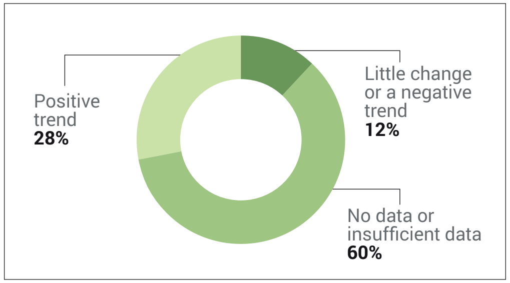
North America continues to have significant shortfalls in data and reporting. In comparison with data from MP I, improvement was made for environmental indicators with positive trends (67 per cent more indicators) and insufficient or no data indicators (22 per cent less). However, more indicators showed little change or negative trends (75 per cent more) (UNEP 2019a).

North America



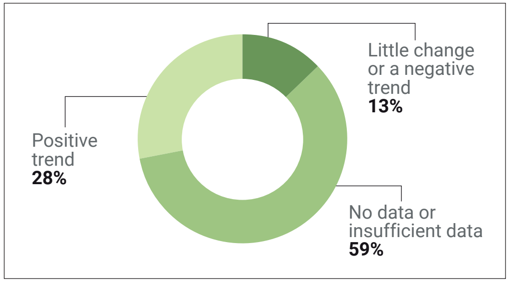
The Latin American and the Caribbean (LAC) region showed improvement in environmental indicators, where 63 per cent more indicators demonstrated positive trends, 15 per cent fewer indicators showed little change or negative trends and 14 per cent fewer indicators had insufficient or no data, compared to data from MP I (UNEP 2019a).

Latin America and the Caribbean

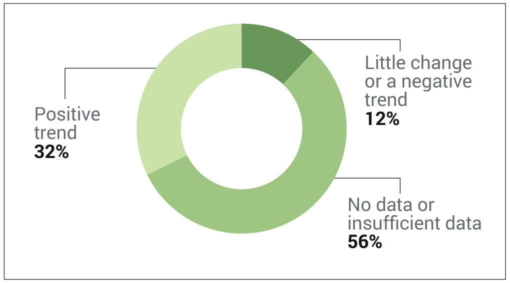


In comparison with data from MP I, the Northern Africa and Western Asia region has shown an increase in positive trends for environmental indicators (123 per cent in Western Asia and 189 per cent in Northern Africa), a decrease of insufficient or no data indicators (24 per cent in Western Asia and 25 per cent in Northern Africa) and an 8 per cent decrease in Western Asia for little change or negative trend indicators, while Northern Africa had no change (UNEP 2019a). Over 50 per cent of environmental indicators lack data in the region, more specifically, cities and communities (SDG 11), responsible consumption and production (SDG 12) and life below water (SDG 14) have the least available environmental data, while ending poverty (SDG 1), clean water and sanitation (SDG 6) and life on land (SDG 15) have the most environmental data.

Northern Africa



Western Asia



Discussion

A new analytical approach based on correlation analysis provides insights on interlinkages related to nature between specific SDG indicator pairs, as well as an understanding of what might be required to improve the ability to understand interlinkages further. However, a simple correlation analysis provides only limited insight into interlinkages that often are complex, and which ultimately need to be further investigated for impactful policy design. The attempt to establish statistical relationships between some of the key drivers and indicators of the environmental dimension of the SDGs has been inconclusive. The state of the environment indicators, considered as the dependent variables in the analysis, are influenced by a multitude of factors beyond the population, GDP (Gross Domestic Product) and regional variables that were included in the analysis, indicating the importance of national and local level analyses of systemic effects. There is a need for data and techniques adequate to undertake full multi-variant analyses, to understand the implications of the full set of the SDG policies and better design new interventions.

Perhaps of greatest value in terms of identifying work that urgently needs to be undertaken, the report identifies vital data gaps. An overview of data gaps and opportunities evaluates which aspects of the environment one can measure versus which aspects presently lack the information needed to understand the current global situation and makes suggestions as to how these gaps could be filled using innovative technologies and techniques. Data gaps refer to gaps in the compilation, analysis, and effective use of data. The analysis in this report highlights the underlying data sparsity for the environmental dimension of the SDGs. Gaps are found not only in the underlying data, but also in the tools and analytical methodologies for understanding the state of the environment, as well as interactions within the environmental dimension of the SDGs and interactions between the environmental dimension of the SDGs and the social and economic dimensions of sustainable development. Strengthening the National Statistical Offices' ability to undertake integrated analyses and explorations of interlinkages will be vital for designing, monitoring, and improving the efficacy of government interventions to achieve the SDGs.

The ability to use integrated metrics and analyses requires an investment in building data and statistical systems which employ both traditional data and new data (such as citizen science, remote sensing, IoT devices and transactional data) and new data science techniques. It is also critical to build a widespread practice of using scientific data as a foundation for decision-making across all three pillars of sustainable development. It is now possible to build environmental data products using big data. However, ensuring that these data products are both useful and used in practice at the national level requires (a) building national data collection, management and data analysis capacity; (b) strengthening the role and ownership of National Statistical Offices and Ministries of Environment in terms of collecting and processing environmental data and (c) establishing a practice by non-environmental government agencies, particularly the Ministries of Finance and Economic Development, of factoring environmental indicators and integrated analyses into their decision making. Strengthening environmental data capacities and availability of science-based standards are needed for policy makers to improve their understanding of the environmental priority actions required and are necessary for reaching sustainable development.

Chapter 1: Background

1.1. Introduction

Focusing on 92 Sustainable Development Goal (SDG) indicators that are relevant to the environment, this report analyses progress made towards achieving the SDG targets and discusses the data gaps.

By exploring the potential and limitations of using a statistical correlation analysis between indicator pairs (state of the environment and drivers of change; state of the environment and state of society), the aim of the report is to improve understanding of the interlinkages between SDG indicators.

This second Measuring Progress report maps those SDG indicators relevant to the environment to the standard driver-pressure-state-impact-response (DPSIR) model used for State of the Environment reporting. The report identifies possible synergies between these SDG indicators using the drivers, state of the environment and state of society grouping. The economy-related SDGs were considered as indirect drivers, as per the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) definition, and thus were not included in the analysis. For those SDG indicators with sufficient data, the report presents a correlation analysis and discusses its outcomes and data challenges. The first Measuring Progress report identified SDG indicators that are essential to the environmental dimension of the 2030 Agenda for Sustainable Development, identified data gaps and analysed progress.

In Chapter 1, the report examines how the environment is featured in the SDGs, in relation with the three adopted indicators grouping. Chapter 2 provides a general analysis of progress made based on the 92 SDG indicators that are most relevant to the environmental dimension of the SDGs and a regional analysis based on the progress in each region. Chapter 3 presents the new analytical approach based on correlation analysis, with the results explained in Chapters 4 and 5. Chapter 6 focuses on Viet Nam and Kenya, while Chapter 7 on data gaps and opportunities looks at which aspects of nature are measurable versus which aspects currently lack the information needed to understand the current global situation, and considers how new technologies and techniques could fill these gaps, before concluding with Chapter 8.

In general, the environmental SDG indicators are not fully capable of showing whether progress is being made towards environmental sustainability. Chapter

6 explores the work of UCL, supported by the UNEP and the *Agence Française de Développement* [French International Development Agency – AFD], to develop the Strong Environmental Sustainability Index. It is a set of indicators that could complement the environmental SDGs, based on a distance-to-target methodology that computes the environmental sustainability gap (ESGAP) between current environmental conditions across a range of issues and science-based standards (Andersen *et al.* 2020) on those issues that would indicate that environmental functions were being maintained at a sustainable level. Two case studies in Viet Nam and Kenya look at the challenges and data availability at the country level to implement the ESGAP approach.

1.2. Sustainable Development Goals

In September 2015, the United Nations Sustainable Development Summit adopted an international framework to guide development efforts, entitled Transforming our World: the 2030 Agenda for Sustainable Development. The Agenda is built around 17 SDGs, divided into 169 targets. As at 28 December 2020, the updated SDG global indicator framework contains 231 unique indicators (a further 12 indicators repeat under two or three different targets). The importance of improving the availability of – and access to – data and statistics related to the environment was recognized through the adoption of a wide range of environmental SDG targets and indicators. On 6 March 2015, at its forty-sixth session, the United Nations Statistical Commission created the Inter-agency and Expert Group on SDG Indicators (IAEG-SDGs), composed of Member States and including regional and international agencies as observers. The IAEG-SDGs was tasked with developing and implementing the global indicator framework for the goals and targets of the 2030 Agenda.

Responsibility for the methodological work, as well as assessment of progress towards the SDG indicators, falls to several ‘custodian agencies’ from the United Nations System and the broader international community. As the leading global environmental authority that sets the global environmental agenda and promotes the coherent implementation of the environmental dimension of sustainable development, UNEP is the custodian of 25 of the environmental SDG indicators.

1.2.1. Environmental targets and indicators

The UNEP Secretariat presented a list of 93 SDG indicators to the UN Environment Assembly Committee of Permanent Representatives at the subcommittee meeting on 20 September 2018. Following the 2020 review of the SDG Global Monitoring Framework, adopted by the Statistical Commission in March 2020, the list of SDG indicators relevant to the environment has been slightly revised, with the number of environmental indicators reduced to 92 (see Annex A, table A.1)[1]. The main changes to the environmental indicators is presented in table 1.1.

Table 1.1. Changes to the SDG indicators related the environment as per the 2020 comprehensive review

Added indicators	Removed indicators
6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	16.8.1 Proportion of members and voting rights of developing countries in international organizations
7.b.1/ 12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita) *previously known as "7.b.1 Investments in energy efficiency as a proportion of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services"* *and "12.a.1 Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies"*	17.6.1 Fixed internet broadband subscriptions per 100 inhabitants, by speed *previously known as "Number of science and/or technology cooperation agreements and programmes between countries, by type of cooperation"*
13.2.2 Total greenhouse gas emissions per year	
17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the Sustainable Development Goals	
17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring	

In March 2019, UNEP launched the report entitled *Measuring Progress: Towards Achieving the Environmental Dimension of the SDGs*, which analysed the state of the environmental dimensions of sustainable development based on the SDG indicators, including the availability of statistical and spatial data. For this publication, simple extrapolation procedures were used to estimate whether the SDG targets at the global and regional level would be met based on the current state

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[1] Many of the SDG indicators have different components that may be relevant to the environment. For example, SDG indicator 16.3.3 Proportion of the population who have experienced a dispute in the past two years and who accessed a formal or informal dispute resolution mechanism, by type of mechanism. The categories of disputes considered in the methodology of this SDG indicator include "Environmental damage (land or water pollution, waste dumping, etc.)".

of the SDG indicators (i.e. no efforts to change the current data trend). A simple extrapolation method was chosen because this method is easy to understand.

At the time of publication of the first Measuring Progress report, for 68 per cent of the environment-related SDG indicators, sufficient data were not available to assess progress. For those indicators where sufficient data were available, conclusions could be drawn. Many of the indicators for which good progress had been made reflected a mix of policy changes, improved reporting, and increased funding efforts. For example, there had been an increase in terrestrial, mountain and marine protected areas; an increase in the effort to combat invasive species; significant progress in installation and use of renewable energy; an increase in sustainability reporting and mainstreaming in policy; and an increase in development assistance for climate change and the environment. However, many of the indicators related to the environment showed a negative trend (such as indicators related to forests, sustainable fisheries, endangered species, domestic material consumption, and material footprint).

1.2.2. A universal interlinked agenda

The adoption of the SDGs in 2015 brought renewed attention to the importance of interlinked action across sectors. SDGs are interconnected in a complex network of interactions of various goals and targets. Universality of the 2030 Agenda implies that none of the SDGs are more important than any other, while their integrated nature results in complex feedbacks to targets in other SDGs. This means that policy coherence is essential to achieve sustainable development and policies should not be developed in isolation. By determining where interlinkages exist between the goals, targets and indicators of the SDG framework, as well as the type (reinforcing or competing) and strength of these relationships, countries can identify where they might allocate scarce resources, and target policy, most effectively. Leveraging the efficiencies presented by interlinkages can inform the strategic direction of disaggregated statistical reporting to support targeted projects and programmes (IAEG-SDGs 2019).

The SDGs have elevated the profile of the environmental dimension of development and how the world monitors it, resulting in environment indicators for 15 SDG goals. Acknowledging interrelationships within the framework is necessary to support effective decision-making and policy development. This report aims to provide further information that can improve the science–policy link. More specifically, this analysis aims to identify where nature-based interventions can simultaneously provide environmental benefits as well as social and economic benefits.

1.3. Analysis of SDG interlinkages

In 1995, UNEP adopted the DPSIR causal framework approach for the Global Environment Outlook assessments. In this systems-analysis view, the driving forces of social and economic development exert pressures on the environment, changing its state. 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 have an impact on the state of the environment, either directly or indirectly, through the driving forces or the pressures.

1.3.1. Scope of SDG targets and indicators related to drivers of change

The concept of ‘drivers of change’ developed by the IPBES was adopted to define the actions included in this analysis. Drivers that impact the environment may also have secondary impacts on the state of society. For example, polluting activities that impact the condition of water ecosystems are likely to have secondary social impacts on access to safe drinking water and mortality rates attributed to unsafe water. This report explores these secondary impacts by investigating the relationship between the SDG indicators that measure the state of the environment and the SDG indicators related to relevant societal impacts.

The range of drivers of change included in this analysis is diverse: it includes those drivers that cover the more common approaches to environmental conservation, protection and management, as well as drivers that tend to negatively impact the environment such as waste generation and domestic material consumption. However, the relationships investigated here between drivers of change, the state of the environment and the state of society are characterized by highly complex causal chains that cannot be captured well by one-way relationships between pairs of indicators. This is further elaborated on in the discussion of the analysis findings.

1.3.2. Scope of SDG targets and indicators related to the state of the environment

The state of the environment includes the quality of the various environmental components (for example air, water, soil, ocean) in relation to the functions that they fulfil. The state of the environment is thus the combination of the physical, chemical and biological conditions that currently exist in the environment. The SDG targets related to nature are evidently found in SDG 6 on water, SDG 14 on oceans, seas and marine resources and SDG 15 on terrestrial ecosystems. However, SDG targets related to nature are also found in other SDGs, such as target 2.5 on genetic diversity and target 11.6 on environmental impact of cities.

Ecosystems can play an important role in water retention, helping to mitigate potential downstream flooding and to avoid related costs to property and livelihoods. Biodiversity and ecosystem services help society to adapt to and mitigate climate change, helping reduce the risk of climate-change-related or other natural hazards and mitigate the impacts. In addition, their function in supplying clean air to towns and cities directly affects human health.

1.3.3. Scope of SDG targets and indicators related to the state of society

Human well-being and nature or the environment are linked (UNEP 2019a). For example, human well-being is dependent upon renewable natural resources, which should be used and managed within boundaries that allow the resource to renew itself. The potential for the delivery of services from ecosystems depends on ecosystems being in specific states, with ecological thresholds constituting an inherent property of these systems. Biodiversity and ecosystems provide a wide range of services to human societies and economies. There is a need to better understand the linkages and interdependencies of socioeconomic and gender-related outcomes or well-being and nature.

An effective integration of social condition, environmental dynamics and institutional responses would enrich the process of informed decision-making on sustainable resource use and development practices. The state of society indicators considered in this report are limited by the availability of data. They are found in SDG 1 on poverty, SDG 2 on sustainable agriculture and nutrition, SDG 3 on health, SDG 4 on education, SDG 6 on availability of water, SDG 7 on energy, SDG 11 on resilient cities and SDG 13 on climate action. Additionally, environmental sustainability contributes significantly towards achieving SDG 5 on gender equality. However, there are almost no explicit gender targets and indicators included in the environment-related SDGs (UNEP 2019b).

SDG indicators 1.5.1/11.5.1/13.1.1 and 1.5.2/11.5.3 look at the human and economic impact of disasters. While the destruction caused by rapid-onset disasters (such as hurricanes) tends to be through their immediate physical impacts, slow-onset disasters (such as drought) also create crises through their economic and social impacts (Randall n.d.). Natural disasters can cause large-scale, widespread death, loss of property and disturbance to social systems and life. Communities have always had to deal with natural hazards, and will always have to, but today's disasters are often exacerbated by human activities. Through disregard for the effects of human actions on nature, human activities are changing the natural balance of the Earth, interfering as never before with the climate system, the oceans, ecosystems and biological resources. The Sendai Framework 2015–2030 urges humanity to reduce risk by avoiding decisions that create risk, by reducing existing risk and by building resilience.

SDG indicators 2.1.1, 2.1.2 and 2.2.2 look at different aspects of food (in)security and its effects on humans. Food relies on nature's resources, but by exploiting them without care for ecological balances, over the years humans have gained more abundant food but often accompanied by increasing environmental degradation. Of the several hundred thousand known plant species, some 120 are cultivated for human food. Just nine of these crops supply over 75 per cent of global plant-derived energy intake and of these, only three – wheat, rice and maize – account for more than 50 per cent (FAO n.d.a). That means humans are using large areas of land for just a few crops, leaving less room for diversity in nature.

SDG indicators 4.a.1 and 6.1.1 cover access to drinking water. Fresh water plays a fundamental role in supporting the environment, society and the economy. However, the world's freshwater ecosystems are threatened by increased pollution, urbanization, rising food and energy production, water-related disasters, and human displacement (UNEP 2017).

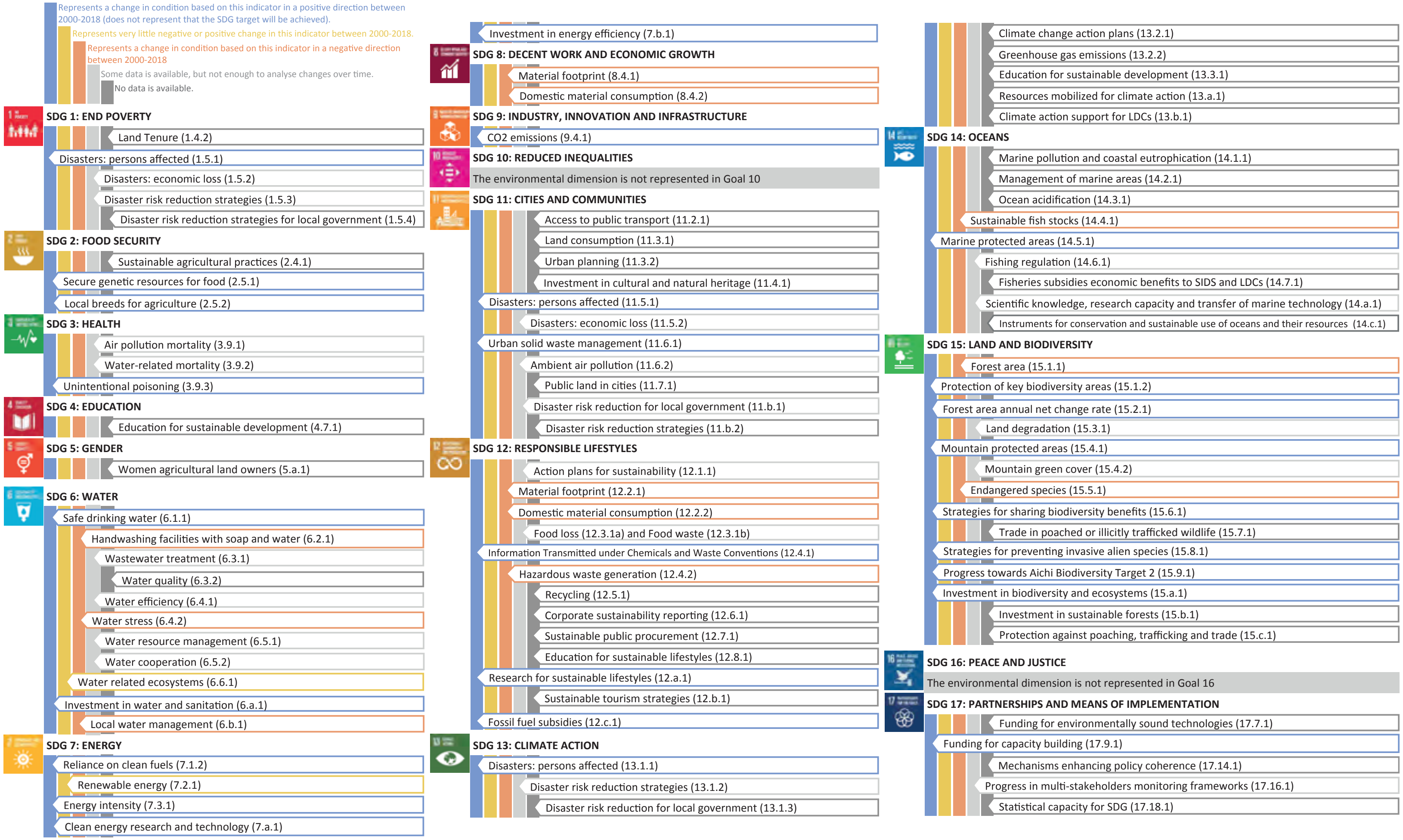
SDG 7.1.2 monitors access to clean energy. Energy is central to economic activity and social well-being. The International Renewable Energy Agency (IRENA) has analysed the socioeconomic benefits of renewable energy since 2011. Its analysis concludes that, "in addition to supporting climate stabilization goals, a significant uptake of renewables and energy efficiency measures offers important macroeconomic benefits" (IRENA 2017). According to IRENA estimates, savings from reduced health and environmental externalities, which are not fully reflected in conventional economic accounting systems, far offset the costs of the energy transition.

Chapter 2: The state of the environment

Note: The regional analysis is based on the Sustainable Development Goals (SDGs) regional groupings, except for North America and Europe, which have been separated.

A full description of the SDG regions, including the countries in each, is included in Annex B. In summary, the description of sub-Saharan Africa includes the SDGs region of sub-Saharan Africa; the description for Asia and the Pacific includes the SDGs regions of Central and Southern Asia, Eastern and South-Eastern Asia and Oceania; the description of Europe is based on the European component of the SDGs region of Europe and North America; the description of Latin America and the Caribbean is based on the SDGs region of Latin America and the Caribbean; the description of North America is based on the North American component of the SDGs region of Europe and North America; and the description of Northern Africa and Western Asia includes the SDGs region of Northern Africa and Western Asia.

Figure 2.0.1. Global scorecard on the environmental dimension of the SDGs

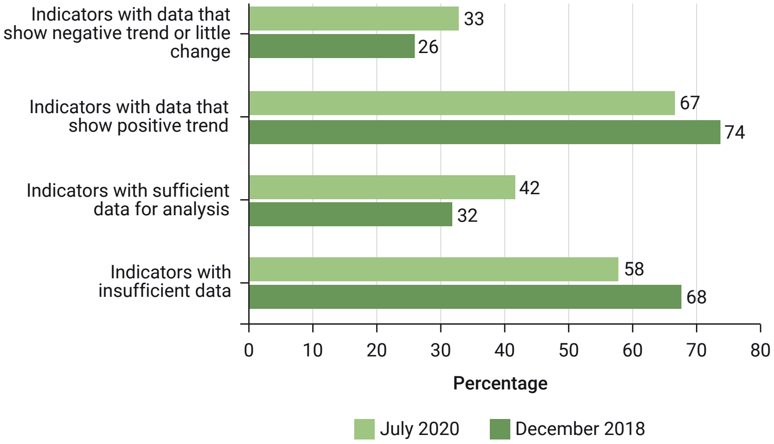


2.1. Global progress on the environmental dimension of the SDGs

The 92 environmental indicators are contained in 15 of the 17 SDGs (exceptions are SDG 10 on reduced inequalities and SDG 16 on peace and justice). These indicators were updated at the 2020 Comprehensive Review and annual refinements from the fifty-first session of the Statistical Commission in March 2020. The updated list of environmental indicators included the addition of a few indicators (refer to table 1.1).

Data published in the first Measuring Progress report (as at December 2018) showed that 32 per cent of SDG environment indicators had sufficient data to be assessed (30 indicators out of 93). Of those 30 indicators, 22 indicated improvements in the environment - followed a positive trend (73 per cent) and 8 indicated little change or a negative trend (27 per cent) (UNEP 2019a). This second Measuring Progress report shows a welcome increase in the number of indicators that have sufficient data to be assessed. At the same time, this report reflects that the additional data reveal a less promising picture in terms of progress towards meeting the environmental SDGs. In July 2020, 42 per cent of SDG indicators have sufficient data (39 indicators), but of those 39 indicators, 26 indicators follow a positive trend (67 per cent) and 13 indicators (33 per cent) show little change or a negative trend.

Figure 2.1.1. Evolution of SDG progress from December 2018 to July 2020



This diminution in the percentage of indicators showing positive progress, however, is due to the ability to gather sufficient data for more indicators. Improvement in data availability is measured by the reduction in the number of indicators without data between 2019 and 2020.

Although data availability has improved, currently 58 per cent of environmental indicators have insufficient data to assess progress. This may be related to the newly developed methodologies for a number of environmental indicators that were reclassified as Tier II, with 19 SDG indicators reclassified as Tier II in 2019–2020 (please refer to Annex A, table A.3). Indicators with improvements in data from no data or not enough data to enough data are funding and investment for the environment (6.a.1, 7.a.1 and 7.b.1), adverse human environmental impact of cities (11.6.1), management of chemicals and waste (12.4.1), invasive alien species (15.8.1) and fossil-fuel subsidies (target 12.c.1). Also, several targets were populated with some data, yet have insufficient data available to analyse progress, such as water quality improvement (6.3.2), water use efficiency (6.4.1), food loss and waste (12.3.1a and 12.3.1b), illegal, unreported and unregulated fishing (14.6.1) and land degradation (15.3.1).

Several indicators are experiencing positive trends, including increased shares of safe drinking water and investment in water and sanitation (6.1.1 and 6.a.1), higher shares of clean fuels (7.1.2), increased clean energy research and energy efficiency investments (7.a.1 and 7.b.1) and lower rates of energy intensity (7.3.1). Additionally, the targets on land and biodiversity show increases in the protection of key biodiversity and mountain protected areas (15.1.2 and 15.4.1), increases in forest area annual net change rate (sub-indicator of 15.2.1), and biodiversity with improvement in strategies on preventing invasive alien species (15.8.1), progress towards the Aichi Biodiversity Target 2 (15.9.1) and larger investments in biodiversity and ecosystems (15.a.1) (figure 2.0.1).

Indicators experiencing negative trends include a decreased proportion of the population using hand-washing facilities with soap and water (6.2.1), increased water stress levels and a decrease in local water management (6.4.2 and 6.5.1), an increase in the consumption of domestic material products and increased material footprint (12.2.1 and 12.2.2), consumption and production patterns with an increase in hazardous waste generated per capita (8.4.1/8.4.2 and 12.4.2), oceans with a decrease in sustainable levels of fish stocks (14.4.1), and land and biodiversity, with a decrease in the proportion of total forest area and in the Red List Index (15.1.1 and 15.5.1) (figure 2.0.1).

Populating the SDG indicators fully will help overcome the challenge of reviewing progress at the national level. It is equally important to use disaggregated data by age, sex and key populations to fine-tune policy responses according to local contexts and the needs of specific ecosystems. Improved data, including gendered data, and indicators would provide more systemic insights into the risks entailed in continuing to operate outside planetary boundaries. Using the full set of SDG indicators to measure progress would enhance the ability of governments and the United Nations High-level Political Forum, by complementing and adding depth to the tracking of progress through the Voluntary National Reviews (VNRs).

2.2. State of the environment indicators – where is the world heading?

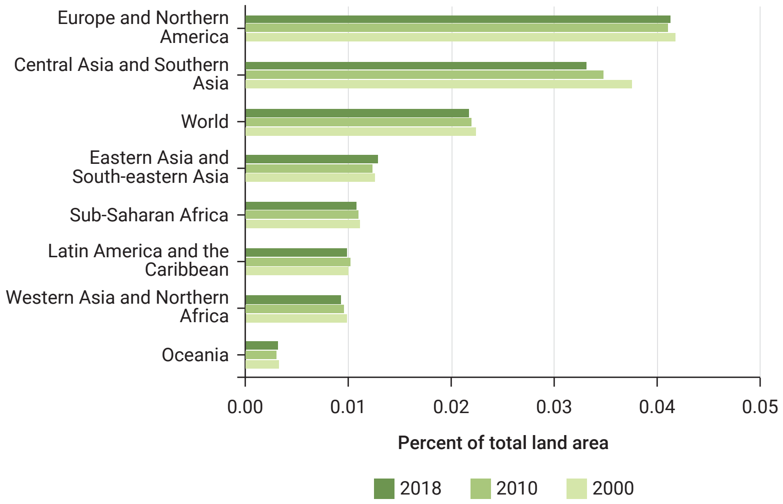
Within the scope of this report, SDG indicators were categorized into three groups (please refer to sections 1.2 and 3.2). Understanding the status of the state of the environment indicators can help provide a better picture of the actions that are implemented and that impact this state. Indicators represent the availability and quality of water resources, state of marine ecosystems, green land cover and degradation, extinction risk of species and air quality. Although national data are available for nine out of the 12 state of the environment indicators, it is imperative to present all indicators and the reasons they are essential for the conservation of nature.

2.2.1. Availability and quality of water resources

Change in the extent of water-related ecosystems over time (6.6.1)
Freshwater pollution is prevalent and increasing in many parts of Latin America, Africa and Asia (United Nations 2018). Monitoring and improving water quality in water bodies is essential for the sustainability of freshwater ecosystems, fisheries, biodiversity and for assessing the quality of water used for irrigation, ensuring a threshold of minimal pollutants (UNEP 2018a).

The change in the extent of water-related ecosystems over time comprises five stand-alone sub-indicators, of which two are based on satellite data and three on in situ data. Currently, data available in time series relate to two categories: ”water body extent – permanent and maybe permanent”[2] and ”water body extent – permanent” and cover 214 countries and territories between 2000 and 2018. Data indicate a decrease in extent for permanent and maybe permanent water bodies at the global level and the regional level, except for Eastern Asia and South-Eastern Asia.[3] The latter witnessed an increase of 1.3 per cent in this category of water body extent between 2000 and 2018. Limited national data are available for the extent of wetlands (inland and human made), open water bodies and rivers. The decreasing extent of water bodies has deleterious impacts on society, especially on women and girls, as it takes longer for them to access these resources, thus limiting the time available for them to undertake paid labour (WHO 2016b).

Figure 2.2.1. Water body extent (permanent and maybe permanent)



Water quality and quantity data for groundwater, open water bodies and rivers (sub-indicator of 6.6.1) are also available for a limited number of countries for 2017. Findings from piloting this sub-indicator have indicated limited availability of data related to river flow and an absence of groundwater data at the national level (UNEP 2018b). Freshwater resources are vital for the preservation of biodiversity and for the continuity of life on Earth, but these resources are threatened by significant solid waste and wastewater pollution, along with the impact of climate change on their availability and extent. This affects the proportion of bodies of water with good ambient water quality (6.3.2).

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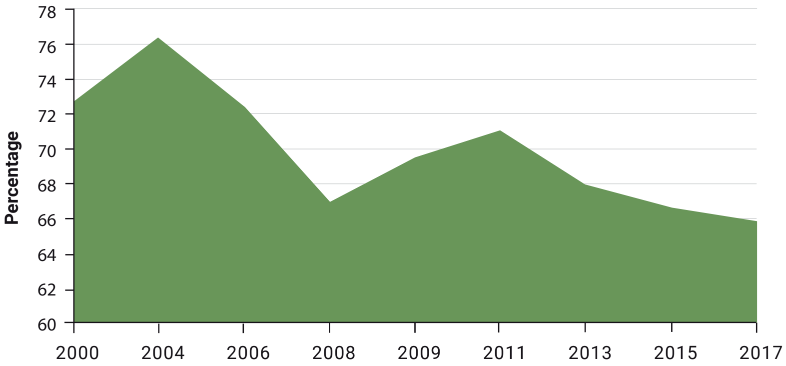
[2] ‘Maybe permanent’ includes seasonal water bodies and water bodies that are not confirmed yet as permanent or seasonal.

[3] Regions and sub-regions are based on the SDG regional grouping detailed in Annex B and accessed from https://unstats.un.org/unsd/methodology/m49/

There are not abundant global or regional data on the proportion of water bodies with good ambient water quality. However, national data are available for 48 countries across continents, starting in 2017. The methodology recommends following a five-year reporting cycle, taking 2017 as the baseline year and 2020 as the first reporting cycle for data collected between 2015 and 2019. Regular collection and testing of water samples from a variety of nationally located water bodies is required to generate data for this indicator. This might necessitate financial and human assistance to enhance national capacities for monitoring timely and spatial data on the quality of water bodies (UNSD 2020a).

2.2.2. Marine ecosystems

Figure 2.2.2. Proportion of fish stocks within biologically sustainable levels



Proportion of fish stocks within biologically sustainable levels (14.4.1)

The sustainability of global fish resources is declining. Fish stocks within biologically sustainable levels decreased by almost 10 per cent between 2000 and 2017 at the global level (UNSD 2020b), while 34 per cent of global marine fish stocks were considered to be at biologically unsustainable levels or overfished in 2017 (FAO 2020a). The increasing demand for fish and fish products caused by the shift to a healthier diet, growing population and freshwater demand (for agriculture, urban supply and energy production) are drivers that are impacting the sustainability of fish resources (FAO 2020a). Regionally, the highest percentages of stocks fished at unsustainable levels were recorded in the Mediterranean and Black Sea at 63 per cent, the South-East Pacific at 55 per cent and the South-West Atlantic at 53 per cent in 2017. Although global fish stock resources at biologically sustainable levels are still in decline, governments are implementing policy and management regulations that are leading to the recovery of some overfished stocks to biologically sustainable levels (FAO 2019a). Global and major fishing area data are currently available for this indicator. The Food and Agriculture Organization of the United Nations (FAO), as the custodian agency, has built national statistical capacities and developed a questionnaire approach that allows countries to use a simplified method to report individually on the sustainability of fish stocks (UNSD 2020a).

Index of coastal eutrophication (a) and floating plastic debris density (b) (14.1.1)

Coastal eutrophication can lead to serious damage to marine ecosystems, which are vital sea habitats, and can cause the spread of harmful algal blooms. The index of coastal eutrophication methodology recommends reporting on "concentrations and ratios of nitrogen, phosphorous and silica in the nutrient loads delivered by rivers to coastal waters" and is expressed in kilograms of carbon per square kilometre of river basin area per day (UNEP 2018c). This approach is currently being piloted in countries. Chlorophyll-a concentration in surface waters has been selected as a proxy indicator and data are collected as part of the core indicators of the Regional Seas Convention and Action Plans. On the other hand, floating plastic debris density methodology recommends using beach litter originating from national land-based sources as a proxy indicator and data are collected as part of the core indicators of the Regional Seas Convention and Action Plans.

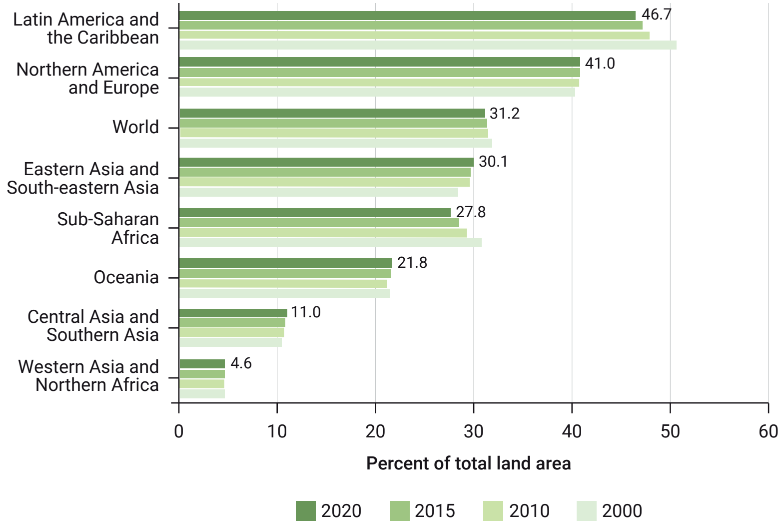
Average marine acidity (pH) measured at agreed suite of representative sampling stations (14.3.1)

Ocean acidification can have a detrimental impact on marine ecosystems and can lead to significant decrease of an ocean's species or make it harder for them to locate suitable habitats and food. In addition, the impact of ocean acidification on coastal zones can have a direct impact on humans, since oceans generate employment and food (IOC-UNESCO 2020). Data for average marine acidity were released for four countries between 2010 and 2019, namely Australia, Canada, France and New Zealand, at various sites. The purpose of this indicator is to monitor the carbon system by measuring four parameters: pH, total dissolved inorganic carbon, carbon dioxide partial pressure and total alkalinity. Each country's government decides which sites to select, as long as the same sites are measured regularly to capture the changes in the parameters' values. When 50 per cent or more of coastal nations report values, regional values are able to be aggregated (UNSD 2020a).

2.2.3. Green land cover and degradation

Forest area as a proportion of total land area (15.1.1)

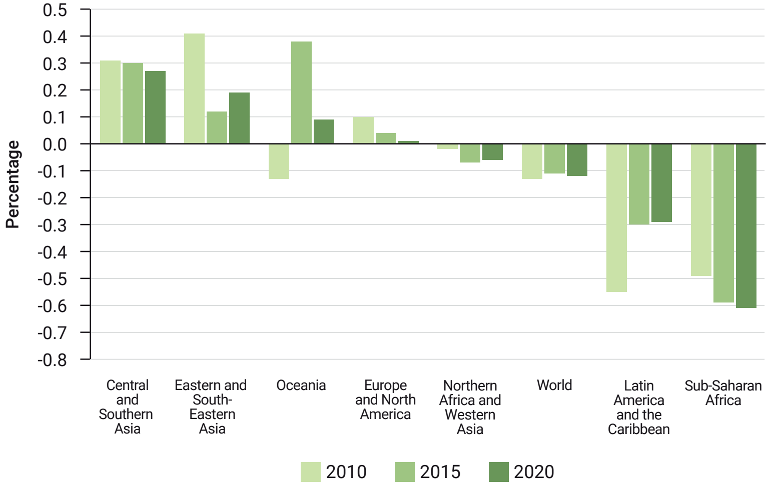
Figure 2.2.3. Forest area as a proportion of total land area



As forests play an important role in purifying the air, preventing land degradation, providing shelter and varied ecosystems for fauna and flora, and providing income and food for the surrounding communities, sustainable forest management must be reached to ensure biodiversity and support the livelihoods of surrounding communities. Globally, the proportion of forest area to total land area decreased by 2.4 per cent between 2000 and 2020, with data available for all countries and territories. Central Asia and Southern Asia witnessed the largest increase (6.2 per cent), while Eastern Asia and South-Eastern Asia's proportion of forest area increased by 5.8 per cent and Northern America and Europe by 1.2 per cent between 2000 and 2020 (UNSD 2020b). Increases can be attributed to afforestation and landscape restoration efforts, often on abandoned agricultural land, along with natural expansion of forests (FAO 2020b). Not all regions witnessed an increase, however. The largest proportional decrease of forest area to total land area is measured in sub-Saharan Africa at 10.4 per cent, followed by Latin America and the Caribbean at 8.2 per cent and Western Asia and Northern Africa at 0.8 per cent. This decrease is attributed to the conversion of forest land to agricultural use for crops and grazing (FAO 2019a).

Progress towards sustainable forest management (15.2.1)

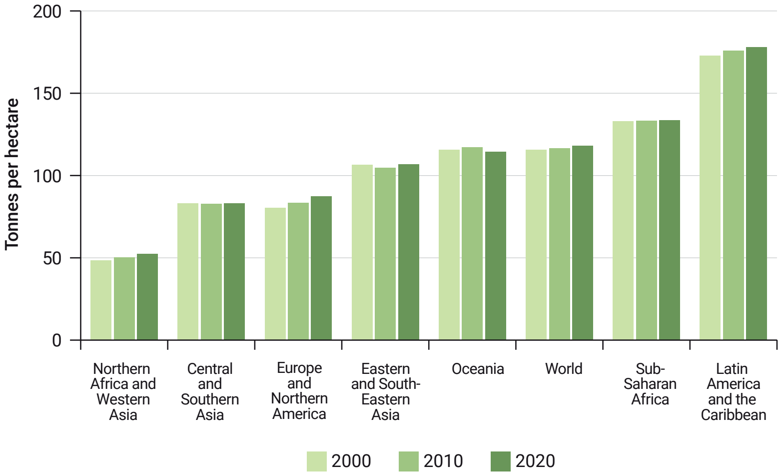
Figure 2.2.4. Forest area annual net change



As forests have multiple benefits, whether for biodiversity, humans or animal species, monitoring their growth serves in identifying and altering unsustainable practices and in commending sustainable practices that will protect their crucial role in planetary health.

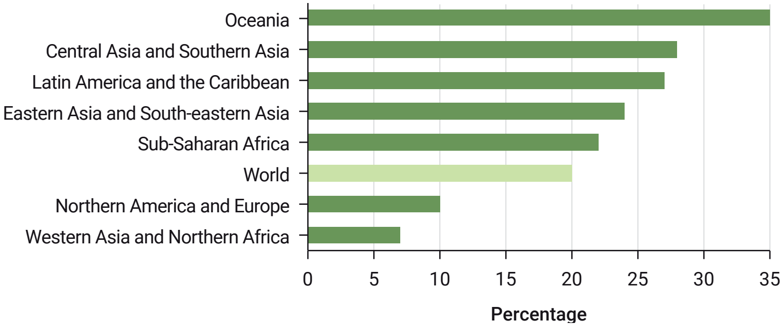
The progress towards the sustainable forest management indicator is formed of five sub-indicators that represent the economic, social and environmental dimensions of sustainable forest management. Two sub-indicators (above-ground biomass stock in forest and forest area annual net change rate) are considered as state of the environment indicators while the other three (forest area under a long-term management plan, forest area under an independently verified forest management certification scheme and forest area within legally established protected areas) are driver indicators. Available data are taken between 2000 and 2020 and vary based on the sub-indicator. The above-ground biomass indicator shows a positive trend towards sustainable forest management between 2000 and 2020. Although the annual net change rate of forest areas is decreasing, there was a loss of forest area between 2010 and 2020. The highest forest area loss can be found in sub-Saharan Africa, Western Asia and Northern Africa. According to FAO, large-scale cropping, grazing and subsistence agriculture are causing the forest area loss in these regions (FAO 2019a).

Figure 2.2.5. Above-ground biomass



Proportion of land that is degraded over total land area (15.3.1)

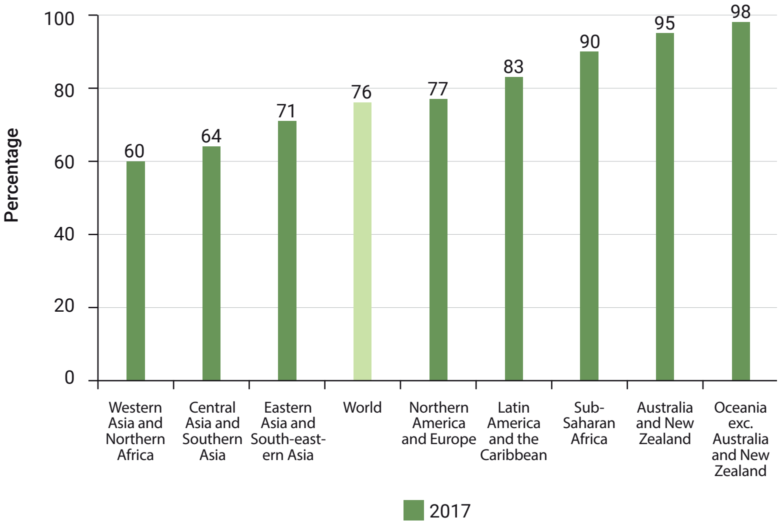
Figure 2.2.6. Land degraded over total land area, 2015



Healthy land represents a valuable resource for securing biodiversity and ensuring ecosystem services and also plays a role in economic growth and improved livelihoods for people (UNCCD 2016). Global land degradation was estimated at 20 per cent in 2015. Northern America, Europe, Western Asia and Northern Africa had the lowest rates, with degraded land at or below 10 per cent. The rest of the world experienced higher land degradation rates, varying from 22 per cent in sub-Saharan Africa to 35 per cent in Oceania. National data on indicator 15.3.1 were first collected in 2018, covering 124 countries and territories. These data will be updated every four years and categorize land into degraded and not degraded land based on the changes in land cover, land productivity dynamics and soil organic carbon stock (Mattina *et al.* 2018). Based on the data requirements for this report,[4] data for this indicator were not included in the analysis due to the availability of only one data point at the time of writing this report. Population growth, affluence, urbanization and increased competition among users are exacerbating land degradation (Cowie *et al.* 2018).

Mountain Green Cover Index (15.4.2)

Figure 2.2.7. Mountain Green Cover Index



The SDGs and the Aichi Biodiversity Targets acknowledge the importance of preserving mountains and their ecosystems within global policy frameworks and their significant role for biodiversity and as a refuge for various species (UNEP *et al.* 2020).

The global Mountain Green Cover Index amounted to 76 per cent in 2017, with regional variations of between 60 and 76 per cent for Western Asia and Northern Africa, Central and Southern Asia and Eastern and South-Eastern Asia. On the

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[4] The data requirement in this report is to have at least two data points since 2000 at the national level (Chapter 3).

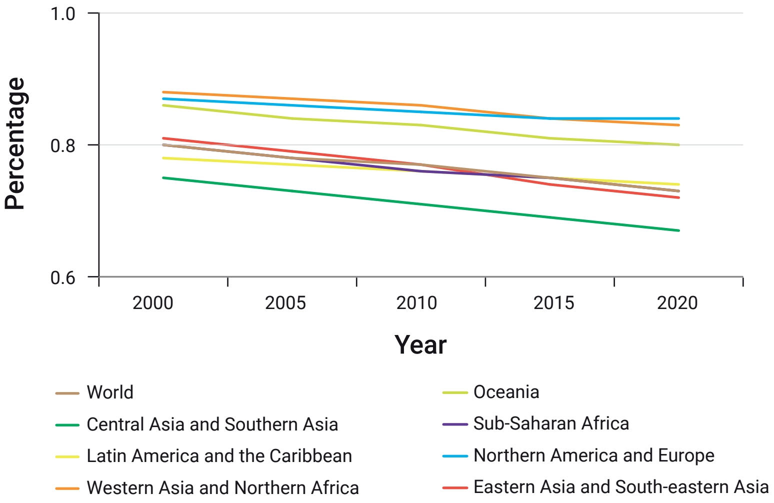
other hand, Latin America and the Caribbean, sub-Saharan Africa and Oceania[5] indicated values above the world average for the same year. At the time of the statistical analysis (July 2020), published data for the Mountain Green Cover Index were available for 159 countries and territories for 2017 only, hence they were not included in the analysis. However, updated data were published at the national level at distinct intervals over the 2000–2018 period and disaggregated by elevation in the subsequent update(s) of the SDG Global Indicators Database.

Monitoring mountain green cover (forests, grasslands and croplands) variations over time provides an indication of their health and measures whether mountain ecosystems are moving towards conservation or away from it. An increase denotes conservation efforts made by countries through reforestation, restoration or afforestation, while a decrease indicates overgrazing, land clearing and forest exploitation, among other factors (UNSD 2020a).

2.2.4. Extinction risk of species

Red List Index (15.5.1)

Figure 2.2.8. Red List Index



The Red List Index provides information on the status of biodiversity at the national, regional and global levels and the known species list is updated as often as the information is available. Tracking the status of species across the globe provides essential information to assess the efforts made to conserve biodiversity, and to determine the species status at the national level and develop relevant policies.

The Red List Index at the global and regional levels indicates an overall descending trend, representing a higher risk for known species' extinction. Data are available for all countries and territories between 2000 and 2020. For this period, the highest extinction risk for known species was measured in Central and Southern Asia with a decrease of 11 per cent, followed by Eastern and South-Eastern Asia with a 10 per cent decrease. The Red List Index is aggregated by species including mammals, birds, corals, amphibians and cycads, with data indicating the highest risk of extinction for corals while amphibians are the most threatened animal group (IUCN n.d.a). Similarly, thematic Red List Indices are available at the regional level, indicating the status of subsets of species that are of particular policy relevance, such as pollinator species.

Proportion of local breeds classified as being at risk of extinction (2.5.2)

Animal genetic resources are considered to be directly linked to biodiversity and represent an essential share of agricultural ecosystems. National data for SDG indicator 2.5.2 are available for 77 countries and territories from 2000 until 2019. A high percentage of known breeds is considered at risk, with 65 per cent of local breeds categorized as 'unknown' status.[6] Diverse animal genetic resources are immensely important in meeting increasing demands for food and agriculture. Local breeds hold special traits related to their particular environments that enable essential resilience to harsh environments and endemic diseases (FAO 2014). Sixty-one per cent of known breeds have unknown risk status, with 2,021 known breeds considered at risk, 4,351 with unknown status and 720 not at risk (FAO 2020c). Reported countries' data indicated a decrease of four per cent in the percentage of local livestock breeds at risk between 2018 and 2019. Europe[7] reported that 84 per cent of breeds are considered at risk, while the Republic of South Africa indicated 71 per cent and South America 44 per cent. FAO states that adequate conservation of animal genetic resources in medium- and long-

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[5] Australia and New Zealand have been represented separately from Oceania due to the unavailability of data to calculate regional aggregates.

[6] An unknown risk status is considered "if (i) no population sizes are reported or (ii) the most recent population size reported refers to a year more than 10 years before the year of calculation (10 year cut off point)" (Global SDG Indicators Database, metadata repository).

[7] Regions and sub-regions are based on the SDG regional grouping detailed in Annex B and accessed from https://unstats.un.org/unsd/methodology/m49/

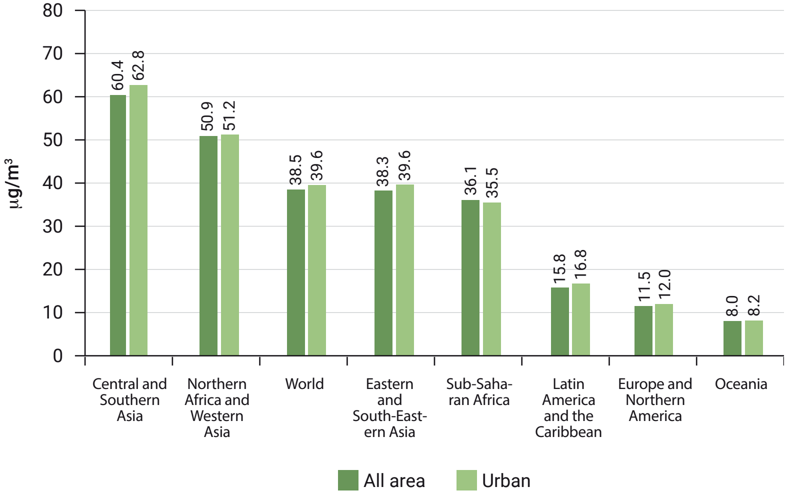
term conservation facilities is alarming based on the proportion of local livestock breeds being at risk (FAO 2019a). Although indicator 2.5.2 is supposed to cover terrestrial and aquatic species, it currently covers terrestrial species only. A global assessment report of aquatic genetic resources was released identifying 694 wild relatives and farmed species across 92 countries (FAO 2019b).

2.2.5. Air quality

Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted) (11.6.2)

The global annual mean level of fine particulate matter $PM_{2.5}$ was estimated at 38.5 µg/m³ for rural and urban areas for 2016, while the World Health Organization (WHO) Air Quality Guidelines recommend a concentration of only 10 µg/m³ for $PM_{2.5}$. According to WHO, only 16 per cent of the assessed population have annual mean levels that comply with Air Quality Guidelines (WHO 2016a). Central and Southern Asia's annual mean level was measured at 60.4 µg/m³ and Northern Africa and Western Asia was 50.9 µg/m³, while the rest of the regions had lower concentrations than the global annual mean level.[8] Although particulate matter concentrations in urban areas are generally higher than in urban and rural areas combined, sub-Saharan Africa has estimated the annual mean level at 36.1 µg/m³ for urban and rural combined, while having a concentration of 35.5 µg/m³ for urban areas.

Figure 2.2.9. Annual mean level of fine particulate matter $PM_{2.5}$



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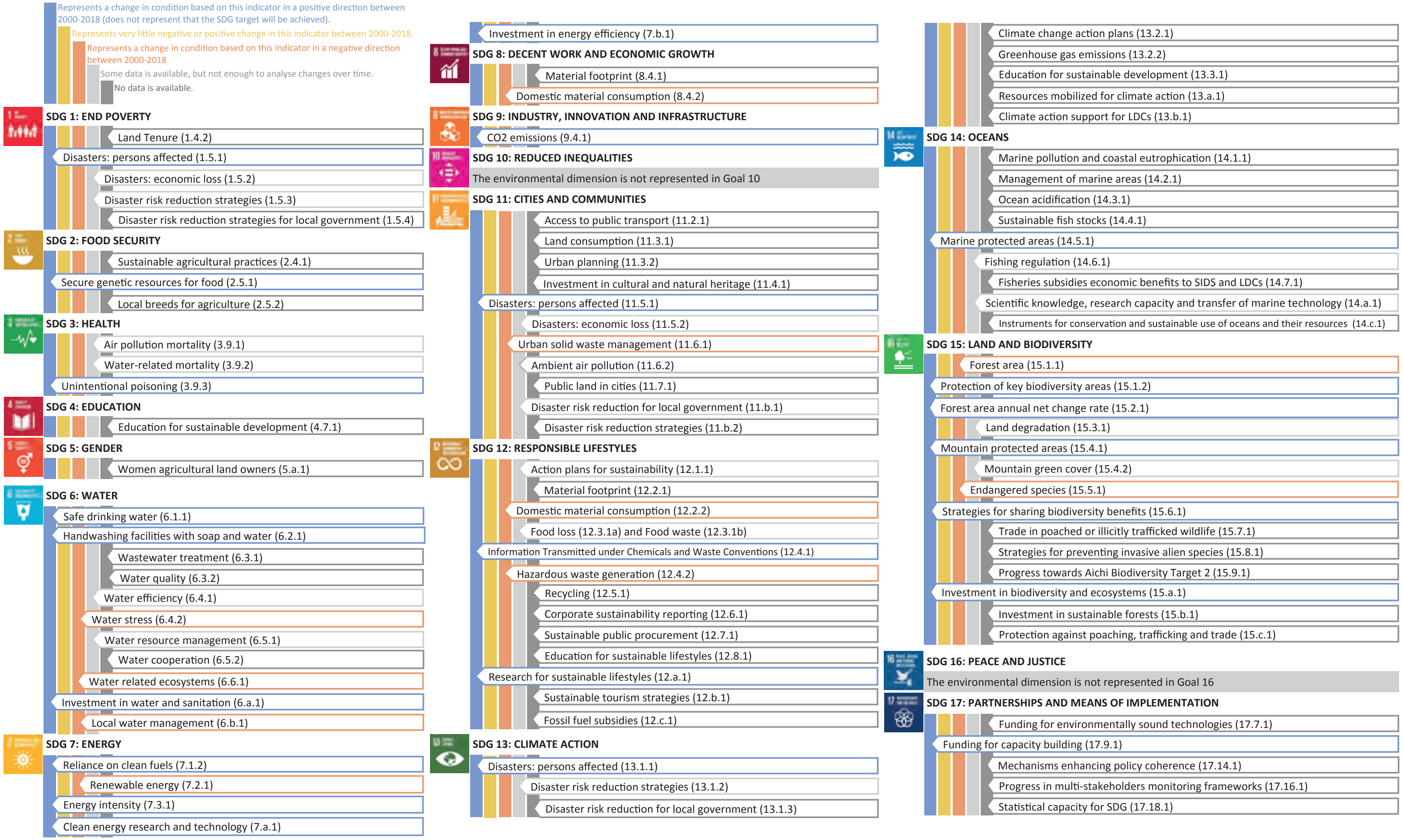
[8] Regions and sub-regions are based on SDG regional grouping detailed in Annex B and accessed from https://unstats.un.org/unsd/methodology/m49/

2.3. Sub-Saharan Africa: Regional progress on the environmental dimension and state of the environment indicators of the SDGs

Figure 2.3.1. Scorecard on the environmental dimension of the SDGs in sub-Saharan Africa



2.3.1. Sub-Saharan Africa introduction

Sub-Saharan Africa saw an improvement in the number of environmental indicators with a positive trend (47 per cent more indicators), and a decrease of 17 per cent and 9 per cent for indicators with little change or a negative trend and insufficient or no data, respectively, in comparison with data from the first Measuring Progress report (UNEP 2019a). A new layer of challenges to sub-Saharan Africa's delivery of the SDGs has been added. Regional projections show that extreme weather events and environmental degradation through the loss of access to land, along with the COVID-19 pandemic, could push more people into extreme poverty (The Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network 2020). Compounding these dynamics are several other shocks from the beginning of 2020, including locust invasions in Eastern Africa and the Horn of Africa, with massive destruction of crops and livestock feeds. In the midst of these, and on a positive note, some environmental indicators are shown to be faring better. For example, the region is witnessing positive change in clean energy (SDG 7) and life on land (SDG 15). Although 65 per cent of indicators lack data, data availability for a number of environmental indicators has improved from no data or one data point to more data points, which is an indication that the data gap for SDG indicators is reducing – albeit very slowly. Nevertheless, more efforts are needed to build the capacity of countries in sub-Saharan Africa in terms of data collection and reporting.

2.3.2. Statistical availability

Persistent constraints of data availability remain in the quest to monitor and report on the region's progress on the environmental dimension of the SDGs. For instance, fewer than 15 countries report on their progress regarding the proportion of local livestock breeds classified as being at risk (SDG indicator 2.5.2) or the proportion of bodies of water with good ambient water quality (SDG indicator 6.3.2). Three state of the environment indicators report only one data point, namely air pollution (SDG indicator 11.6.2), degraded land (SDG indicator 15.3.1) and Mountain Green Cover Index (SDG indicator 15.4.2). In addition, four state of the environment indicators report time series. Forest area annual net change (SDG sub-indicator of 15.2.1) indicates negative change-of-rate with a decrease of almost 25 per cent between 2010 and 2020, while above-ground biomass stock shows an increase of 0.4 per cent between 2000 and 2020. In addition, negative change for water body extent (SDG indicator 6.6.1), forest area (SDG indicator 15.1.1) and species at risk (SDG indicator 15.5.1) is reported for the region and at the sub-regional level between 2000 and the latest available year. Significant decrease is reported in Western Africa for water body extent and forest area, and in Middle Africa for water body extent.

2.3.3. Progress and gaps

Interestingly, the analysis of SDG trends in Africa reveals a more varied and nuanced picture of whether sub-Saharan African countries are progressing sufficiently to achieve the SDGs by 2030. To increase their momentum on SDG progress, all countries in the sub-Saharan region should adopt the framework of sustainability, to create linkages and feedbacks that can accelerate the progress of the 12 state of the environment indicators. Regional reports show most African Governments are relatively well-positioned to take this trajectory. For instance, a good number of countries (48 out of 54 countries) have made significant efforts to endorse the SDGs and incorporate them into national strategies and development plans (The Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network 2020). Furthermore, most countries have identified government units to coordinate SDG implementation and have prioritized specific targets and indicators. The available data show that though progress may be slow in most of the countries, efforts have been made to institutionalize data monitoring and reporting. Steps taken include the establishment of national statistical and data focal points, multi-stakeholder partnerships and open data platforms. However, what is glaringly lacking among many of them is structured communication and information-sharing, including in the critical areas of stakeholder engagement. Another hurdle is the limited funding and resources, which have been shown to severely hinder SDG implementation and monitoring across all countries in the region.

2.3.4. Regional initiatives

As captured in the 2019 Measuring Progress report, countries in the region currently stand at varying levels of SDG implementation. The COVID-19 pandemic and its impact have grouped African countries (sub-Saharan and Northern Africa countries) under the green recovery plan to advance the SDGs and the goals of the strategic framework of the African Union, Agenda 2063 (African Ministerial Conference on the Environment 2020). Accordingly, it will be imperative for development partners to work more closely with the countries on technical and financial capacity development to pave the way for more rigorous implementation, tracking and reporting across all the relevant SDG areas. Key among the promising areas of intervention would be increased collaboration between entities such as United Nations organizations, the national environmental protection entities and the designated national statistics offices. Moreover, improved partnerships between United Nations organizations (including donors, major groups and stakeholders) and country-based offices of Resident Coordinators would be a plus, particularly in advocating for the prioritization of national data centres and in furthering aspects of national development planning and budgeting at the highest political levels. To bolster such moves, it will be necessary to use the Resident Coordinators' channel to encourage governments to create open data platforms and increase opportunities for crowdsourcing of data, including through citizen science and private-sector participation.

2.4. Asia and the Pacific: Regional progress on the environmental dimension and state of the environment indicators of the SDGs

Figure 2.4.1. Scorecard on the environmental dimension of the SDGs in Central and Southern Asia

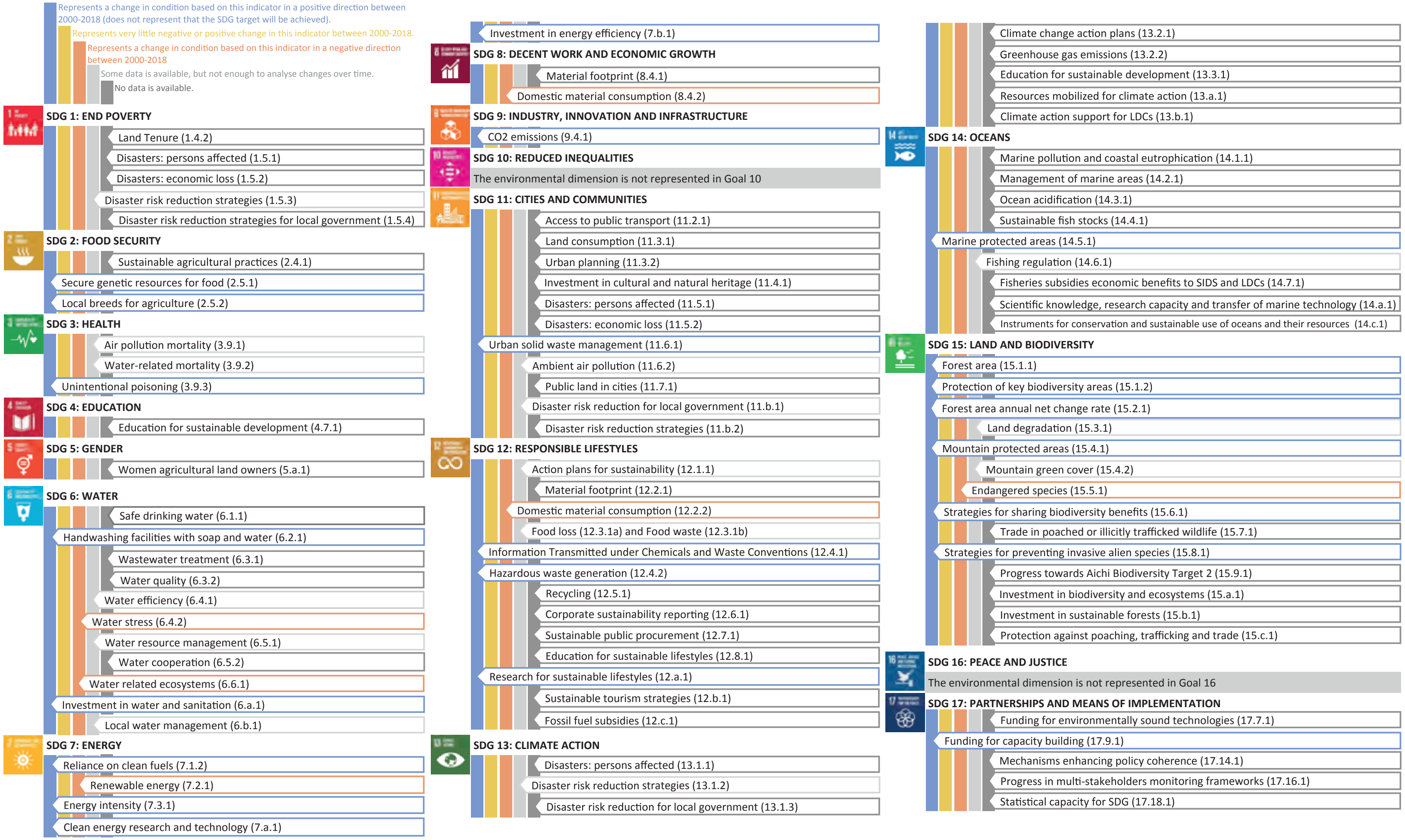
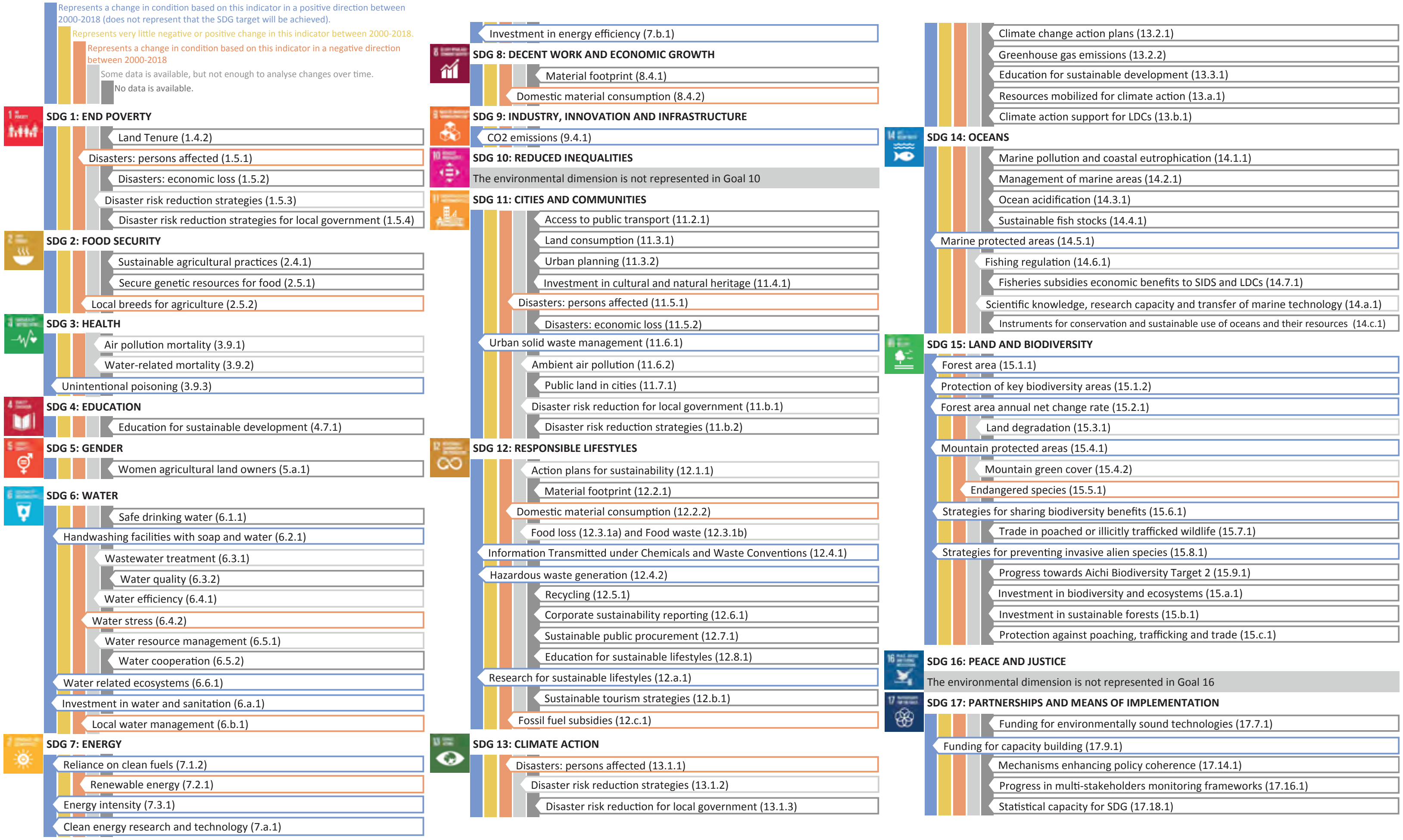


Figure 2.4.2. Scorecard on the environmental dimension of the SDGs in Eastern and South-Eastern Asia



- 🟦 Represents a change in condition based on this indicator in a positive direction between 2000-2018 (does not represent that the SDG target will be achieved).
- 🟨 Represents very little negative or positive change in this indicator between 2000-2018.
- 🟧 Represents a change in condition based on this indicator in a negative direction between 2000-2018
- ⬜ Some data is available, but not enough to analyse changes over time.
- ⬛ No data is available.

SDG 1: END POVERTY
- ⬛ Land Tenure (1.4.2)
- 🟧 Disasters: persons affected (1.5.1)
- ⬛ Disasters: economic loss (1.5.2)
- ⬜ Disaster risk reduction strategies (1.5.3)
- ⬛ Disaster risk reduction strategies for local government (1.5.4)

SDG 2: FOOD SECURITY
- ⬛ Sustainable agricultural practices (2.4.1)
- ⬛ Secure genetic resources for food (2.5.1)
- 🟧 Local breeds for agriculture (2.5.2)

SDG 3: HEALTH
- ⬜ Air pollution mortality (3.9.1)
- ⬜ Water-related mortality (3.9.2)
- 🟦 Unintentional poisoning (3.9.3)

SDG 4: EDUCATION
- ⬛ Education for sustainable development (4.7.1)

SDG 5: GENDER
- ⬛ Women agricultural land owners (5.a.1)

SDG 6: WATER
- ⬛ Safe drinking water (6.1.1)
- 🟦 Handwashing facilities with soap and water (6.2.1)
- ⬜ Wastewater treatment (6.3.1)
- ⬛ Water quality (6.3.2)
- ⬜ Water efficiency (6.4.1)
- 🟧 Water stress (6.4.2)
- ⬜ Water resource management (6.5.1)
- ⬛ Water cooperation (6.5.2)
- 🟦 Water related ecosystems (6.6.1)
- 🟦 Investment in water and sanitation (6.a.1)
- 🟧 Local water management (6.b.1)

SDG 7: ENERGY
- 🟦 Reliance on clean fuels (7.1.2)
- 🟧 Renewable energy (7.2.1)
- 🟦 Energy intensity (7.3.1)
- 🟦 Clean energy research and technology (7.a.1)
- 🟦 Investment in energy efficiency (7.b.1)

SDG 8: DECENT WORK AND ECONOMIC GROWTH
- ⬛ Material footprint (8.4.1)
- 🟧 Domestic material consumption (8.4.2)

SDG 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE
- 🟦 CO2 emissions (9.4.1)

SDG 10: REDUCED INEQUALITIES

The environmental dimension is not represented in Goal 10

SDG 11: CITIES AND COMMUNITIES
- ⬛ Access to public transport (11.2.1)
- ⬛ Land consumption (11.3.1)
- ⬛ Urban planning (11.3.2)
- ⬛ Investment in cultural and natural heritage (11.4.1)
- 🟧 Disasters: persons affected (11.5.1)
- ⬛ Disasters: economic loss (11.5.2)
- 🟦 Urban solid waste management (11.6.1)
- ⬜ Ambient air pollution (11.6.2)
- ⬛ Public land in cities (11.7.1)
- ⬜ Disaster risk reduction for local government (11.b.1)
- ⬛ Disaster risk reduction strategies (11.b.2)

SDG 12: RESPONSIBLE LIFESTYLES
- ⬜ Action plans for sustainability (12.1.1)
- ⬛ Material footprint (12.2.1)
- 🟧 Domestic material consumption (12.2.2)
- ⬜ Food loss (12.3.1a) and Food waste (12.3.1b)
- 🟦 Information Transmitted under Chemicals and Waste Conventions (12.4.1)
- 🟦 Hazardous waste generation (12.4.2)
- ⬛ Recycling (12.5.1)
- ⬛ Corporate sustainability reporting (12.6.1)
- ⬛ Sustainable public procurement (12.7.1)
- ⬛ Education for sustainable lifestyles (12.8.1)
- 🟦 Research for sustainable lifestyles (12.a.1)
- ⬛ Sustainable tourism strategies (12.b.1)
- 🟧 Fossil fuel subsidies (12.c.1)

SDG 13: CLIMATE ACTION
- 🟧 Disasters: persons affected (13.1.1)
- ⬜ Disaster risk reduction strategies (13.1.2)
- ⬛ Disaster risk reduction for local government (13.1.3)
- ⬛ Climate change action plans (13.2.1)
- ⬛ Greenhouse gas emissions (13.2.2)
- ⬛ Education for sustainable development (13.3.1)
- ⬛ Resources mobilized for climate action (13.a.1)
- ⬛ Climate action support for LDCs (13.b.1)

SDG 14: OCEANS
- ⬛ Marine pollution and coastal eutrophication (14.1.1)
- ⬛ Management of marine areas (14.2.1)
- ⬛ Ocean acidification (14.3.1)
- ⬛ Sustainable fish stocks (14.4.1)
- 🟦 Marine protected areas (14.5.1)
- ⬜ Fishing regulation (14.6.1)
- ⬛ Fisheries subsidies economic benefits to SIDS and LDCs (14.7.1)
- ⬜ Scientific knowledge, research capacity and transfer of marine technology (14.a.1)
- ⬛ Instruments for conservation and sustainable use of oceans and their resources (14.c.1)

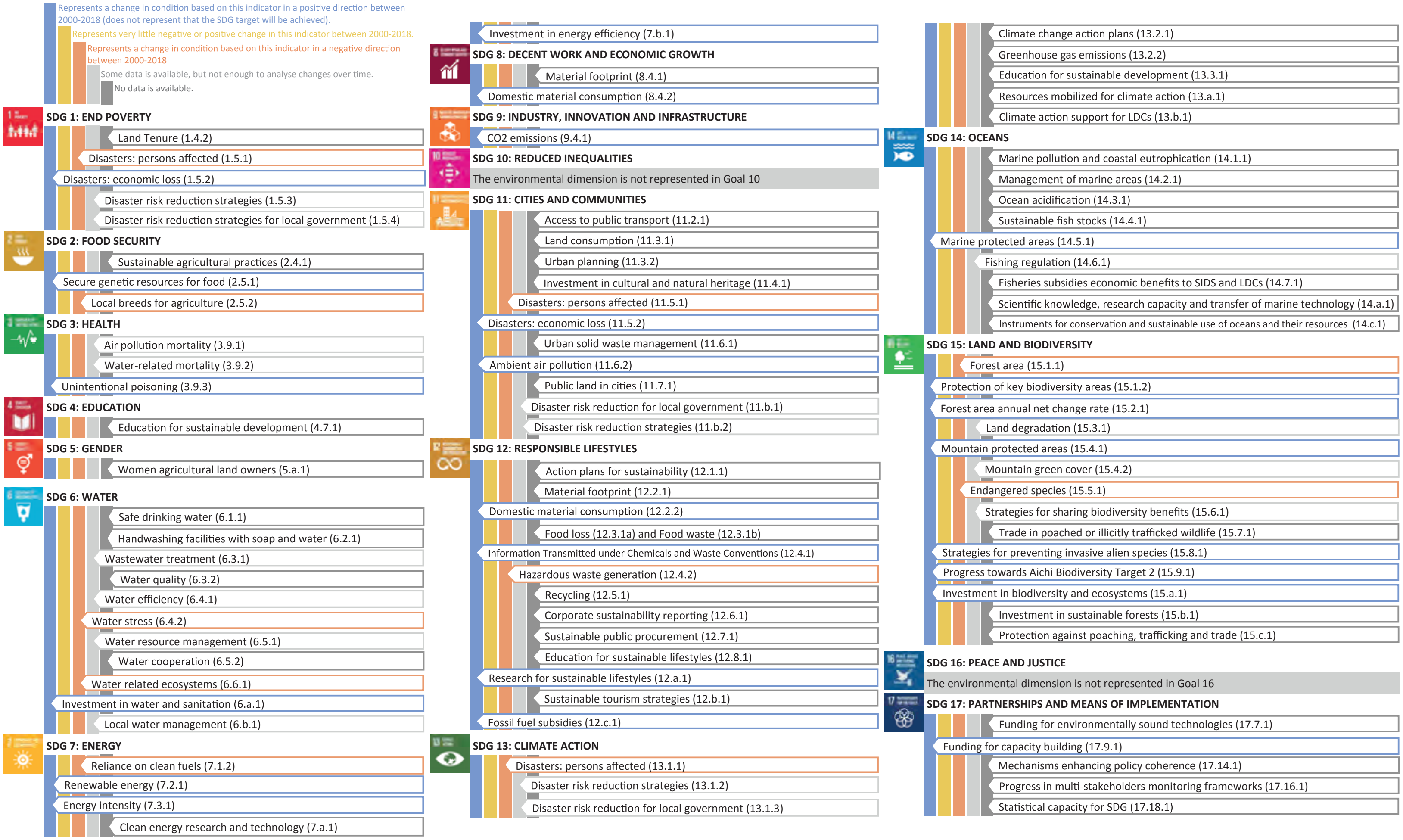
SDG 15: LAND AND BIODIVERSITY
- 🟦 Forest area (15.1.1)
- 🟦 Protection of key biodiversity areas (15.1.2)
- 🟦 Forest area annual net change rate (15.2.1)
- ⬜ Land degradation (15.3.1)
- 🟦 Mountain protected areas (15.4.1)
- ⬜ Mountain green cover (15.4.2)
- 🟧 Endangered species (15.5.1)
- 🟦 Strategies for sharing biodiversity benefits (15.6.1)
- ⬛ Trade in poached or illicitly trafficked wildlife (15.7.1)
- 🟦 Strategies for preventing invasive alien species (15.8.1)
- ⬛ Progress towards Aichi Biodiversity Target 2 (15.9.1)
- ⬛ Investment in biodiversity and ecosystems (15.a.1)
- ⬛ Investment in sustainable forests (15.b.1)
- ⬛ Protection against poaching, trafficking and trade (15.c.1)

SDG 16: PEACE AND JUSTICE

The environmental dimension is not represented in Goal 16

SDG 17: PARTNERSHIPS AND MEANS OF IMPLEMENTATION
- ⬛ Funding for environmentally sound technologies (17.7.1)
- 🟦 Funding for capacity building (17.9.1)
- ⬛ Mechanisms enhancing policy coherence (17.14.1)
- ⬛ Progress in multi-stakeholders monitoring frameworks (17.16.1)
- ⬛ Statistical capacity for SDG (17.18.1)

Figure 2.4.3. Scorecard on the environmental dimension of the SDGs in Oceania[9]



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[9] Oceania, as identified in the SDG regional grouping, includes the following countries/territories that were not included in this report's analysis section: American Samoa, Christmas Island, Cocos (Keeling) Islands, Cook Islands, French Polynesia, Guam, Heard Island and McDonald Islands, New Caledonia, Niue, Norfolk Island, Northern Mariana Islands, Pitcairn, Tokelau, United States minor outlying islands, and Wallis and Futuna Islands.

2.4.1. Asia and the Pacific introduction

In comparison with data from the first Measuring Progress report, Asia and the Pacific witnessed an overall decrease in the number of environmental indicators with little change or a negative trend (50 per cent fewer in Central and Southern Asia, 41 per cent fewer in Oceania and 21 per cent fewer in Eastern and South-Eastern Asia), and an increase in the positive trend indicators (92 per cent more in Oceania, 40 per cent more in Eastern and South-Eastern Asia and 29 per cent more in Central and Southern Asia), while the insufficient or no data indicators showed no change in Central and Southern Asia, and 6 and 8 per cent fewer indicators in Eastern and South-Eastern Asia and Oceania, respectively (UNEP 2019a). The countries of the Asia and the Pacific region share a strong commitment towards the 2030 Agenda for Sustainable Development, which is evident in numerous regional initiatives, including the adoption in 2017 of the Regional Road Map for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific. The countries of the region remain very active in their submissions of VNRs to the High-level Political Forum on Sustainable Development, with 14 countries submitting their VNRs in 2019,[10] 10 submitting their VNRs in 2020,[11] and an additional 10 planning to submit their VNRs in 2021.[12] Despite this active commitment from the region, the VNRs that have been submitted remain generally data-poor regarding the environmental dimension of the SDGs.

The overall progress on the SDGs in the region is lagging, as highlighted in the 2019 Progress Report of the aforementioned Regional Road Map and further confirmed by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) Asia and the Pacific SDG Progress Report in 2020, which assessed that with the current rate of progress, despite some marked improvements under individual targets, the region is not likely to meet any of the 17 SDGs by 2030 (ESCAP 2020). The lack of progress is most evident under goals with a strong environmental component, with a particularly urgent need to accelerate progress under SDG 12, 13 and 14. The lack of progress on measurable environmental indicators is coupled with poor data availability on many indicators pertinent to the environmental dimension of sustainable development, with limited information hindering a reliable assessment of progress.

Taking a more detailed look at the state of the 92 environmental indicators, the most striking trend is the lack of data, with almost half of the indicators having no data for most countries in the region (ESCAP n.d.). The percentage of indicators with no available data in countries across the region ranges from 38 per cent (Malaysia) to as high as 66 per cent (Brunei Darussalam). The number of measurable environmental indicators also varies among the countries in the region, from sufficient data to assess the progress of 48 per cent of the environment-related indicators in Malaysia to as few as 25 per cent in Tuvalu.

2.4.2. Statistical availability

Taking a closer look at the state of the 12 state of the environment indicators in the region, the most evident issue is the lack of measurable progress due to a lack of data. Of these 12 indicators, only four indicators have sufficient data to assess progress in all of the countries in the region, namely water ecosystems (SDG indicator 6.6.1), forest area (SDG indicator 15.1.1), forest annual change rate and above-ground biomass stock (SDG sub-indicators of 15.2.1) and species at risk (SDG indicator 15.5.1). One additional indicator, local breeds (SDG indicator 2.5.2), has sufficient data to assess progress in 12 countries in the region, while the remaining indicators have either no data or insufficient data to assess progress in all countries. While there are not sufficient data for marine pollution (SDG indicator 14.1.1), partial data are available for coastal eutrophication (SDG indicator 14.1.1.a) allowing for a partial assessment, with no data available for plastic pollution (14.1.1b). On the other hand, ocean acidification (SDG indicator 14.3.1) and fish stocks (SDG indicator 14.4.1) have no available data yet for countries in this region. Progress[13] on the state of the environment indicators in the region is either slow or lacking, with a need for a trend reversal for two of the indicators: marine pollution (SDG indicator 14.1.1) and species at risk (SDG indicator 15.5.1). The situation is not too dissimilar at the sub-regional level, where a lack of data on most state of the environment indicators remains the primary issue. Only two indicators have been assessed[14] as being on track to achieve their target by 2030: permanent water body extent (SDG indicator 6.6.1) in Central Asia and Southern Asia and forest area (SDG indicator 15.1.1) in Eastern and South-Eastern Asia.

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[10] Kingdom of Cambodia, Republic of Fiji, Republic of Indonesia, Republic of Kazakhstan, Mongolia, Republic of Nauru, New Zealand, Islamic Republic of Pakistan, Republic of Palau, Republic of the Philippines, Democratic Republic of Timor-Leste, Kingdom of Tonga, Turkmenistan, Republic of Vanuatu

[11] People's Republic of Bangladesh, Brunei Darussalam, Republic of India, Kyrgyz Republic, Federated States of Micronesia, Federal Democratic Republic of Nepal, Independent State of Papua New Guinea, Independent State of Samoa, Solomon Islands, Republic of Uzbekistan

[12] Kingdom of Bhutan, People's Republic of China, Republic of Indonesia, Japan, Lao People's Democratic Republic, Malaysia, Republic of the Marshall Islands, Myanmar, Islamic Republic of Pakistan, Kingdom of Thailand

[13] In the absence of specific target values, the assessment of progress is based on a number of regional target values set using a 'champion area' approach based on identifying the top performers in the region and setting their average rate of change as the region's target rate.

[14] Assessment made based on median values as per the ESCAP methodology. For more information, please see https://data.unescap.org/resource-guides/progress-assessment-methodology

2.4.3. Progress and gaps

Overall, there is an urgent need to accelerate progress on most measurable indicators, both for what concerns the 12 state of the environment indicators and the wider range of 92 environment-related indicators, at the regional and sub-regional level. The lack of data remains an obstacle for assessing progress in the region, signifying a strong need for capacity-building and regional initiatives to advance the availability of state of the environment indicators. Following the recent reclassification of all indicators to Tier I or Tier II and the consequent efforts of custodian agencies towards the dissemination of approved methodologies and capacity development in the region, including the UNEP's efforts in particular under SDG 12 and 17, data availability is expected to improve.

2.4.4. Regional initiatives

Since 2015, momentum has been building in the region in terms of developing national statistics on the environment to implement and monitor progress on the environmental dimension of SDGs through the application of the United Nations Framework for the Development of Environment Statistics (FDES) and the United Nations System of Environmental–Economic Accounting (SEEA). About 30 countries (including Australia, People's Republic of China, Republic of India, Republic of Indonesia, New Zealand, Republic of the Philippines and Socialist Republic of Viet Nam) have piloted, produced or published one or more SEEA accounts.

Countries in the region seek support for a variety of environmental statistics, the most common topics being water, land, energy, and waste. SEEA land accounts especially attract attention as they provide a solid foundation for land and resource management and are important for analysing several priority policy issues such as disaster risk reduction, biodiversity, and climate change. Land accounts will ease the production of multiple nature-related, land-based SDG indicators, which is considered a very positive development. The momentum for land accounts is also driven by the increased availability of suitable satellite data and geographic information system (GIS) software, yet several capacity and technical barriers exist for national statistical institutions to make use of this type of big data for official statistics production. From 2020 onwards, the development of tools to ease this transition is therefore a priority for regional statistics capacity support (Musunuru and Marshall 2020).

With regard to oceans, ESCAP and UNEP jointly promoted technical guidance on ocean accounting based on the SEEA, the System of National Accounts, and SEEA Experimental Ecosystem Accounting in 2019. The guidance facilitates data- and information-sharing among environmental monitoring systems, scientific institutions and policy frameworks for implementation and progress monitoring of SDG 14. National pilots were carried out in the People's Republic of China, Malaysia, the Independent State of Samoa, the Kingdom of Thailand and the Socialist Republic of Viet Nam to develop the guidance and strengthen national capacities and partnerships to achieve SDG 14. Visual aids have been developed to generate policy support for increased uptake by countries.[15] Work is continuing under the umbrella of the Global Ocean Accounts Partnership (The Global Ocean Accounts Partnership n.d.).

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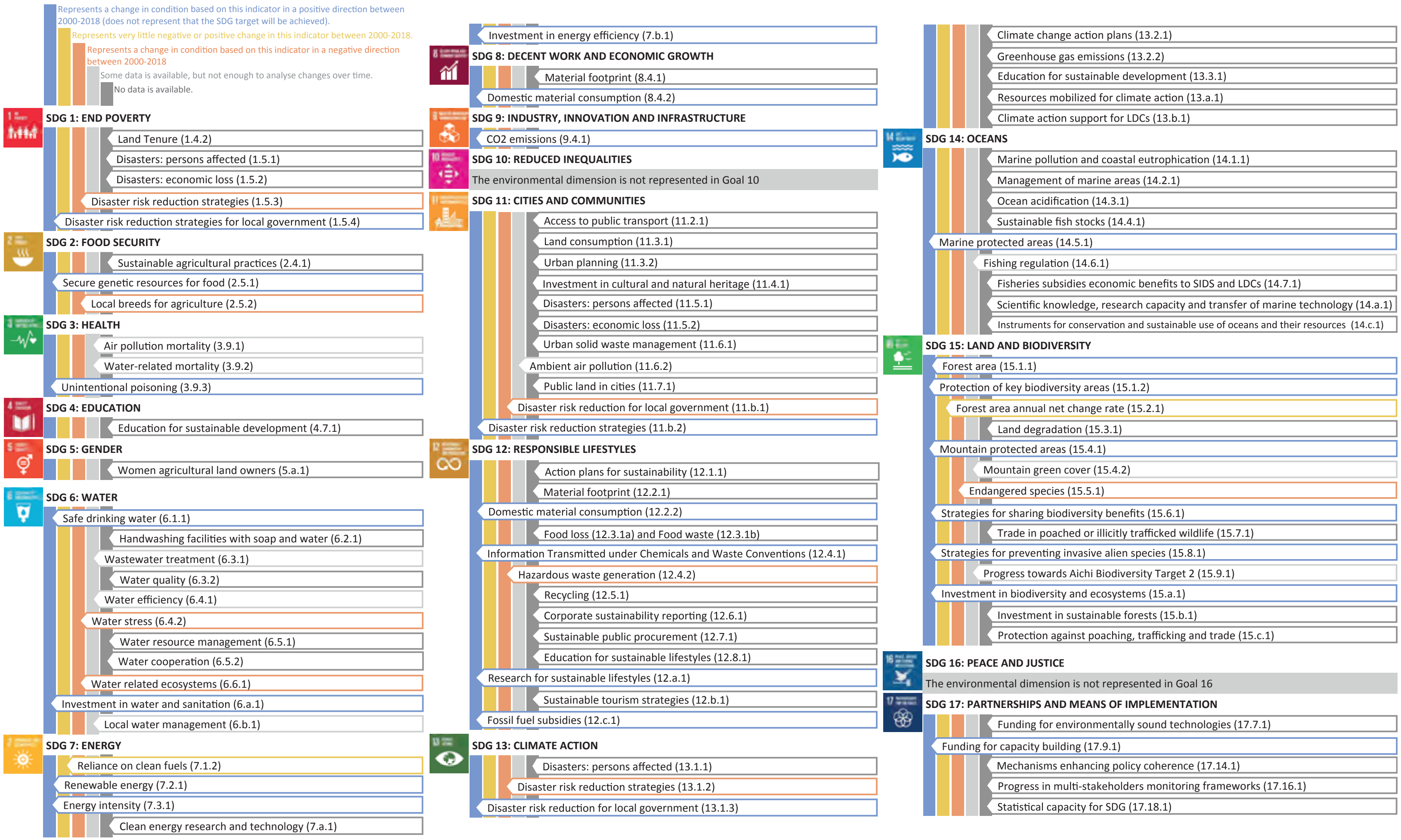
[15] Please see https://www.youtube.com/watch?v=0N4wttrs554&feature=youtu.be

2.5. Europe and Northern America: Regional progress on the environmental dimension and state of the environment indicators of the SDGs

Figure 2.5.1. Scorecard on the environmental dimension of the SDGs in Europe[16]



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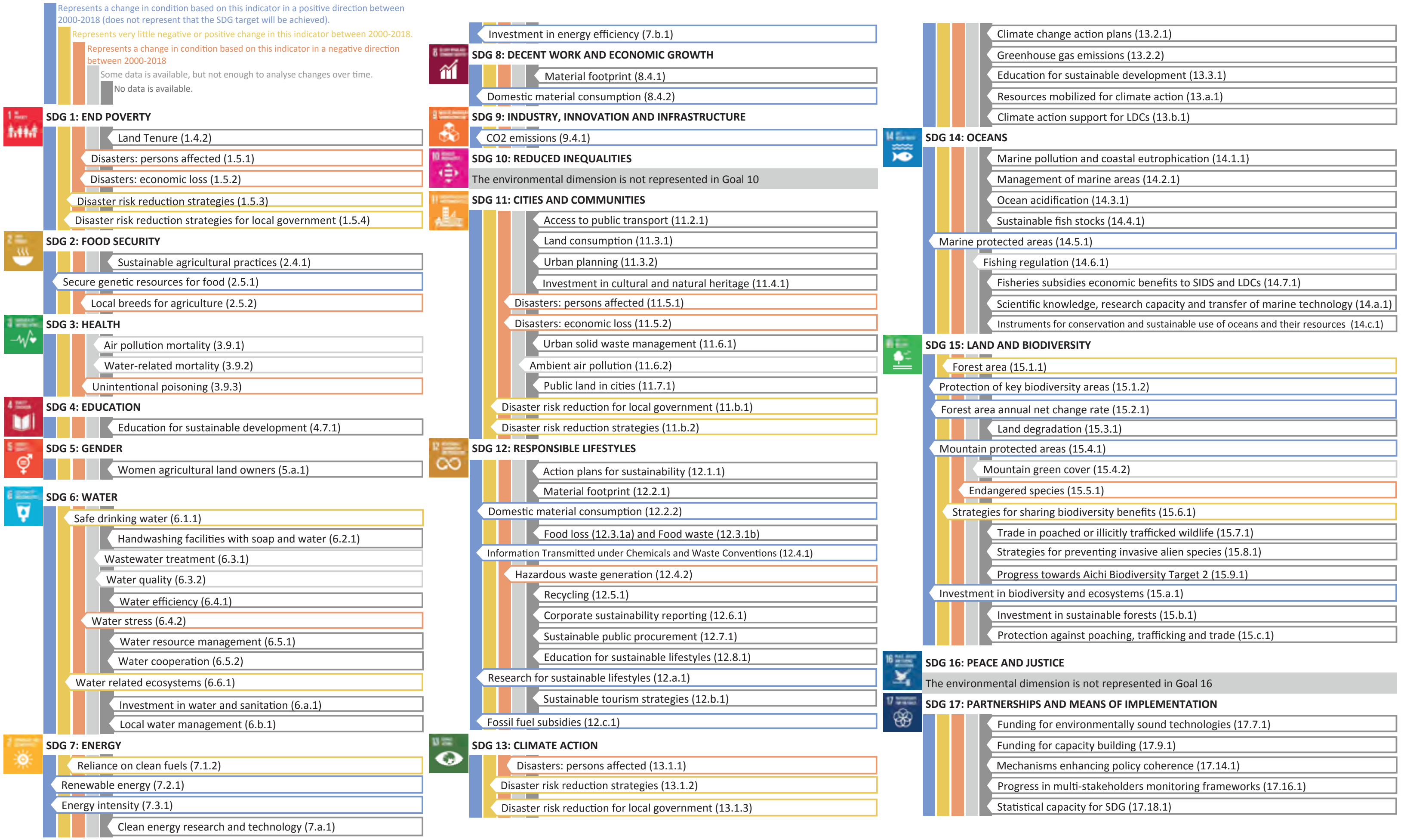
16 Includes data for Northern, Southern, Eastern and Western Europe.

Figure 2.5.2. Scorecard on the environmental dimension of the SDGs in North America



Represents a change in condition based on this indicator in a positive direction between 2000-2018 (does not represent that the SDG target will be achieved).

Represents very little negative or positive change in this indicator between 2000-2018.

Represents a change in condition based on this indicator in a negative direction between 2000-2018

Some data is available, but not enough to analyse changes over time.

No data is available.

SDG 1: END POVERTY
- Land Tenure (1.4.2)
- Disasters: persons affected (1.5.1)
- Disasters: economic loss (1.5.2)
- Disaster risk reduction strategies (1.5.3)
- Disaster risk reduction strategies for local government (1.5.4)

SDG 2: FOOD SECURITY
- Sustainable agricultural practices (2.4.1)
- Secure genetic resources for food (2.5.1)
- Local breeds for agriculture (2.5.2)

SDG 3: HEALTH
- Air pollution mortality (3.9.1)
- Water-related mortality (3.9.2)
- Unintentional poisoning (3.9.3)

SDG 4: EDUCATION
- Education for sustainable development (4.7.1)

SDG 5: GENDER
- Women agricultural land owners (5.a.1)

SDG 6: WATER
- Safe drinking water (6.1.1)
- Handwashing facilities with soap and water (6.2.1)
- Wastewater treatment (6.3.1)
- Water quality (6.3.2)
- Water efficiency (6.4.1)
- Water stress (6.4.2)
- Water resource management (6.5.1)
- Water cooperation (6.5.2)
- Water related ecosystems (6.6.1)
- Investment in water and sanitation (6.a.1)
- Local water management (6.b.1)

SDG 7: ENERGY
- Reliance on clean fuels (7.1.2)
- Renewable energy (7.2.1)
- Energy intensity (7.3.1)
- Clean energy research and technology (7.a.1)
- Investment in energy efficiency (7.b.1)

SDG 8: DECENT WORK AND ECONOMIC GROWTH
- Material footprint (8.4.1)
- Domestic material consumption (8.4.2)

SDG 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE
- CO2 emissions (9.4.1)

SDG 10: REDUCED INEQUALITIES
- The environmental dimension is not represented in Goal 10

SDG 11: CITIES AND COMMUNITIES
- Access to public transport (11.2.1)
- Land consumption (11.3.1)
- Urban planning (11.3.2)
- Investment in cultural and natural heritage (11.4.1)
- Disasters: persons affected (11.5.1)
- Disasters: economic loss (11.5.2)
- Urban solid waste management (11.6.1)
- Ambient air pollution (11.6.2)
- Public land in cities (11.7.1)
- Disaster risk reduction for local government (11.b.1)
- Disaster risk reduction strategies (11.b.2)

SDG 12: RESPONSIBLE LIFESTYLES
- Action plans for sustainability (12.1.1)
- Material footprint (12.2.1)
- Domestic material consumption (12.2.2)
- Food loss (12.3.1a) and Food waste (12.3.1b)
- Information Transmitted under Chemicals and Waste Conventions (12.4.1)
- Hazardous waste generation (12.4.2)
- Recycling (12.5.1)
- Corporate sustainability reporting (12.6.1)
- Sustainable public procurement (12.7.1)
- Education for sustainable lifestyles (12.8.1)
- Research for sustainable lifestyles (12.a.1)
- Sustainable tourism strategies (12.b.1)
- Fossil fuel subsidies (12.c.1)

SDG 13: CLIMATE ACTION
- Disasters: persons affected (13.1.1)
- Disaster risk reduction strategies (13.1.2)
- Disaster risk reduction for local government (13.1.3)
- Climate change action plans (13.2.1)
- Greenhouse gas emissions (13.2.2)
- Education for sustainable development (13.3.1)
- Resources mobilized for climate action (13.a.1)
- Climate action support for LDCs (13.b.1)

SDG 14: OCEANS
- Marine pollution and coastal eutrophication (14.1.1)
- Management of marine areas (14.2.1)
- Ocean acidification (14.3.1)
- Sustainable fish stocks (14.4.1)
- Marine protected areas (14.5.1)
- Fishing regulation (14.6.1)
- Fisheries subsidies economic benefits to SIDS and LDCs (14.7.1)
- Scientific knowledge, research capacity and transfer of marine technology (14.a.1)
- Instruments for conservation and sustainable use of oceans and their resources (14.c.1)

SDG 15: LAND AND BIODIVERSITY
- Forest area (15.1.1)
- Protection of key biodiversity areas (15.1.2)
- Forest area annual net change rate (15.2.1)
- Land degradation (15.3.1)
- Mountain protected areas (15.4.1)
- Mountain green cover (15.4.2)
- Endangered species (15.5.1)
- Strategies for sharing biodiversity benefits (15.6.1)
- Trade in poached or illicitly trafficked wildlife (15.7.1)
- Strategies for preventing invasive alien species (15.8.1)
- Progress towards Aichi Biodiversity Target 2 (15.9.1)
- Investment in biodiversity and ecosystems (15.a.1)
- Investment in sustainable forests (15.b.1)
- Protection against poaching, trafficking and trade (15.c.1)

SDG 16: PEACE AND JUSTICE
- The environmental dimension is not represented in Goal 16

SDG 17: PARTNERSHIPS AND MEANS OF IMPLEMENTATION
- Funding for environmentally sound technologies (17.7.1)
- Funding for capacity building (17.9.1)
- Mechanisms enhancing policy coherence (17.14.1)
- Progress in multi-stakeholders monitoring frameworks (17.16.1)
- Statistical capacity for SDG (17.18.1)

2.5.1. Europe introduction

Geographical groupings include Northern, Southern, Eastern and Western Europe (United Nations groupings). Sub-regional groups include the European Union (EU), South-Eastern Europe, Eastern Europe, the Caucasus, the Russian Federation and Central Asia.

There is strong momentum in the region to implement the 2030 Agenda for Sustainable Development and to monitor and report on progress. Despite this, of the 92 SDG indicators related to the environmental dimension, over half (53 per cent) do not have data (49 of the 92). Environmental indicators showing positive trends increased significantly (167 per cent more indicators), indicators with little change or negative trends decreased (23 per cent) and indicators with insufficient or no data to analyse decreased (18 per cent), in comparison with data from the first Measuring Progress report (UNEP 2019a). At the goal level, the least data available for the region is for clean water and sanitation (SDG 6), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), climate action (SDG 13), life below water (SDG 14) and partnerships for the goals (SDG 17).

According to Eurostat's statistical overview on the progress towards meeting the SDGs for EU-27 countries[17], moderate progress is being made in achieving goals on sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12) as well as partnerships for the goals (SDG 17). On the other hand, no change or negative change is observed for climate action (SDG 13), and the statistical overview indicates insufficient time series data to report on clean water and sanitation (SDG 6) and life below water (SDG 14) (Eurostat 2020).

2.5.2. Statistical availability

In Europe, two state of the environment indicators show a positive trend. Data show a slight increase in the proportion of forest area (SDG indicator 15.5.1) for the entirety of Europe (1 per cent), with a significant increase in Southern Europe (8 per cent) and Western Europe (6 per cent) between 2000 and 2017. In addition, the above-ground biomass stock and forest area net annual change rate (SDG sub-indicators of 15.2.1) have increased for all sub-regions.

Three state of the environment indicators related to water ecosystems and species show negative trends. The available data for local breeds classified as being at risk as a share of local breeds with known level of extinction (SDG indicator 2.5.2) show an increased trend between 2000 and 2019, except for in seven countries. Moreover, the Red List Index (SDG indicator 15.5.1) shows a significant 7 per cent decline across the whole region between 2000 and 2020. As for water ecosystems, the proportion of water body extent (permanent and maybe permanent) (SDG indicator 6.6.1) shows a decrease between 2000 and 2018 for the European region as a whole, except for Northern and Western Europe.

Four indicators have no sufficient data to analyse their trend, namely water quality (SDG indicator 6.3.2), air pollution (SDG indicator 11.6.2), land degradation (SDG indicator 15.3.1) and mountain greening (SDG indicator 15.4.2).

2.5.3. Progress and gaps

In order to strengthen capacities with regards to data collection, statistical tabulation and measuring environmental SDG indicators' progress in countries in Eastern European, Caucasus and Central Asia (EECCA), UNEP has been collaborating with the United Nations Economic Commission for Europe (UNECE) in the planning and organization of regional networking and capacity-building events on environmental data and information-sharing, and on in-country capacity-building on all environmental statistics for the SDGs. In addition, UNEP has implemented, where relevant, partnership activities with United Nations Development Programme (UNDP) Country Offices, UNECE and ESCAP, as well as other SDG custodian agencies, namely, UN-Habitat, FAO and International Union for Conservation of Nature (IUCN). These training activities targeted national statistical offices (NSOs) and line agencies with responsibilities in environmental monitoring and data collection and contributed to the development of enhanced coordination, collaboration and exchange of best practices within and between EECCA countries. This increased collaboration and exchange of best practices benefited from the mainstreaming of common approaches for monitoring regionally agreed environmental indicators and especially the Shared Environmental Information System principles of open access to data, as well as international methodologies for reporting on environmental SDG indicators.

Nevertheless, more capacity-building is needed to continue supporting countries in the region, particularly countries from EECCA, as they establish and continue developing their national SDG indicator frameworks and start reporting on state of the environment indicators, including the 12 SDG indicators that are the focus of this analysis.

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[17] The EU SDG indicators are based on a set of 100 indicators, looking at aspects of the SDGs that are relevant from an EU perspective. Two-thirds of the EU SDG indicators are aligned with the global indicator framework for the Sustainable Development Goals.

2.5.4. Regional initiatives

The UNECE Statistical Division, in its capacity of supporting the monitoring of progress towards SDGs and their targets in the region, coordinates regional reporting through developing a road map for setting up SDG reporting in the UNECE region, provides guidance on measuring sustainable development, and enhances national capacities for reporting on SDGs. In addition, several task forces and/or expert groups have been established by UNECE to guide the development and follow-up of the road map on statistics for the SDGs (Conference of European Statisticians (CES) Steering Group on Statistics for Sustainable Development Goals) and to explore specific thematic areas in more depth.

In particular, the UNECE Joint Task Force on Environmental Statistics and Indicators (UNECE JTFESI)[18] supports efforts by countries from EECCA to produce environmental indicators and implement Shared Environmental Information System principles of open access to data and the SEEA, in collaboration with UNSD, UNEP and the European Environment Agency (EEA). The UNECE JTFESI also promotes the development of environmental statistics and an increase in data availability for measuring environment-related SDGs.

2.5.5. North America introduction

As North America comprises 12.2 per cent of the world's landmass, 368.7 million people and 16.6 per cent of global carbon emissions, advancing the SDG framework in this region is critical to achieving the 2030 Agenda for Sustainable Development. Indeed, both Canada and the United States of America advocated strongly for the SDGs and have ensured that their supporting architecture of targets and indicators are ambitious, measurable and action-oriented. Yet, with less than 10 years to go, progress has been inadequate, especially in the face of growing polarization of environmental issues in the region. Furthermore, environmental justice in both countries continues to be a shortcoming and a priority. Despite important gains, many indicators are stagnating or have insufficient and/or no data to measure change, whereas indicators related to biodiversity and disaster risk management are regressing.

North America continues to have significant shortfalls in data and reporting. In comparison with data from the first Measuring Progress report, there was an improvement in environmental indicators with positive trends (67 per cent more indicators) and insufficient or no data indicators (22 per cent fewer indicators). However, more environmental indicators showed little change or negative trends (75 per cent more), based on data from the Global SDG Indicators Database (UNEP 2019a). In the United States of America, data are reported through the national reporting platform,[19] yet only five (20 per cent) of the 25 indicators for which UNEP is the custodian agency have been reported. None of these indicators have been updated in three years. Indicators marked as 'in progress' have decreased from 14 to one (4 per cent) and 19 of the remaining 25 (76 per cent) are marked as 'exploring data sources'. Inconsistencies in reporting methodologies pose a challenge. For example, the United States of America monitors indicator 6.3.2 (water quality), but variations in methodologies make global comparison difficult. The United States Environmental Protection Agency (US EPA) and the United Nations are collaborating to address this challenge, with updated guidance on reporting on the SDGs expected to be released in 2021.

Canada has made some progress on SDG reporting since the 2019 Measuring Progress report. Of the 25 UNEP custodian environmental SDG indicators, five indicators (20 per cent) are reported, and 11 (44 per cent) are 'under-development', while the remaining nine (36 per cent) are marked as 'exploring data sources'.[20] Though SDG reporting is sporadic, Canada continues to update its environmental indicators on air, water, climate and wildlife through Statistics Canada and the national statistics office.

The year 2020 was marked by unprecedented periods of political, social and economic change. Flooding, hurricanes and extreme weather events, including one of the worst fire seasons on record in California, disrupted communities and livelihoods all over the continent. The global COVID-19 pandemic plunged the region into a recession, with Canada implementing its largest economic relief package since World War II (Freeland 2020). Despite economic, social and political disruptions, many in North America have realized that there is an opportunity for the recovery from the COVID-19 pandemic to bring transformative change towards a more sustainable society.

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[18] Please see https://www.unece.org/environmental-policy/environmental-monitoring-and-assessment/about-us/joint-task-force-on-environmental-statistics-and-indicators.html

[19] Data presented here are based on national SDG data, taken from https://sdg.data.gov/.

[20] Data presented here are based on national SDG data, taken from Statistics Canada.

2.5.6. Statistical availability

Based on the Global SDG Indicators Database, North America shows a 1 per cent increase in forest area (SDG indicator 15.1.1) between 2000 and 2017 and a 3 per cent increase in above-ground biomass stock (SDG sub-indicator of 15.2.1) between 2000 and 2020. Additionally, Canada continues to record low rates of deforestation due to increased efforts in sustainable forestry management. It lost only 0.5 per cent of total forest area between 1990 and 2017 and, through long-term management plans, has increased forest area by 8.14 per cent (SDG sub-indicator of 15.2.1), in 2019 (Natural Resources Canada 2020).

Aside from forests, a trend reversal is needed for three other indicators: local livestock breeds classified as being at risk (SDG indicator 2.5.2), water body extent (SDG indicator 6.6.1) and species at risk (SDG indicator 15.5.1). The decline in the proportion of local breeds classified as being at risk (SDG indicator 2.5.2) is particularly concerning, with 92 per cent identified as being in decline. Based on national data, Canada has seen a significant decline, going from 77 per cent in 2016 to 92 per cent in 2020. In the United States of America, the number is similarly high at 90 per cent in 2019.

The Global SDG Indicators Database indicates that two environment-related indicators have a single data point available: Mountain Green Cover Index (SDG indicator 15.4.2) and annual mean levels of fine particulate matter (SDG indicator 11.6.2). The fine particulate matter concentration, however, complies with the WHO Air Quality Guidelines. Aggregates that show improvements in national air quality do not, however, highlight regional variations. In the United States of America, approximately 150 million people are exposed to pollution that is above regulatory thresholds and deemed harmful to public health. This is especially the case in low-income communities and communities of colour who are at greater risk (American Lung Association 2020). In Canada, indigenous communities continue to be disproportionately affected by toxic exposure and polluted environments (Human Rights Council 2020).

2.5.7. Progress and gaps

North America has recognized the importance of nature to achieving the SDGs, with a commitment to 15.1.1 and 15.2.1. In its 2018–2022 Strategic Plan, the United States Department of Agriculture (USDA) committed to strengthening the stewardship of private lands through technology and research, and to fostering the productive and sustainable use of the national forest system (United States Department of Agriculture 2018). In relation to SDG indicator 12.3.1, no data sources are reported, but the United States of America has created an inter-agency strategy (USDA, US EPA and U.S. Food and Drug Administration) to address the issue of food loss and waste in order to achieve the national goal of a 50 per cent reduction by 2030 (United States Environmental Protection Agency [US EPA] n.d.). Much of the progress happening in the United States of America is driven by local governments such as New York City's OneNYC that localizes the SDGs and utilizes a Voluntary Local Review (modelled on VNRs) (OneNYC 2050 n.d.) and New Jersey's ban on all plastic bags and polystyrene containers to reduce the presence of single-use plastics. In addition, the Sustainable Development Solutions Network's USA branch launched the Zero Carbon Action Plan as a road map and set of policy recommendations for the United States of America to achieve net-zero emissions by 2050 (Sustainable Development Solutions Network n.d.).

With one-fifth of the world's fresh water and the longest coastline in the world, Canada joined 30 other countries in July 2020 in the Global Ocean Alliance. They collectively pledged to conserve at least 30 per cent of the world's oceans by establishing marine protected areas. Working towards SDG 15 (life on land), Canada also joined the High Ambition Coalition, which advocates to conserve 30 per cent of the world's lands by 2030. The country has committed CAD 3 billion to the Natural Climate Solutions Fund for planting trees and supporting other forest, wetland and farmland management projects related to carbon sequestration. Despite insufficient reporting on SDG indicators 15.1.1, 15.2.1 and 15.3.1, these commitments signal an ambitious agenda for Canada to protect and preserve nature.

The advancements to address the SDGs in North America are commendable, but continued shortfalls in official reporting and agreed-upon methodologies make assessing progress difficult. Some progress has been made on methodological approaches to data collection with the development of all Tier III indicators methodologies within the SDG framework in 2020.

2.5.8. Regional initiatives

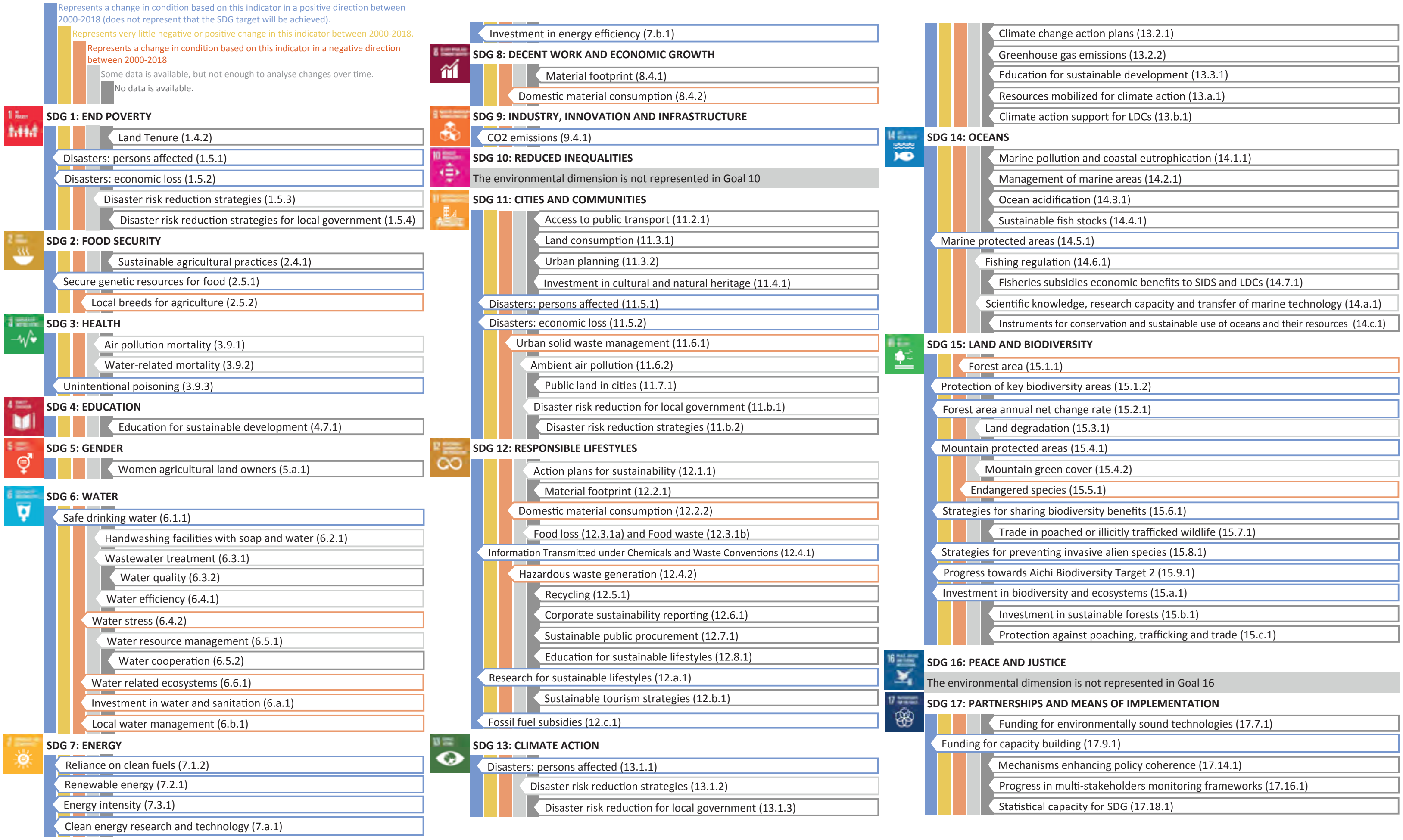
The SDGs are framed as national goals, but with federalist countries as diverse – economically, geographically and jurisdictionally – as the United States of America and Canada, applying the SDG framework consistently is a challenge. Monitoring, reporting and implementation have produced complex results and there is evidently crucial work that remains to be done before 2030. Relative gains have been made on SDG 6 (clean water), SDG 12 (responsible consumption and production), and SDG 15 (life on land), but SDG 14 (life below water) and SDG 17 (partnerships and means of implementation) are either stagnating or regressing. Reporting and monitoring efforts for all SDGs require significant improvement.

As Canada and the United States of America continue to develop COVID-19 pandemic recovery plans, 2021 offers a unique opportunity to address shortcomings and make significant advancements towards the global SDGs. Canada's federal government is aiming to 'build back better', with a green economy as a cornerstone of their COVID-19 recovery plan (Government of Canada 2020). With the United States of America having now re-joined the Paris Agreement, the new Administration is sponsoring a stimulus plan that invests in clean energy and has committed to a science-based agenda for a more sustainable, equitable society. These national commitments will also require that both Governments improve in leveraging local and grass-roots political will to meet the breadth and pace of action that the science demands. Moreover, there is growing recognition in the region that private-sector adaptation finance and nature-based solutions need to be scaled up considerably if the SDGs targets are to be met.

Reviewing progress to date, there is palpable renewed optimism in 2021 that concrete progress will be made in achieving the SDGs. In fact, through a year characterized by appreciation for being outdoors, support for protecting nature has grown throughout North America. In 2020, the Canadian Government sponsored the Nature-Based Climate Solutions Summit in February and co-hosted a round table on Canada's Action on Nature-Based Solutions for Climate Adaptation in December, while allocating nearly CAD 4 billion in funding over the next decade. In the U.S, local governments and coalitions are also committing to nature-based solutions, particularly for the benefits of enhancing coastal management and reducing disaster risk at a reasonable cost.

2.6. Latin America and the Caribbean: Regional progress on the environmental dimension and state of the environment indicators of the SDGs

Figure 2.6.1. Scorecard on the environmental dimension of the SDGs in Latin America and the Caribbean



2.6.1. Latin America and the Caribbean introduction

The Latin American and the Caribbean (LAC) region is a mosaic of nations that exhibit strong social, political and economic heterogeneity, anchored not only in historical and cultural factors, but also in their biogeographical diversity. Therefore, regional strategies to reconcile economic growth, reduction of inequalities and the environmental dimension of the SDGs are strongly related to the capacity of governments to generate policies that respond to these challenges.

Countries in the region show great economic and social disparities, but with a common denominator of heavily relying on natural resources extraction. This puts monitoring and reporting on the environmental dimension of the SDGs at the forefront of sustaining the political process towards sustainable development. This transition towards the sustainable growth models pursued as part of the 2030 Agenda for Sustainable Development requires the establishment of a robust framework of open, disaggregated and scientifically sound environmental data and information capable of addressing in depth the priority issues for the region.

The region has shown improvement in environmental indicators: 63 per cent more indicators followed positive trends, 15 per cent fewer indicators showed little change or negative trends and 14 per cent fewer indicators had insufficient or no data, compared with data from the first Measuring Progress report (UNEP 2019a). However, the analysis of the 92 environmental indicators reveals a scenario characterized by unequal institutional and statistical capacities among countries, data gaps in key areas and topics, and a general lack of solid baselines and consistent data series, making it difficult to identify trends. Forty-two per cent of the environmental indicators had no data, 28 per cent showed a positive change trend and seven per cent of the indicators had some data but not enough for analysis. Regional analysis of indicators indicates that clean water and sanitation (SDG 6), affordable and clean energy (SDG 7) and life on land (SDG 15) had the most data, with all environmental indicators within SDG 7 showing a positive trend. On the other hand, climate action (SDG 13), life below water (SDG 14) and partnerships for the goals (SDG 17) had the least available data to measure the status or progress.

2.6.2. Statistical availability

As for the availability of the state of the environment indicators, SDG 15 on life on land (which includes five out of the 12 state of the environment indicators) represents by far the best represented set of indicators, with the greatest spatial and temporal coverage. Although forest areas (SDG indicator 15.1.1) have shown an overall decrease of almost 10 per cent across the region since 1990, this regional aggregate masks a noteworthy area of success – in the Caribbean, the extent of forested area has increased by more than 40 per cent over the 1990 baseline. In addition, above-ground biomass stock (SDG sub-indicator of 15.2.1) indicates a positive trend for the entire region, while the Red List Index followed a 4 per cent downward trend between 2000 and 2020.

In LAC, there is an increase in the proportion of local breeds classified as being at risk (SDG indicator 2.5.2), except for in Central America where a decrease in the proportion is measured. In relation to water ecosystems, the extent of body of water (SDG indicator 6.6.1) – with data largely based on remote-sensing data and estimates – shows a decrease for the LAC region, except for Central America. Meanwhile, the proportion of bodies of water with good ambient water quality (SDG indicator 6.3.2) indicates a value for 2017 of above 50 per cent for the Federative Republic of Brazil, the Republic of Chile and Jamaica, and below 50 per cent for the Republic of El Salvador and the Republic of Peru. In addition, air pollution (SDG indicator 11.6.2), degraded land (SDG indicator 15.3.1) and Mountain Green Cover Index (SDG indicator 15.4.2) have only one data point.

2.6.3. Progress and gaps

Several analyses carried out recently by various scientific institutions in LAC agree that the gaps between countries and the region's own weaknesses can be narrowed if the appropriate strategies are implemented and all stakeholders are involved. These include institutional and regulatory aspects related to the costs and institutional efforts required for sustained data production and curation, and technical aspects in terms of capacity-building in agencies linked to information capture, processing, analysis and management, where some budgetary considerations and access to financing are essential.

In this sense, the region has recently been very active in joining a growing number of international agreements and commitments, which have resulted in substantial but uneven improvement in many countries. Thus, the 2030 Agenda for Sustainable Development has become an excellent guiding and monitoring framework for national progress on the path to sustainable development for LAC.

2.6.4. Regional initiatives

Despite its substantial weaknesses in statistical and data capacities, the region has made significant progress in recent years through institutional and political efforts to strengthen and systematize its regional, sub-regional and national information systems. This is evident in some countries that are leading important initiatives in the field of information generation and, notably, in their promising use of a variety of sources such as administrative records and geospatial data (for example from remote sensing) to develop official statistics.

2.7. Northern Africa and Western Asia: Regional progress on the environmental dimension and state of the environment indicators of the SDGs

Figure 2.7.1. Scorecard on the environmental dimension of the SDGs in Northern Africa

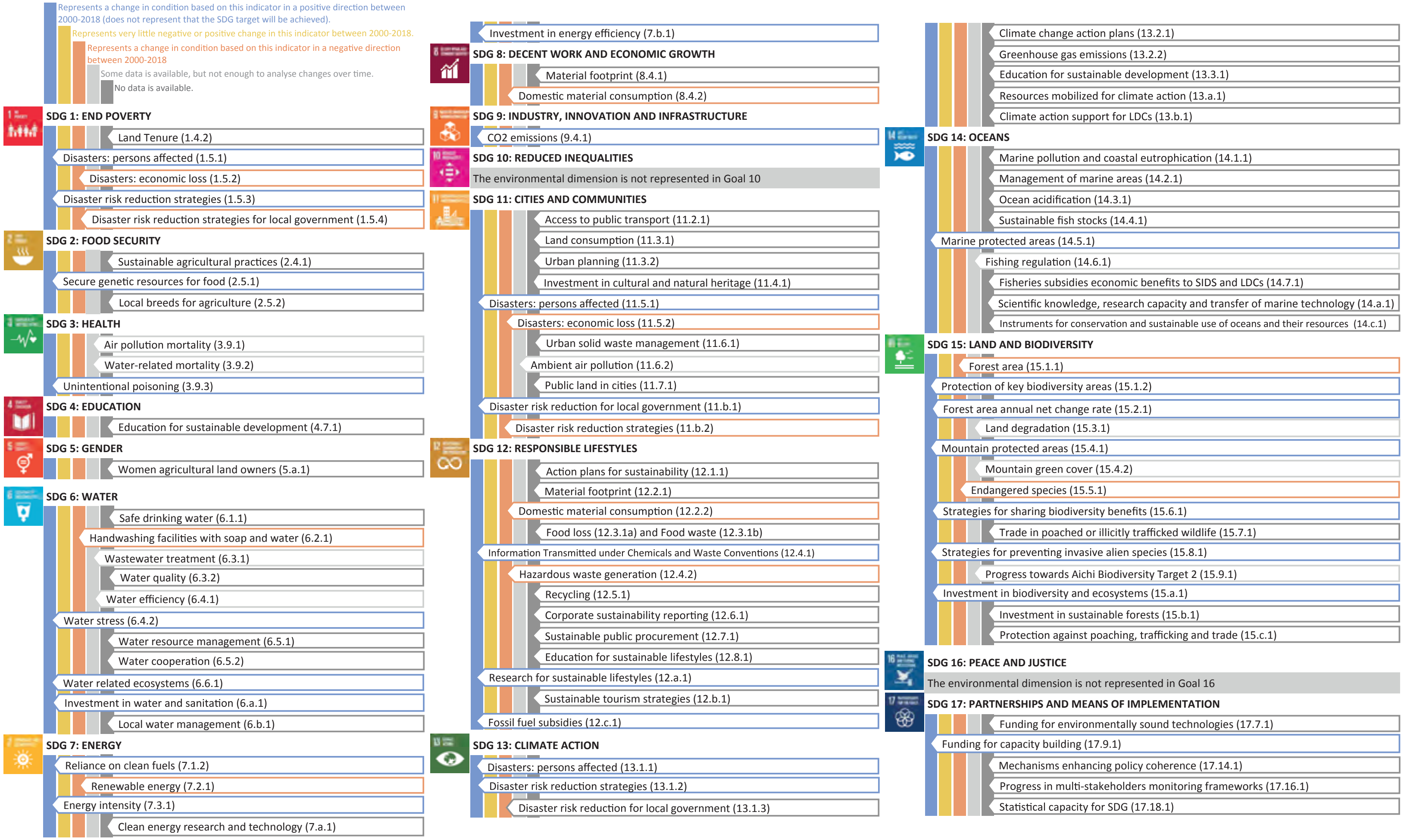
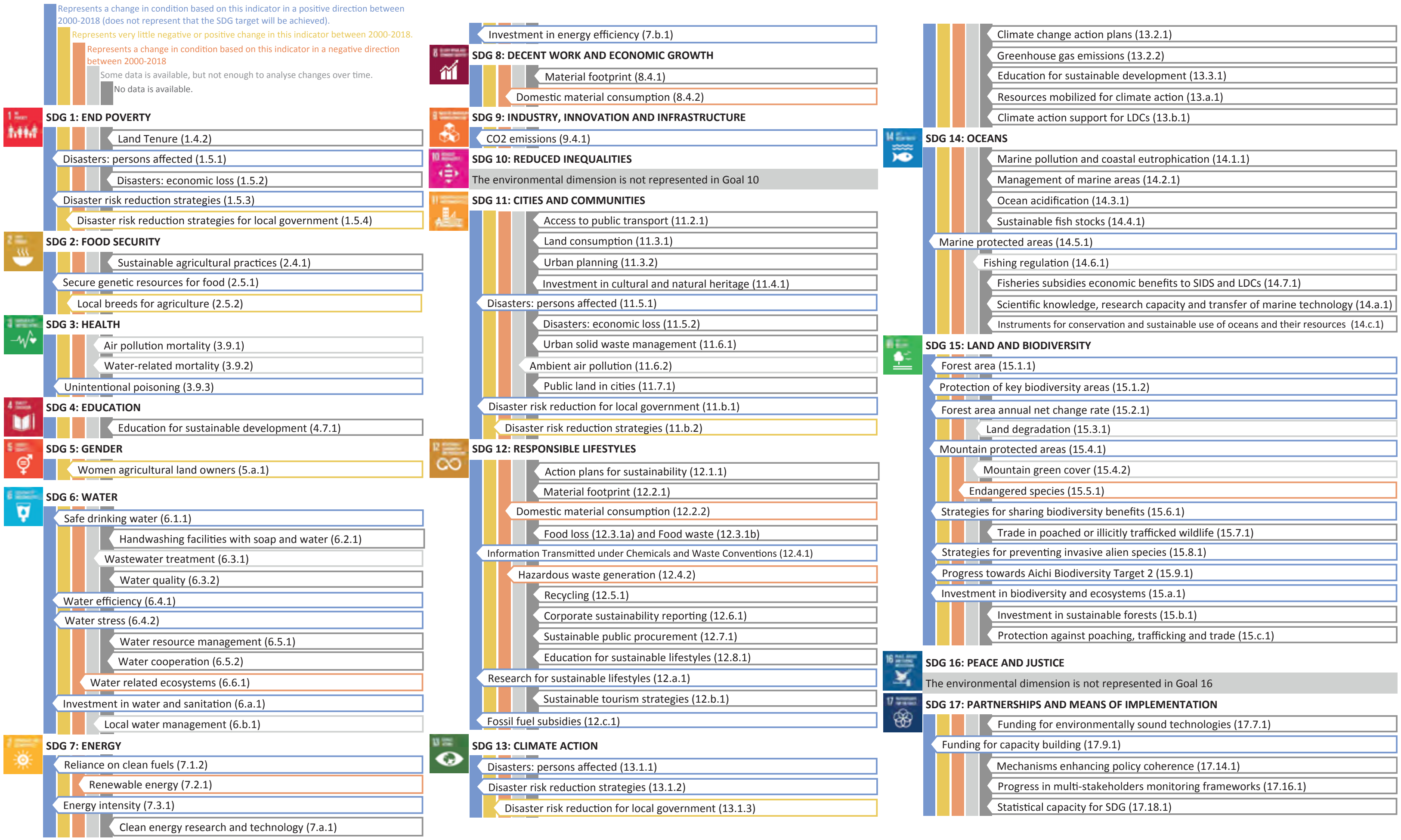


Figure 2.7.2. Scorecard on the environmental dimension of the SDGs in Western Asia



2.7.1. Northern Africa and Western Asia introduction

The SDG performance of countries in Western Asia varies greatly. Conflicts in some countries lead to poor and declining performance on most SDGs, particularly on food security (SDG 2), health (SDG 3) and peace and justice (SDG 16). Three countries from the region (Republic of the Sudan, Syrian Arab Republic and Republic of Yemen) are among the bottom 50 countries on the SDGs dashboard in 2020 (Sachs *et al.* 2020). Countries less affected by conflicts perform best on ending poverty (SDG 1) and partnerships and means of implementation (SDG 17). The region still faces major challenges in accomplishing most of the SDGs. When considering the environmental dimensions of the SDGs, most countries are facing three main issues: difficulties around agriculture and sustainable land use (such as poor nitrogen management), a struggle to ensure the transition towards more circular and green economies, and high CO_2 emissions related to fossil-fuel exports.

In comparison with data from the first Measuring Progress report, the region has shown an increase in environmental indicators with positive trends (123 per cent in Western Asia and 189 per cent in Northern Africa), a decrease in indicators with insufficient or no data (24 per cent in Western Asia and 25 per cent in Northern Africa) and an 8 per cent decrease in Western Asia for indicators with little change or a negative trend, while Northern Africa had no change (UNEP 2019a). Over 50 per cent of environmental indicators lack data in the region: more specifically, cities and communities (SDG 11), responsible consumption and production (SDG 12) and life below water (SDG 14) have the least available environmental data, while ending poverty (SDG 1), clean water and sanitation (SDG 6) and life on land (SDG 15) have the most environmental data.

2.7.2. Statistical availability

At the regional level, there are three indicators across the region that do not have data – marine pollution (SDG indicator 14.1.1), ocean acidification (SDG indicator 14.3.1) and fish stocks (SDG indicator 14.4.1) – while two indicators have national data only – local breeds (SDG indicator 2.5.2) and proportion of bodies of water with good ambient water quality (SDG indicator 6.3.2). Statistics also show four indicators having time series data for the region since 2000, namely: water ecosystems (SDG indicator 6.6.1), with a positive change for the region yet negative trend for Western Asia; and proportion of forest area (SDG indicator 15.1.1), indicating a negative change for the region except Western Asia with an 11 per cent increase between 2000 and 2017. A negative trend is highlighted for Northern Africa for forest area annual net change rate and above-ground biomass stock, while Western Asia indicates a positive trend for the same indicators (SDG sub-indicators of 15.2.1). However, the overall trend of the Red List Index (SDG indicator 15.5.1) shows a consistent decline, meaning that more species are at risk from extinction across the region. Statistics for the remaining indicators show data for one specific year only, which hinders analysis of the change over time, namely air pollution (SDG indicator 11.6.2), degraded land (SDG indicator 15.3.1) and Mountain Green Cover Index (SDG indicator 15.4.2).

2.7.3. Progress and gaps

At present, the protracted conflicts, economic marginalization and increased stress on the environment and economy in the region are all endangering the progress of sustainable development. As such, addressing climate change is particularly critical to successfully implementing sustainable development in Western Asia, as several pertinent climate hazards faced by this region underline the interconnected nature of sustainable development. Impacts of climate change are expected to be felt in water resources, agriculture, biodiversity, public health and coastal development across Western Asia. Additionally, the economic, social and environmental impacts and costs resulting from climate-related extreme events such as heatwaves, floods, cyclones, droughts and sand and dust storms are already evident in the region. Indeed, under business-as-usual conditions, it is expected that unsustainable development will continue, accompanied by exponential population growth that exceeds the environment's carrying capacity. Already, uncontrolled human consumption in the region has led to an increase in municipal solid waste production, 90 per cent of which is disposed of in unlined landfill sites, with leachate from these posing a potential risk to groundwater quality. The pursuit of SDG target 12.4 is generally hampered by technical, administrative and financial shortcomings in some countries.

In terms of positive progress, the region has witnessed remarkable developments in access to infrastructure, primarily covering water and sanitation and affordable and clean energy. However, the measured environmental indicators are limited due to a lack of technical and financial assistance, which limits clear interpretation of the impact of these developments on the region's environment.

2.7.4. Regional initiatives

In order to advance the availability of state of the environment indicators, the UNEP West Asia Office is currently implementing a number of initiatives at both the regional and national levels, through its collaboration with the League of Arab States and the United Nations Economic and Social Commission for Western Asia (ESCWA) that began in 2008 to support regional work on sustainable consumption and production (SCP). This has included showcasing best practices, reviewing progress and exchanging views on the needs and priorities of the region in order to promote a shift towards SCP. It has supported implementation of the 10 Year Framework of Programmes on Sustainable Consumption and Production Patterns (10YFP) adopted at Rio+20 in 2012 and is also aligned with the 2030 Agenda for Sustainable Development and the SDGs. A key objective of this work is to encourage the utilization of approaches, tools and policies that contribute towards protecting the environment and conserving water and energy and other natural resources, while contributing to poverty eradication and responsible lifestyles. In addition to regional initiatives, national technical support is provided to countries to build their capacities in environmental statistics and data management.

At the Gulf Cooperation Council (GCC) sub-regional level, an initiative to develop the GCC Environment Outlook in 2021 represents the baseline information and assesses data availability. Efforts are being made to fill in the data gaps in close collaboration with the GCC-Stat.

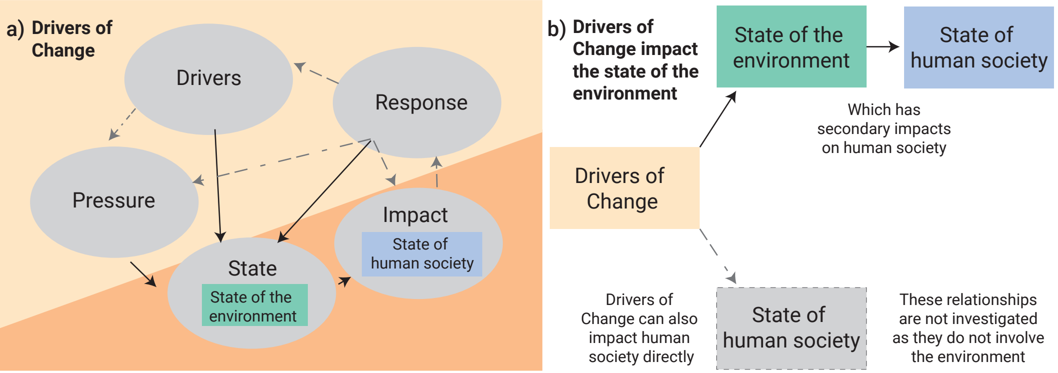
Chapter 3: Methodology

3.1. Theory of change

To define the scope of the actions that are included in this analysis, this report adopts the concept of 'drivers of change'. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) describes this concept as "all those external factors that affect (either positively or negatively) nature, anthropogenic assets, nature's contributions to people and good quality of life. They include institutions and governance systems and other indirect drivers, and direct drivers (both natural and anthropogenic)" (IPBES 2019b). The IPBES concept of 'drivers of change' sits within a wider causal framework for describing the interactions between society and the environment called the DPSIR (driver, pressure, state, impact and response) framework, which the UNEP has used as the theoretical framework for its work on integrated environmental assessments (UNEP 2017; 2019) (Figure 3.1.1). This broad definition was adopted in order to include a wide range of actions that impact the environment.

Drivers of change relate to the drivers, response and pressure components of the DPSIR framework. Drivers of change that tend to impact the environment negatively, such as current patterns of economic development, inequalities in access to resources and institutional power and tourism, are typically associated with the driver and pressure components of the framework, whereas drivers of change that tend to impact the environment positively, such as protection and sustainable environmental management policies, are typically associated with its response component. The state of the environment is associated with the state component of the framework and is linked directly to the response component and indirectly to the drivers component via the pressure component. The state of society is associated with the impact component of the framework and is impacted directly by the state component. Several relationships in the DPSIR framework are not investigated in this work, such as the direct link between the response and impact components of the framework as illustrated in Figure 3.1.1.

Figure 3.1.1. Concept of drivers of change and relationships between drivers of change, the state of the environment and the state of society

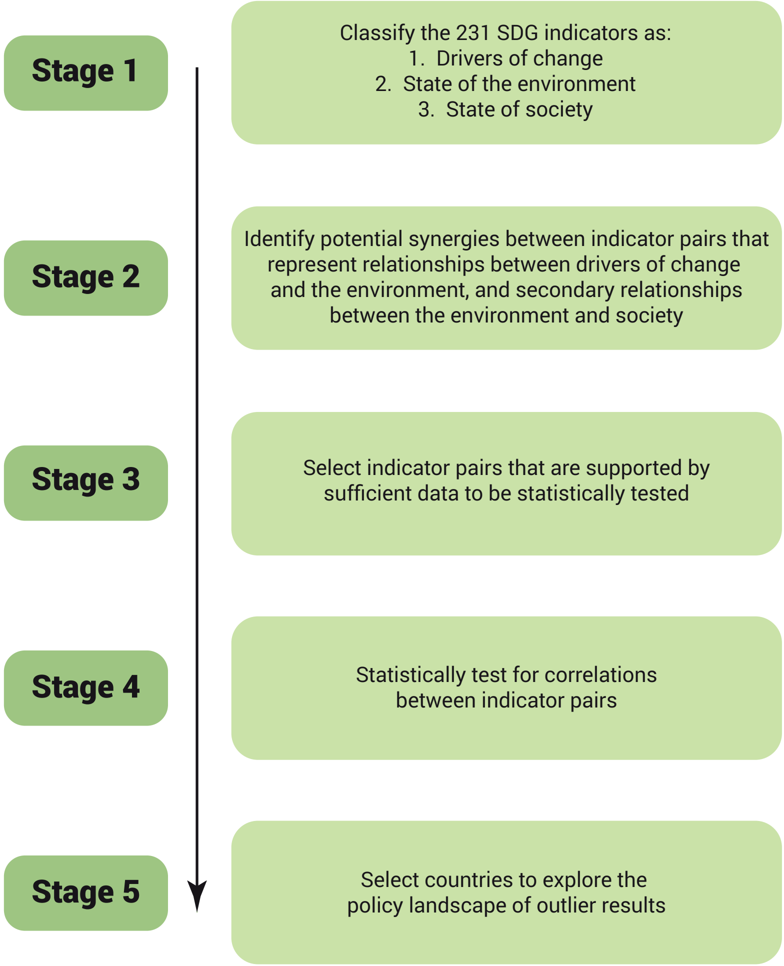


Notes: a) Represents how the concept of 'drivers of change' and the relationships investigated here relate to the DPSIR framework; and b) represents the relationships between drivers of change, the state of the environment and the state of society that are investigated in this work. Relationships that are investigated in this work are indicated with complete arrows. Dashed arrows indicate relationships that are not investigated here.

3.2. Analytical approach

A data-driven approach is taken, whereby the relationship between the indicators of the Sustainable Development Goal (SDG) framework and their underlying data is used to identify topics to explore in the report. The analytical approach that relies on identifying possible synergies between pairs of indicators and investigating their correlation is broken into five stages (Figure 3.2.1).

Figure 3.2.1. Overview of the five stages of the analytical approach



The first stage is based on classifying the 231 unique indicators of the SDG framework as drivers of change, state of the environment or state of society. Stage 2 identifies potential synergies between pairs of indicators to investigate the relationship between direct drivers of change and the state of the environment, and secondary relationships between the state of the environment and the state of society. Stage 3 selects the indicators to investigate based on the availability of their underlying data, while Stage 4 consists of performing the correlation analysis between the pairs of indicators. The last stage identifies the positive outlier countries that appear to be translating actions into environmental improvements. Each stage of the analytical approach is described in detail below.

A number of assessments of interactions between the SDGs already exist (Scharlemann et al. 2020; Breuer, Janetschek, and Malerba 2019). To date, such assessments have mainly focused on interactions at the goal (Breuer, Janetschek, and Malerba 2019) or target level (Nerini et al. 2018) , or on specific goals or targets (International Council for Science [ICSU] 2017), actors (Price Waterhouse Cooper 2016) or countries (Weitz et al. 2019), and have used a range of quantitative and qualitative methods. To date, only a single study (Pradhan et al. 2017) has investigated SDG interactions at the indicator level and considered the entire SDG monitoring framework across all countries. Pradhan et al. (2017) used Spearman's rank correlation to assess correlations between pairs of SDG indicators for all indicators and countries where time series data were available.

The work presented here advances on the study in two important ways. Firstly, rather than investigating all possible combinations of indicators, this report takes an evidence-based approach to identify pairs of indicators for which there is evidence of a relationship between indicators. This evidence-based approach provides hypotheses for investigating indicator pairs which justifies their investigation and aids interpretation of results. Secondly, in practice the links between indicators are context-specific and depend on a number of factors, such as geography, demographics or the socioeconomic situation (Breuer, Janetschek, and Malerba 2019). A modelling framework is used here to investigate the correlation between indicator pairs while controlling for potentially confounding factors, including the population, gross domestic product (GDP) and geographic region of each country included in the analysis.

3.2.1. Stage 1: Classifying SDG indicators

The 231 unique SDG indicators are classified into one of three groups. For brevity, a system of abbreviations is adopted for naming the SDG indicators.

Group 1: Drivers of change

One hundred and two SDG indicators from 15 goals are related to drivers of change that impact the environment, as detailed in the IPBES Global Assessment (Merino *et al.* 2018). Some drivers of change may have a positive impact on the environment, such as protection of key biodiversity areas (response). Other drivers of change are likely to have a negative impact on the environment, such as current patterns of economic development (driver). Note that there is an overlap in terms of the drivers of change and the state of society (for example GDP per capita is a driver of change and also a state indicator). The drivers of change include indicators considered as direct drivers and indirect drivers. In this report, only direct drivers of change were included in the statistical analysis, given the availability of underlying data.

Group 2: State of the environment

There are 12 SDG indicators, from five goals, that relate to the state of the environment. These indicators measure ecosystem health and environmental conditions (including pollution). They include indicators related to the availability and quality of water resources, marine ecosystems, green land cover and degradation, extinction risk of species and air quality.

Group 3: State of society

There are 66 SDG indicators, from 13 goals, related to the state of society. These indicators cover a range of issues such as poverty, health, and social inequality.

Some of the 231 SDG indicators are not relevant to any of the above three groups and thus are excluded from further consideration.

3.2.2. Stage 2: Identifying potential synergies between indicator pairs

Scientific evidence and expert consultation were used to identify potential synergies between indicator pairs. The IPBES Global Assessment provides a global review of the scientific evidence for the primary environmental and secondary social effects of drivers of change, which encompass the driver, pressure and response components of the DPSIR framework (Figure 3.1.1). Using this evidence base, potential synergies were identified between pairs of SDG indicators and their sub-indicators to investigate the relationship between direct drivers of change and the state of the environment, and secondary relationships between the environment and the state of society. In addition, consultation with the Expert Group on Measuring Progress: Nature and the SDGs[21] supplemented the identification of possible synergies through an online meeting followed by an online survey. In total, 2,118 potential synergies were identified between SDG indicators and their underlying sub-indicators: 1,581 synergies between indicators related to direct drivers of change and the state of the environment, and 537 synergies between indicators related to the secondary relationships between the environment and the state of society.

The identification of synergies was limited to considering one-way relationships between direct drivers of change and the state of the environment, and between the state of the environment and the state of society. The Stockholm Environment Institute takes a different approach to identifying synergies between SDG indicators at multiple scales by using network analysis and expert solicitation to consider two-way relationships between SDG indicators (Weitz *et al.* 2019; Weitz, Carlsen, and Trimmer 2019). This approach produces high-resolution analysis in specific contexts, but is not appropriate for the global scale of analysis presented here covering the 193 United Nations Member States and the 231 unique indicators in the SDG monitoring framework.

3.2.3. Stage 3: Assessing data availability

The selection of SDG indicators is limited based on the availability of their underlying data. Several SDG indicators did not have a methodological approach for data collection (classified as Tier III) at the time of the analysis or data are not produced regularly by countries (classified as Tier II) (UNSD 2020c). In addition, a deficiency in environment-related data disaggregated by gender hindered the assessment at the disaggregated level.

An assessment of the availability of underlying data was performed for each selected SDG indicator or sub-indicator in terms of the number of United Nations Member States that have reported data for at least two years since 2000. Of the 2,118 potential synergies that were identified in stage 2, only 429 potential synergies possessed enough underlying data to be able to investigate.

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[21] An Expert Group for the second Measuring Progress report was formed to guide the development of the report, co-chaired by Paul Ekins (University College London) and Huadong Guo (Chinese Academy of Sciences) and including experts from various international and academic institutions. For more information, please see EGM 1 and EGM 2.

Data used in this report were extracted from the Global SDG Indicators Database between January and June 2020. Additional updated SDG indicator data were added to the analysis on 21 July 2020. The subsequent updates of the Global SDG Indicators Database are not considered in this analysis due to the time needed to perform the statistical analysis and develop this report.

3.2.4. Stage 4: Investigating relationships between indicators pairs

The investigation of the pairwise relationships between a selected group of SDG indicators helps in determining whether there is evidence to support a statistically significant correlation between them. The analysis is based on comparing two indicators across the population of countries over the length of time for which matching data can be found. The sample is the matched country and year observations for each indicator, so the sample size per relationship is limited by the indicator with the smallest amount of available data (at least two data points). Correlation is estimated using Pearson's correlation coefficient, which is calculated as:

$$\rho_{x,y} = \frac{cov(x,y)}{\sigma x \sigma y}$$

The estimated correlation coefficient, $P_{X,Y}$, takes on values from -1 to +1 and gives a measure of the correlation between the two variables, with +1 being a perfect positive correlation where an increase in one variable is matched by an increase in the other and -1 indicating a negative relationship where an increase in one variable is correlated with a decrease in the other variable. The magnitude of the coefficient is one measure of its significance, however hypothesis testing was carried out to determine the significance of the observed coefficient based on the sample size. The null hypothesis for the test is H_0: $\rho = 0$ indicating that there is no statistically significant difference between the estimated coefficient and zero. The significance level was set at $\alpha = .05$. A p-value of less than the significance level will result in rejecting the null hypothesis that the coefficient is not significantly different from zero and there is some association between the two variables. The p-value is the probability of observing the results under the null hypothesis and alpha (α) is the threshold specified for making a decision about this value. Alpha is specified in advance and then the p-value is calculated; if the p-value falls below alpha then the null hypothesis is rejected.

There are a number of important aspects to note with regard to this approach. Firstly, the relationship measured by the correlation coefficient is assumed to be linear. If there is a non-linear association between two variables, this approach will not be able to capture it. When assessing the data, many of the indicators were highly skewed and varied widely across the sample, given the extreme differences between some countries. As this can distort the correlation coefficient, a log transformation of the indicator measurements was applied before analysis to mitigate data skewness. The values estimated lend themselves well to this transformation, being generally positive values, such as percentages, square kilometres, hectares, etc. and having a large variance in scale which this transformation helps to compress, reducing the impact of outliers. In addition, the geographic and ecological/taxonomic scale at which some indicators are reported will have limited how useful they were for this analysis. For example, a Red List Index for marine species (see, for example, Nieto *et al.* 2015) would be a more intuitive indicator to investigate in relation to marine protected areas, rather than the global Red List Index which is used for indicator 15.5.1.

Secondly, although exploring the correlation is useful to identify associations between indicator, confounding factors can influence the observed relationship. For example, a country that has experienced significant GDP growth may observe improvements in two indicators at the same time such that there appears to be a correlation between the two variables that are unrelated but both influenced by GDP. In order to attempt to mitigate the influence of this phenomenon, a linear regression model was developed to estimate the relationship between the indicator pairs which also included variables to capture changes in population and GDP. A fixed effect is used to account for regional factors and the full model formulation is given as:

$$log\ (Y) = \beta_1 log(X) + \beta_2 log(pop) + \beta_3 log(GDP) + I_{region}$$

Where:

Y: state of the environment indicator being assessed
X: driver of change or state of society indicator
pop and *GDP:* country population and GDP at the observed year
I_{region}: fixed effect estimate for each geographical region
β_1, β_2 and β_3: model coefficients estimated by maximum likelihood that give a measure of the relationship between each variable and the dependent variable Y.

A hypothesis testing was conducted on the coefficient of interest(β_1) to assess whether, after having accounted for the influence of these confounder variables, there is still sufficient evidence for a relationship between the variables with the same significance level of $\alpha = .05$ used. Additionally, the model framework allows the calculation of R^2 values which give a measure of how good the model is and how much of the variance in the dependent variable the model captures. Another threshold of $R^2 = 0.2$, an appropriate threshold for this type of exploratory investigation, was set as a means of having further confidence in the validity of there being a statistically significant relationship between the investigated pair of indicators.

The Pearson correlation test and the modelling framework each produce a correlation coefficient. The sign (positive or negative) of the correlation coefficient indicates the direction of the relationship between a pair of indicators. When interpreting the direction of the correlation between indicator pairs, the model coefficient is used rather than the Pearson test coefficient as this informs about the direction of the relationship when confounding factors are taken into account.

Because some indicators were classified as both drivers of change and state of society indicators (such as 7.1.2 Primary reliance on clean fuels), such indicators could be included in both the analysis of relationships between direct drivers of change and the state of the environment, and the analysis of relationships between the state of the environment and the state of society (Figure 3.1.1). In these cases, such indicators are specified differently in the models, and such models will produce different results for the same pair of indicators. A driver of change indicator is analysed as an independent variable (the cause) in terms of its relationship with the state of the environment indicator which is specified as the dependent variable (the effect) in the model. In contrast, a state of society indicator is specified as the dependent variable (the effect) and is analysed in relation to the state of the environment indicator, which is specified as the independent variable (the cause). The direction of the investigated relationship is described graphically in Figure 3.3.1.

The approach adopted in this report is an exploratory, rather than causal, analysis. The obtained results do not suggest or conclude any causal relationship between the investigated pair of indicators. They simply indicate that evidence suggests a link between the two indicators.

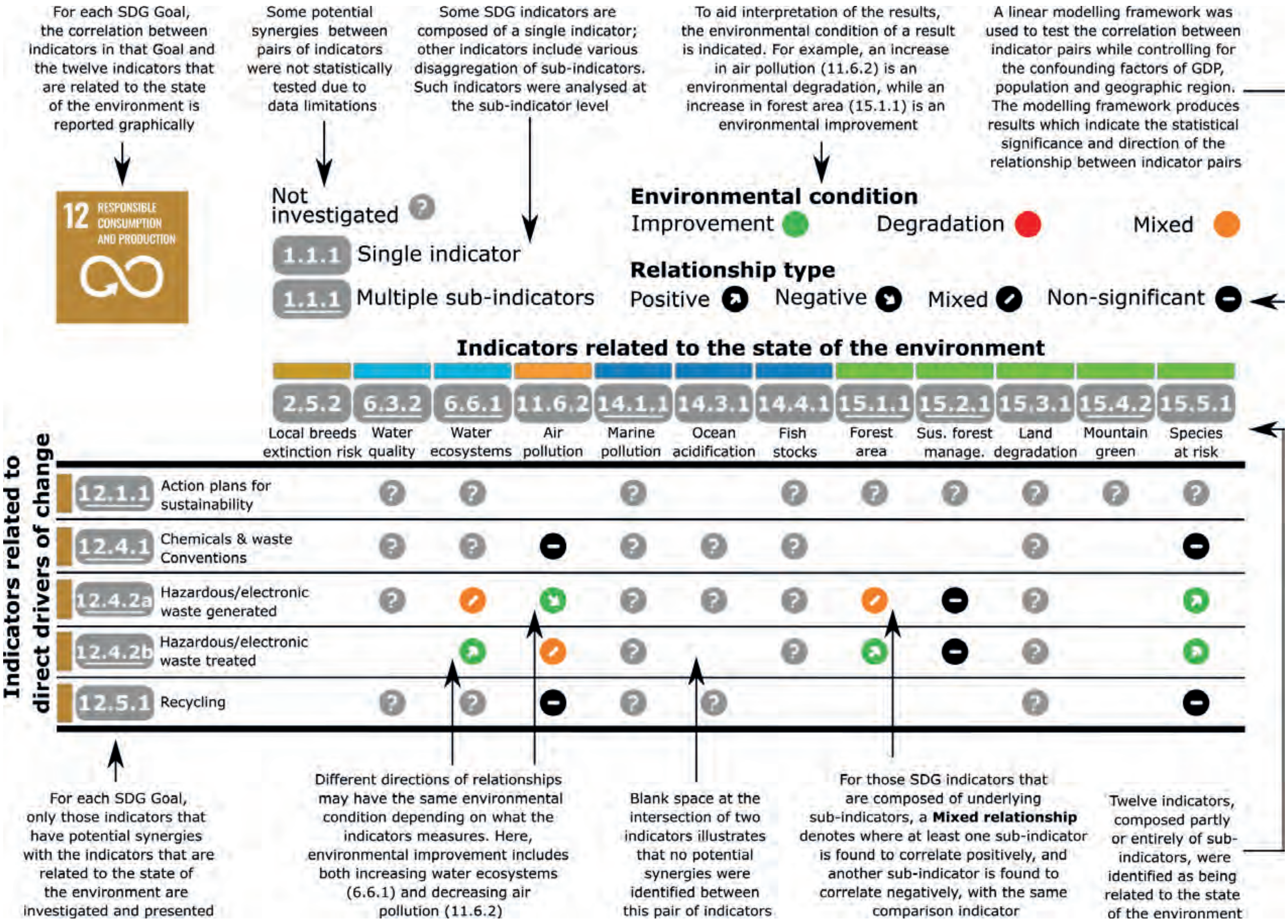
3.2.5. Stage 5: Identification of outlier countries

Based on the results of the statistical analysis, graphical display of the data underlying significant indicator pairs was used to identify countries that appear to be outliers in comparison to other countries in terms of relationships between indicator pairs that indicate environmental improvement. The identification of outlier countries provides the basis for experts to further investigate the reasons why some countries' indicators suggest that they are doing particularly well in terms of their responses and the state of their environment.

3.3. Presentation of results

The results are presented in this report in two consecutive chapters. Chapter 4 reports the results of the analysis comparing indicators related to direct drivers of change with indicators related to the state of the environment. Chapter 5 reports the results of the analysis comparing indicators related to the state of society with indicators related to the state of the environment. Within these chapters, each SDG containing indicators that were included in this analysis is discussed separately, and results of the statistical analysis are presented graphically at the goal level. Figure 3.3.1 serves as an example of the details and how these graphics should be interpreted to better understand the results of the statistical analysis.

Figure 3.3.1. Presentation of results – an example



For each SDG Goal, the correlation between indicators in that Goal and the twelve indicators that are related to the state of the environment is reported graphically

Some potential synergies between pairs of indicators were not statistically tested due to data limitations

Some SDG indicators are composed of a single indicator; other indicators include various disaggregation of sub-indicators. Such indicators were analysed at the sub-indicator level

To aid interpretation of the results, the environmental condition of a result is indicated. For example, an increase in air pollution (11.6.2) is an environmental degradation, while an increase in forest area (15.1.1) is an environmental improvement

A linear modelling framework was used to test the correlation between indicator pairs while controlling for the confounding factors of GDP, population and geographic region. The modelling framework produces results which indicate the statistical significance and direction of the relationship between indicator pairs

Not investigated ?

1.1.1 Single indicator

1.1.1 Multiple sub-indicators

Environmental condition

Improvement 🟢 Degradation 🔴 Mixed 🟠

Relationship type

Positive ↗ Negative ↘ Mixed ⊘ Non-significant ⊖

Indicators related to the state of the environment

Indicators related to direct drivers of change

	2.5.2 Local breeds extinction risk	6.3.2 Water quality	6.6.1 Water ecosystems	11.6.2 Air pollution	14.1.1 Marine pollution	14.3.1 Ocean acidification	14.4.1 Fish stocks	15.1.1 Forest area	15.2.1 Sus. forest manage.	15.3.1 Land degradation	15.4.2 Mountain green	15.5.1 Species at risk
12.1.1 Action plans for sustainability		?	?		?		?	?	?	?	?	?
12.4.1 Chemicals & waste Conventions		?	?	⊖	?	?	?			?		⊖
12.4.2a Hazardous/electronic waste generated		?	🟠⊘	🟢↘	?	?	?	🟠⊘	⊖	?		🟢↗
12.4.2b Hazardous/electronic waste treated			🟢↗	🟠⊘	?		?	🟢↗	⊖	?		🟢↗
12.5.1 Recycling		?	?	⊖	?	?				?		⊖

For each SDG Goal, only those indicators that have potential synergies with the indicators that are related to the state of the environment are investigated and presented

Different directions of relationships may have the same environmental condition depending on what the indicators measures. Here, environmental improvement includes both increasing water ecosystems (6.6.1) and decreasing air pollution (11.6.2)

Blank space at the intersection of two indicators illustrates that no potential synergies were identified between this pair of indicators

For those SDG indicators that are composed of underlying sub-indicators, a **Mixed relationship** denotes where at least one sub-indicator is found to correlate positively, and another sub-indicator is found to correlate negatively, with the same comparison indicator

Twelve indicators, composed partly or entirely of sub-indicators, were identified as being related to the state of the environment

Chapter 4: Correlations between direct drivers of change and the state of the environment

The methodology has identified various indicators from the SDG global framework as actions targeting nature. These indicators are spread across various goals, including SDG 2 on ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture, SDG 6 on ensuring availability and sustainable management of water and sanitation for all, SDG 7 on ensuring access to affordable, reliable, sustainable and modern energy for all, SDG 8 on promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, SDG 12 on ensuring sustainable consumption and production patterns, SDG 14 on conserving and sustainably using the oceans, seas and marine resources for sustainable development and SDG 15 on protecting, restoring and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, and halting and reversing land degradation and halting biodiversity loss. The state of the environment in this chapter is described in its physical and ecological form. However, only a gender-inclusive approach can grasp the environmental dimension in a holistic way that includes the social, cultural and economical dimensions (UNEP 2019b). The interlinkages of direct drivers of change indicators and the state of the environment indicators are presented in detail in this chapter.

SDG 2: Food security

4.1. SDG 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture

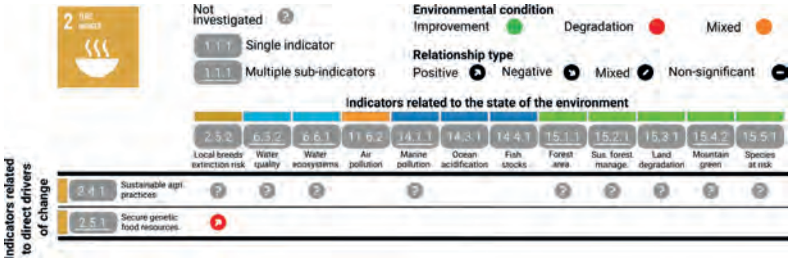
SDG 2 integrates and links food security, nutrition, and sustainable and climate-resilient agriculture. Conserving genetic resources is crucial to ensure food security and sustainable development for present and future generations. Genetic resources for food and agriculture refer to the diversity of plants, animals, aquatic resources, forests, micro-organisms, and invertebrates – which are the strategic reservoir on which all human food production systems depend (FAO 2015).

In 2018, the State of Food Security and Nutrition in the World report was released, sounding the alarm that the world is not on track to meet SDG 2 on ending hunger (FAO *et al.* 2018). In many production systems and countries, biodiversity in terms of food and agriculture and the ecosystem services it provides is reported to be in decline (FAO 2019c). The Global Biodiversity Outlook (CBD 2020a) concluded that biodiversity is declining and that none of the Aichi Biodiversity Targets will be met. Nor is biodiversity being highlighted as a priority in Voluntary National Reviews (VNRs) of progress towards the implementation of the 2030 Agenda for Sustainable Development. A recent study conducted in 30 countries indicated that only 20 per cent of countries mention biodiversity as a national priority in their SDG progress reports (UNEP-WCMC 2020). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) found that current negative trends in biodiversity and ecosystems will undermine progress towards 80 per cent (35 out of 44) of SDG targets related to poverty, hunger, health, water, cities, climate, oceans, and land (SDGs 1, 2, 3, 6, 11, 13, 14 and 15) (IPBES 2019a).

If managed appropriately, the species directly used as products in crop, livestock, forest and aquaculture systems can also support other types of production (FAO 2020d). All food systems depend on biodiversity and a broad range of ecosystem services that support agricultural productivity, soil fertility, and water quality and supply. Furthermore, at least one-third of the world's crops depend upon pollinators (University of California - Berkeley 2006).

Overall, the achievement of SDG 2 is positively supported by direct drivers of change, but a positive correlation is dependent on the type of production systems pursued to achieve zero hunger. Low-input and ecosystem-based approaches to agriculture are particularly compatible with supporting the conservation and sustainable use of biodiversity. The protection of local plant breeds – a key component of this – is the subject of this section.

Figure 4.1.1. Correlation analysis results for SDG 2 indicators



4.1.1. Local breeds extinction risk (SDG indicator 2.5.2) and secure genetic food resources (sub-indicator of 2.5.1)

Secure genetic food resources (SDG sub-indicator 2.5.1) presents the number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities. Proportion of local breeds classified as being at risk of extinction (SDG indicator 2.5.2) presents the percentage of local livestock breeds among local breeds with risk status classified as being at risk of extinction at a certain moment in time, as well as their trend over time.

Local breeds were positively – though weakly – correlated with plant breeds for which sufficient genetic resources are stored. The result suggests that despite increasing the number of plant breeds with conserved genetic resources, the proportion of local breeds classified as being at risk is increasing in countries.

To understand this result, it is important to disclose that the number of resources conserved under medium- or long-term storage conditions provides only an indirect measurement of the total genetic diversity, targeting secure management for future use. Overall, this means positive variations are approximated to an increase in the agro-biodiversity secured, while negative variations are approximated to a loss of it.

The weak relationship can be explained by the fact that the conservation of plant and animal genetic resources for food and agriculture in medium- or long-term conservation facilities (ex situ, in gene banks) is no guarantee that they can be easily used in breeding programmes, or even directly on-farm. Nevertheless, it is widely agreed that the existence of these facilities is considered the most trusted means of conserving genetic resources worldwide.

KEY NOTE 1. REPUBLIC OF SOUTH AFRICA – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS

Plant conservation in the Republic of South Africa is part of a highly coordinated, functional and effective network that aims to protect both flora and fauna. Priorities are identified through the critical biodiversity areas (CBAs) and under the mandate to mitigate challenges presented by the drivers that are associated with past and current extinctions. There are different in domo conservation strategies that may have positively impacted biodiversity, such as conservation agencies entering into contract agreements with landowners who retain ownership to the land. In those areas, the management of biodiversity is under the auspices of the conservation agencies, covering 75,000 hectares with aims to increase to 360,000 hectares in the future.

The approach to target plant biodiversity conservation in agricultural production lands is mainly guided by a systematic biodiversity planning strategy. The Republic of South Africa is home to several different biodiversity hotspots (such as Cape Floristic Region, Succulent Karoo, and the Maputaland-Pondoland-Albany corridor) and the biggest known threats that potentially lead to extinctions, such as alien invasive species, habitat transformation, climate change, and the overexploitation of resources. There are strategies for conservation and development, including the management of protected areas, community-based conservation and co-management, wildlife tourism and bioprospecting (van Wilgen et al. 2020; Hoveka, van der Bank and Davies 2020; Frantz 2018).

Since the 1990s, the extinction frequency over the past 300 years is thought to have plateaued to about 1.26 extinctions annually. Such information is only available because of long-term biodiversity monitoring surveys that are associated with conservation agencies such as South African National Parks (SANParks). Although past records may show some plants as being extinct, efforts to verify this have led to new evidence showing that records are not always accurate, as some rare species may in fact occur in difficult-to-reach geographical locations. This is seen in the growth of Lazarus taxa in recent years, which is possible due to advancing knowledge of post-extinction recoveries (Burgess and Shen 2014; Condamine, Rolland and Morlon 2013). It is especially valid for strict endemics occurring in areas that are not under continuous ecosystems monitoring by conservationists. A strong impetus to incorporate community-based conservation activities (or citizen science) – such as the Custodians of Rare and Endangered Wildflowers (CREW) programme led by the South African National Biodiversity Institute (SANBI) and the Botanical Society of South Africa – has been highly successful in surveying, documenting and identifying endemics that are in urgent need of conservation. In situ and ex situ conservation strategies are a strong feature in plant biodiversity management and at least 400 indigenous edible plant species and wild crop variants are conserved in gene banks. Sustainable harvesting of wild plant species for plant-based industries for the South African bioeconomy allows for the economic exploitation of plant biodiversity while concurrently aiming to prevent future extinctions. Through rigorous scientific studies, informed decision-making is thus possible around new biological invasions and their control. Invasive species eradication programmes have also been implemented to limit the expansion of biological invasion. Finally, country-wide public awareness and education initiatives sensitize South African society to the importance of conservation in preventing future biodiversity losses.

Consequently, the world is experiencing an increase in the risk status of extinction for local breeds (FAO n.d.b). However, several countries appear to be bucking this trend by both increasing their conservation of plant genetic resources and decreasing the proportion of at-risk local breeds. Examples include the United Kingdom of Great Britain and Northern Ireland, Ukraine, the Republic of Bulgaria, the Republic of South Africa and the United Republic of Tanzania.

4.1.2. Conclusion

The information collected for these indicators is key to safeguarding precious animal varieties and supporting the livelihood of the world's population with sufficient, diverse and nutritious diets. The indicators have a direct link to biodiversity, as animal or livestock genetic resources represent an integral part of agricultural ecosystems (FAO 2007). Furthermore, there are indirect links to malnutrition and undernourishment, which are addressed in Chapter 5. Plant genetic resources for food and agriculture are an essential part of the biological basis for world food security and contribute to the livelihoods of over a billion people. A diverse resource base is critical to human survival and well-being and contributes to the eradication of hunger. Animal genetic resources are crucial in adapting to changing socioeconomic and environmental conditions, including climate change.

Additionally, and based on the results, there are some outlier countries whose underlying data suggest that, concerning some indicators, they are doing particularly well in terms of their responses (the first indicator) and the state of their environment (the second indicator).

As seen in Key Note 1, the Republic of South Africa appears to be both increasing the conservation of plant genetic resources and decreasing the proportion of local breeds at risk. This special performance could be explained by a highly concerted and organized effort that includes various stakeholders in the management of the country's biodiversity. Current estimates indicate that 2,576 plant species may face the threat of extinction in the Republic of South Africa but continuous monitoring programmes led by SANBI, such as the Threatened Species Programme, are in place. Since 2005, the programme's implementation in regions with high levels of species endemism and species radiations has proved to be a highly effective conservation management practice. The circumstances observed in such outlier countries may inform decision-making in other countries to support such efforts and implement similar targeted policies.

SDG 6: Water

6 CLEAN WATER
AND SANITATION

4.2. SDG 6 Ensure availability and sustainable management of water and sanitation for all

The SDGs were designed as an ‘indivisible whole’, but interactions between various goals need to be analysed and better understood. Several previous assessments began to explore interactions, including synergies and possible conflicts, between the SDGs (Nilsson, Griggs and Visbeck 2016; Scharlemann *et al.* 2020). UN-Water analysed the links and interdependencies between the targets of SDG 6 and other goals to identify the importance of mainstreaming water and sanitation in the policies and plans of other sectors, and looked at how managing these interlinkages supports the social, economic and environmental dimensions of the 2030 Agenda for Sustainable Development (UN-Water 2016).[22]

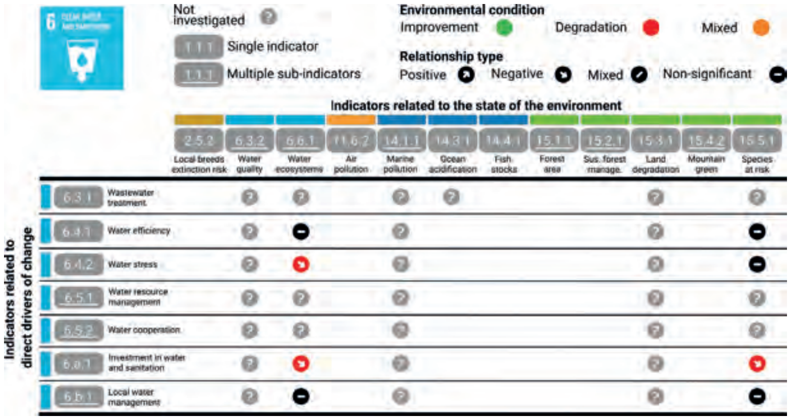
Nature-based solutions use the features and complex system processes of nature, such as the ability to store carbon and regulate water flow, in order to achieve desired outcomes, such as disaster risk reduction, improved human well-being and socially inclusive green growth (UNEP 2018d). They are inspired and supported by natural processes to contribute to the improved management of water resources, food security and agriculture, biodiversity, environment, disaster risk reduction, urban settlements and climate change (World Water Assessment Programme [WWAP] 2018). By being mindful of the actual carrying capacity of natural resources and ecological environment, nature-based solutions can reflect the original intention of the SDGs.

There is a strong link between water security, economic activity and human development (UN-Water 2018). Water sustains the natural environment and is a factor for systems to produce ecological services (Nikolova 2017). Here, the analysis focuses on the relationship between the SDG 6 themes and the state of the environment indicators, including water quality (6.3.2), water ecosystems (6.6.1), marine pollution (14.1.1), land degradation (15.3.1) and species at risk (15.5.1).

Wastewater treatment is a key step in ensuring the water system is a clear and healthy habitat for living beings in rivers, lakes, ponds and ocean. Good or bad wastewater treatment positively or negatively impacts the terrestrial and ocean water systems, which might indicate a correlation between wastewater treatment and these systems. On the other hand, water efficiency and water stress have no direct relationship with water quality and marine pollution. However, when agricultural production, domestic water demand and natural ecosystems compete for water, there can be an impact on water ecosystems, land degradation and endangered species.

Sustainable water resource management, water cooperation, investment in water and sanitation, and adequate local water management can help overcome inequalities related to freshwater resources, save and efficiently use water, improve water quality, and maintain healthy aquatic and terrestrial ecology and biodiversity, thereby positively impacting the state of the environment indicators.

Figure 4.2.1. Correlation analysis results for SDG 6 indicators



Based on possible synergies between indicators and SDGs data sets of United Nations Member States, several relationships were identified. However, due to a lack of data, only a few relationships were investigated: water use efficiency (6.4.1), water stress (6.4.2), investment in water and sanitation (6.a.1), local water management (6.b.1), water ecosystems (6.6.1), and species at risk (15.5.1).

4.2.1. Water ecosystems (SDG indicator 6.6.1) and water use efficiency (SDG indicator 6.4.1) ⊖

The distribution of global water-related ecosystems is complex and highly diverse in terms of ecosystem types. Meanwhile, understanding the causes and processes that lead to global environmental change is complicated. For example, the world has lost 50 per cent of its wetlands (a very important water-related ecosystem)

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[22] UN-Water coordinates the efforts of United Nations organizations and international organizations working on water and sanitation issues.

since 1900 (Davidson 2014). This loss is caused by the complex mechanism of climate change, human activities, and other factors. It is rather difficult to determine how much correlation this loss has with the improvement of water use efficiency. Furthermore, the improvement of water use efficiency only reflects the development of water-saving technology, while water consumption of human society and economy is the main factor affecting water ecosystems (FAO and UN-Water 2018). Therefore, only when the total water consumption control and ecological water use are satisfied will the improvement of water use efficiency show positive benefits to the ecosystem.

4.2.2. Species at risk (SDG indicator 15.5.1) and water use efficiency (SDG indicator 6.4.1) ⊖

The quantity, distribution characteristics, speed of loss, and endangered status of global species at risk are determined by different factors, such as genes and habitats of species, and the various actions in different countries (IUCN 2019). Improved water use efficiency is often related to actions in a particular area such as agricultural water, industrial water, domestic water or ecological water. Although there may be some indirect relationship between water use efficiency and species at risk, it is a complex and long-term relationship and it is not easy to see the effect in the short term. The investment and improvement of water use efficiency may increase the social and economic benefits from efficiency, which could free up funds and resources that could be used to promote ecological protection and restoration, species population restoration and expansion, and so forth.

4.2.3. Water ecosystems (SDG indicator 6.6.1) and water stress (SDG indicator 6.4.2) ↘

There is a highly competitive relationship between the development and utilization of freshwater resources and the ecological water demand of ecosystems. Within the range of available water resources, the higher the development and utilization of freshwater resources, the less water is left for the ecosystem. Hence, water stress caused by increased freshwater withdrawal has potentially negative effects on the sustainability of natural water resources (UNSD 2020a), as confirmed by the negative correlation between water stress and water ecosystems obtained in this analysis (Annex C).

4.2.4. Species at risk (SDG indicator 15.5.1) and water stress (SDG indicator 6.4.2) ⊖

Theoretically, as the Earth has limited available freshwater resources, the amount of water consumed by water-dependent activities will affect the habitats of organisms that rely on the corresponding water resources and ecological environment. This will, in turn, affect the distribution and quantity of species. However, this is a long and complex process and the impact is hard to quantify. In local areas, the mechanism and path of impact may be clear: increased water stress will lead to the decrease or even extinction of species. However, at the global scale, the real relationship between water stress and species at risk is difficult to describe due to the representativeness of the analysis data and the homogenization effect between different regional data.

4.2.5. Water ecosystems (SDG indicator 6.6.1) and investment in water and sanitation (SDG indicator 6.a.1) ↘

Under the dual effects of global climate change and water-conservancy project development and construction, the global surface water distribution pattern is constantly being reshaped. Based on recent research, all continental regions except Oceania show a net increase in permanent water bodies, with much of the increase coming from reservoir filling (Pekel *et al.* 2016; Borja, Kalantari and Destouni 2020). The increase in reservoir water surface area is a direct result of investment in water conservancy. Hence, the increase in water-conservancy investment on a global scale may show a strong correlation (Annex C) with the change in water ecosystems reflected by the change in permanent water bodies. There are positive and negative effects in the development and utilization of water. The increase in water-conservancy investment means an improvement in water resources development and utilization rate and an increase of water supply and consumption, but it also indicates an increase of sewage discharge and corresponding sewage treatment investment. Therefore, one cannot simply state that the enhancement of investment and pollution control capacity is beneficial for water ecosystems. In fact, only rational development and utilization of water resources can result in positive benefits to the ecological environment.

4.2.6. Species at risk (SDG indicator 15.5.1) and investment in water and sanitation (SDG indicator 6.a.1) ↘

Changes in water ecosystems have diverse effects on the distribution and quantity of water related to endangered species. For example, activities to restore degrading permanent water bodies may help bring back aquatic and terrestrial animals and native plants to these regions. In contrast, increased construction activity resulting from new water-conservancy projects may endanger the habitat and species of the rivers and shore ecosystems. According to the IPBES report in 2019, global species extinction rates are accelerating (IPBES 2019a). From the perspective of change trend, there should be a negative correlation between global-scale permanent surface water and endangered species. Here, the weak negative correlation (Annex C) between investment activities and endangered species may just reflect the negative effect of human interventions.

4.2.7. Water ecosystems (SDG indicator 6.6.1) and local water management (SDG indicator 6.b.1) ⊖

Considering local specificities, proportion of surface water within national borders, the geographical region, and the differences in management practices, the effects of implementing management activities on surface water systems should vary greatly. Taking the Aral Sea in Central Asia as an example, although the surrounding countries and regions are trying to solve the problem of lake degradation through efficient water resources management, it is obvious that human intervention activities will have difficulty leading to significant changes given the trend of regional climate drought. However, for some small countries with limited quantities of surface water such as Morocco, a small management investment may lead to great changes in the water system. These could be the reasons why there is no obvious correlation between local water management and water ecosystems at the global scale.

4.2.8. Species at risk (SDG indicator 15.5.1) and local water management (SDG indicator 6.b.1) ⊖

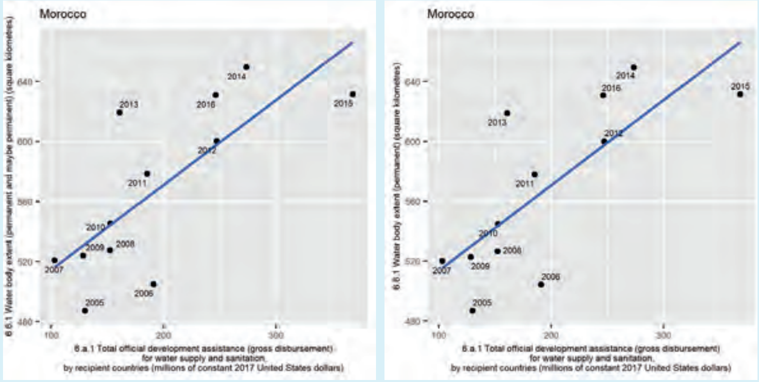
The local water management indicator attempts to quantify the impact of community involvement in laws and regulations affecting water supply, resources planning and management. Although high-efficiency management can save water resources, reduce the pressure of water ecosystems and help

KEY NOTE 2. KINGDOM OF MOROCCO – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS

In 2019, the Kingdom of Morocco ranked as the twenty-second most water-stressed country in the world. It has seen dramatic decreases in its groundwater levels across three main basins. The Souss groundwater saw a decrease of 24 metres over 34 years, while the Sais groundwater saw a staggering drop of 64 metres in 25 years (Kingdom of Morocco, Ministry of Energy, Mines, Water and Environment 2012). Despite these concerns, the country has made tremendous improvements to water security, especially for its rural communities through law no. 10-95. From 1992 to 2012, access to drinking water for rural communities increased from 14 per cent to 92 per cent (Kingdom of Morocco, Ministry of Energy, Mines, Water and Environment 2012).

To address the prevailing water scarcity trends, the Kingdom of Morocco is planning to spend USD 12 billion on waterworks over the next eight years in the Priority Programme for Drinking Water Supply and Irrigation 2020–2027. The project includes funding the construction of dams and irrigation systems to expand the drinking water distribution network to rural areas, improved treatment and reuse of wastewater, and awareness-raising to reduce demand and preserve water resources (GCR Staff 2020). Furthermore, three seawater desalination plants are to be constructed, which will add to Morocco's limited water supply. These treatment plants will secure clean, safe drinking water for domestic use and agriculture throughout the country (Takouleu 2020a). To try and meet SDG Target 6.4, the Government has plans to build 50 dams by 2050 to create water reservoirs that will secure water supply for its population. The new dams would increase water storage capacity to 32 billion m3 by 2050. Restrictions on agricultural water demand will also help the Kingdom of Morocco meet its target to save 2.5 billion m^3 resources nationally (Takouleu 2020b). The increase in the supply of clean water through increased dam storage and water desalination plants, partnered with consumption constraints, will decrease the water deficit in the country. This will produce further positive feedback in water ecosystems while also creating water security for urban and rural populations alike.

Figure 4.2.2. Relationship between total official development assistance for water supply and sanitation and water body extent, Morocco



KEY NOTE 2. KINGDOM OF MOROCCO – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS *(Continued)*

Additionally, the German Government has signed an agreement with the Kingdom of Morocco for a new programme called Rural Resilience. The programme will improve the resilience and living conditions of rural populations that have been severely affected by climate change and water stress (Takouleu 2021). Programmes like these demonstrate how policy can foster socially inclusive green growth, while reducing disaster risk and improving overall human well-being (and, more specifically, the well-being of women in rural areas that depend on agriculture).

protect and restore endangered species, there is no obvious direct relationship between these two indicators. This could be the reason why no correlation between local water management and species at risk has been observed.

4.2.9. Conclusion

Achieving the SDG 6 targets involves a complex system composed of social economy, natural resources and ecological environment, with a complex mutual feedback mechanism among the various parts of the system. Therefore, the interlinkages between SDG 6 target themes and the state of the environment indicators vary under different conditions, be it positive, negative or without a significant correlation.

In an increasingly globalized world, inadequate water management can have impacts across geographical borders and can impact a large number of people (WWAP 2019). As previously mentioned, the ecosystem structure, water management methods and policies, and available funds vary across countries. There is a clear understanding that under the premise of total water consumption control and ecological water use guarantee, a positive effect may be obtained on the water environment and species at risk in the future, by improving water use efficiency and reducing freshwater withdrawal through wise investment activities.

SDG 7: Energy

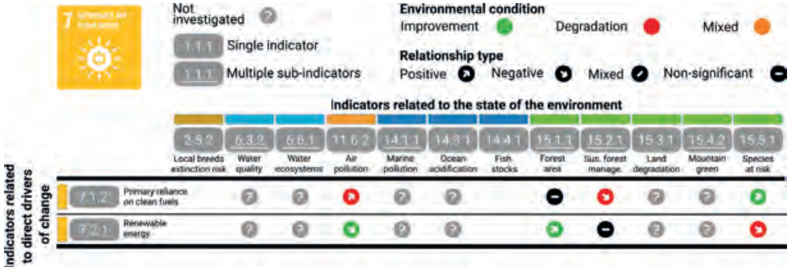
7 AFFORDABLE AND CLEAN ENERGY

4.3. SDG 7 Ensure access to affordable, reliable, sustainable and modern energy for all

Access to modern energy is a primary goal for socioeconomic development. SDG 7 focuses on ensuring access to affordable, reliable, sustainable and modern energy resources for all. Targets include ensuring universal access to affordable, reliable and modern energy services and increasing the use of renewable energy and the rate of improvement in energy efficiency, as well as promoting investment in energy infrastructure and clean energy technology.

Affordable and clean energy services will help expand the socioeconomic benefits for countries and, in the long term, reduce the related environmental impacts. A shift towards renewable energy and greater energy efficiency will slow the depletion of many types of natural resources and support environment-related SDGs. Furthermore, it eases gender inequalities related to acquiring resources for energy at home and its deleterious health impacts, for example through pollutants from wood-fired stoves (WHO 2016b). However, progress towards SDG 7 targets can hinder progress on several of the environment-related targets, especially if technologies and infrastructure needed for renewable energy put stress on ecosystems (Weitz *et al.* 2019). This is primarily because renewable energy is linked to natural resources, such as solar, wind, plants and natural gas. For example, if expansion of renewables entails large-scale bioenergy production or hydropower, these activities can compete with land for food production and available water, which in turn could have implications on terrestrial and inland freshwater ecosystems. Similarly, solar panels require specific mineral and metals, which without efficient recycling could have implications on the achievements of the SDGs related to protection and conservation of natural resources (Weitz *et al.* 2019). Also, offshore wind farms could end up competing with marine and coastal habitats.

Figure 4.3.1. Correlation analysis results for SDG 7 indicators



4.3.1. Air pollution (SDG indicator 11.6.2) and primary reliance on clean fuel (SDG indicator 7.1.2)

One key target of SDG 11 is to reduce the environmental impact of cities by improving air quality. However, around 3 billion people still rely on coal, charcoal and biomass (including wood and animal and crop waste) for cooking and heating (IEA 2017). Fossil-fuel and biomass combustion for electricity production, cooking, heating, transportation and industry are responsible for generating 85 per cent of airborne respirable particulate pollution (e.g. $PM_{2.5}$ and PM_{10}) in the atmosphere (IEA 2016). $PM_{2.5}$ and PM_{10} are particles present in the air that are small enough to penetrate the thoracic region of the respiratory system, resulting in serious impacts on health. Short- and long-term exposure to high concentrations of these particles has been firmly linked with cardiovascular and respiratory morbidity and mortality. Cohen (2004) has estimated that about 3 per cent of cardiopulmonary mortalities worldwide and 5 per cent of lung cancer mortalities worldwide are attributed to particulate matter. It was even found that long-term exposure to $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary deaths by 6 to 13 per cent per 10 µg/m^3 of $PM_{2.5}$ (Cohen *et al.* 2004; Pope III *et al.* 2002; Beelen *et al.* 2008; Krewski *et al.* 2009). The World Health Organization (WHO) has estimated that around 7 million people die every year from exposure to fine particles in polluted air (WHO 2018b). Air pollution affects all regions across the globe but populations in low- and middle-income countries are the most impacted, as they have less access to clean fuels and technologies.

Looking at the 2018 WHO maps (WHO 2018c) of the proportion of people with primary reliance on clean fuels (SDG indicator 7.1.2) and the annual average concentrations of fine particulate matter in urban areas (SDG indicator 11.6.2), it is evident that it is mostly countries with a low percentage of their population relying on clean fuels in Africa and South-East Asia[23] that are suffering from very high levels of ambient air pollution. This is in contrast with the results of the statistical analysis, which reports a positive association between the two indicators. This result is difficult to interpret and may be explained by the spatial mismatch between the urban scale of the SDG indicator 11.6.2 and the national scale of the SDG indicator 7.1.2 which makes the indicators difficult to compare. Another reason for this result may be that polluting fuels and technologies are not the ultimate factor for ambient air pollution but rather for indoor air pollution. Other major sources of ambient air pollution and particulate matter include inefficient

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[23] Regional grouping follows the World Health Organization classification. For more information, please see https://www.who.int/countries

use of energy by industry, agriculture and transport sectors as well as desert dust, waste burning and deforestation in some regions.

4.3.2. Sustainable forest management (SDG indicator 15.2.1) and species at risk (SDG indicator 15.5.1) and primary reliance on clean fuel (SDG indicator 7.1.2)

Figure 4.3.2. Correlation analysis results for indicators of 15.2.1, 15.5.1 and 7.1.2

Forests and above-ground biomass in forests are central to SDG 15. Yet, the Sustainable Development Goals Report 2020 highlights that forest areas continue to decline at an alarming rate (United Nations 2020). Forests provide a critical source of bioenergy, as wood plays an essential role in creating options for affordable and comparatively cleaner energy (due to lower carbon emissions as compared to fossil fuels), particularly in developing countries (Bull 2018). The dependence on biofuel continues through the use of wood stoves, fire pyres and firewood as a lighting source. In developed countries, bioenergy is promoted as an alternative or more sustainable source of hydrocarbons, especially for transportation fuels, such as bioethanol and biodiesel. In least developed countries, traditional biomass is often the dominant domestic fuel, especially in more rural areas without access to electricity or other energy sources (Bull 2018).

Woody biomass from forestry operations is the most commonly used biomass for electricity production. About 2.6 billion people across the globe use traditional biomass, such as wood and charcoal, for cooking (WWF 2011). Recently, industrialized countries have started exploring new technologies for converting biomass into clean energy for producing heat and electricity. Although small-scale production of biofuels may be sustainable and have many beneficial applications, there have been concerns about the sustainability of large-scale production of biofuels, such as biodiversity loss, conflicts with food security and increased net greenhouse gas emissions (Webb and Coates 2012). To meet the increasing demand for wood as a source of bioenergy, the forest area that is managed for wood production is expected to increase by over 300 million hectares by 2050. However, according to the United Nations Framework Convention on Climate Change, fuelwood removal is responsible for 5 per cent of deforestation (UNFCCC 2007). Biofuels are another source of energy from plants. One common form of biofuel is the biodiesel derived from natural plants, such as soy and palm oil. Expansion in biofuels use, and biodiesel in particular, has also been linked to deforestation in many areas around the world, including Brazil and South-East Asia (Gao *et al.* 2011). In Brazil, parts of the Amazon Basin forests are converted to soy production for biodiesel, while in Indonesia and Malaysia, half of palm oil plantations established from 1990 to 2005 occurred in forests, leading to rapid deforestation of lowland tropical rainforests (Koh and Wilcove 2008).

The correlation results here (Annex C) suggest an inverse relationship between progress towards sustainable forest management and the proportion of the population with reliance on clean fuels and technology. The reasons for this could be:

1. Even though the global access rate to electricity is improving, the lack of fast progress in access to clean fuels and technologies is holding back both the efficiency of the global energy system and the improvements in the sustainability of biomass uses (Bull 2018). Modern renewables may not be universally accessible due to the capital investment required, especially in developing countries.

2. The global decline in the proportion of forest area from 31.9 per cent in 2000 to 31.2 per cent in 2020. This represents a net loss of almost 100 million hectares, primarily due to (i) agricultural expansion and harvesting of traditional biomass driven by human population growth in poorer countries (United Nations 2020); and (ii) expanded production of biofuels at the expense of primary forests, in both the Global South and Global North (Brack 2018; Arnold and Persson 2003).

This is in contrast to the positive correlation between the proportion of population with primary reliance on clean fuels and technologies and the Red List Index for species at risk. Potentially an increase in forest area to support biomass production could mean increased habitat availability for forest-specialist species (IUCN n.d.a). However, this is a highly complex relationship to understand and this result should be treated with caution as the Red List Index is an overall index of biodiversity for mammals, birds, amphibians, reef-forming corals and cycads.

4.3.3. Air pollution (SDG indicator 11.6.2) and renewable energy (SDG indicator 7.2.1)

As opposed to primary reliance on clean fuels (SDG indicator 7.1.2) which considers the proportion of the population relying on and using clean fuels and technology, SDG indicator 7.2.1 considers the contribution of renewable energy to the total energy mix. This could include clean fuels, but also dirty fuels (e.g. biomass burning). This in turn affects the energy that is available to be used by a given population.

The burning of both fossil fuels and renewable fuels, for all kinds of end usages, is one of the primary sources of ambient air pollution (EEA 2017a). Renewable energy sources relying on non-oxidative processes – including hydropower, wind and solar – can contribute to a substantial decrease in air pollution, in contrast to biomass fuel burning, which increases emissions, as previously stated. Hence, emissions of air pollutants depend on the choices that countries make for producing energy and electricity. According to the European Topic Centre on Climate Change Mitigation and Energy (ETC/CME) (Moorkens and Dauwe 2019), between 2005 and 2015 almost all European countries witnessed a relative increase in particulate matter emissions and concentrations due to RES consumption and, in particular, increases in biomass consumption. The same report indicated that at the European Union (EU) level, the total estimated effect of RES results in an increase of $PM_{2.5}$ and PM_{10} by 129 kt and 127 kt respectively, in 2015, compared with 2005. This is in contrast to the negative association between the share of renewable energy in the total final energy consumption and the annual mean concentrations of particulate matter in cities found by the correlation analysis between SDG indicators 7.2.1 and 11.6.2. As the share of renewable energy includes all types of RES, it is important to interpret this result with caution. This result is perhaps explained by the impact of a country's income on its choice of energy sources and the share of renewables in generating electricity.

KEY NOTE 3. REPUBLIC OF ESTONIA – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS

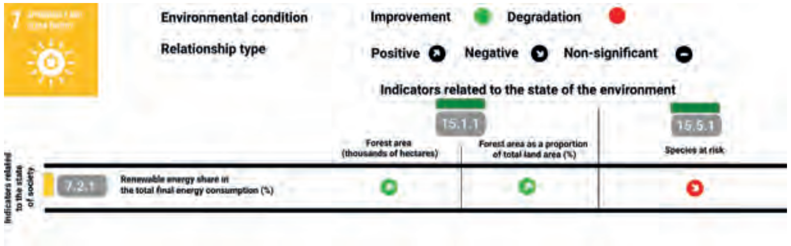
Relative to the above results, in Eastern Europe, the Republic of Estonia's data showed an inverse relationship between primary reliance on clean fuels in relation to ambient air pollution, which is encouraging to investigate further. That is, expansions in cleaner fuel use across the country have seen reductions in ambient air pollution.

The country has four main sources of air pollution: energy production, transport, agriculture and household air pollution from heating and/or cooking (Res Legal n.d.). The expansion in the use of biogas, which is now the Republic of Estonia's biggest source of renewable energy for electricity production, has contributed to cleaner air. In 2018, the country promoted renewable sources for electricity by replacing premium tariffs with an auction-based system and public tenders (reverse auctions) (Res Legal n.d.). In addition, combined heat and power (CHP) plants gained support through their use of both gas and steam to generate electricity for heating. Stations for biomethane fueling stations were constructed and operated to support biomethane use in the transport sector. All of this was made possible by substantial investment in, and financial support for, renewable energy and energy efficiency projects during the past decade.

On the policy side, the Republic of Estonia has established the 2017 National Development Plan of the Energy Sector until 2030 (NDPES 2030), which it is currently using as the guiding policy document of the energy sector. The goals set by NDPES 2030 generally aim to reduce energy consumption and decrease reliance on greenhouse-gas-intensive fuels such as coal and oil shale. The country exceeded its 2020 renewable energy target in 2017 and non- Emissions Trading System (ETS) emissions were below the 2005 level (IEA 2019). The objectives in NDPES 2030 expand the focus on diversifying the Republic of Estonia's energy mix towards more renewables while also mitigating pollution from the oil shale sector (IEA 2019). The General Principles of Climate Policy until 2050 resolution sets a goal for the Republic of Estonia to become a competitive economy with low carbon dioxide emissions. This target requires the country to separate economic growth from raw materials such as oil shale, which currently plays a very significant part in the national economy. Together, these plans will secure clean air, energy independence and reliable fuel sources for the country. However, both policies omitted the importance of gender in minimizing energy consumption and increasing energy efficiency.

4.3.4. Forest area (SDG indicator 15.1.1) and species at risk (SDG indicator 15.5.1) and renewable energy (SDG indicator 7.2.1)

Figure 4.3.3. Correlation analysis results for SDG sub-indicators of 15.1.1, 15.5.1 and 7.2.1



SDG indicator 15.1.1 focuses on forest area as a proportion of total land area (total land area is the total surface area of a country less the area covered by inland waters, such as major rivers and lakes), while indicator 15.5.1 refers to the Red List Index, which measures change in the aggregate extinction risk across groups of species (UNSD 2020a). Forests and biodiversity provide a variety of ecosystem services and are thus important to protect.

One limitation of existing energy statistics is that it is not always known whether RES are being handled sustainably (UNSD 2020a). Results of the statistical analysis indicate that there is a positive association between renewable energy share in the total final energy consumption (SDG indicator 7.2.1) and forest area (SDG indicator 15.1.1). If a country's renewable energy is weighted more heavily towards non-oxidative RES (e.g. wind and/or solar energy) rather than oxidative RES (e.g. biomass burning practices), this would reduce the pressure on forest resources in a country.

In contrast, the negative correlation between renewable energy share in total final energy consumption (SDG indicator 7.2.1) and species at risk (SDG indicator 15.5.1) could be explained if countries' renewable energy is more dependent on oxidative RES. This could result in the unsustainable harvesting and management of forest resources, by decreasing forest area due to unsustainable biomass burning practices and leading to negative impacts on biodiversity. The removal of trees and change in land use to accommodate biofuels production (a renewable energy source) have indeed resulted in damage to habitat and biodiversity loss (Gallagher 2008; The Royal Society, Science Policy Section 2008). For instance, the oil palm plantations in Malaysia and the Republic of Indonesia provide less complex habitat and host fewer species of birds and butterflies compared to primary forests (Braimoh *et al.* 2010). The results of the statistical analysis highlight the complexity of these relationships and the need to consider the percentage of RES in conjunction with the percentage of clean fuel use if the environmental impacts of RES are to be properly understood.

When interpreting these results, it is important to remember that a country's energy mix represents a highly dynamic system depending on demand, availability and many other socioeconomic factors. The proportion of clean or dirty energy sources used and available at any given time could change, leading to different impacts on air quality and/or other natural resources. Therefore, it is important to understand that the interpretation of the above results is complex.

4.3.5. Conclusion

Ensuring access to modern and sustainable energy requires more innovations and for governments to commit to developing and marketing new equipment that use renewable and clean fuels. Simultaneously, these sources have to be widely available, at affordable prices to encourage the public to install and use them.

The interlinkages discussed in this section represent various relationships between the reliance on clean fuels and renewable energy and the state of the environment. Although the environmental benefits of using renewable energy outweigh the benefits of using traditional energy sources, there is a need to consider and reduce the impact on the surrounding environment that renewable sources are installed in, given that the world is shifting towards the use of such energy sources.

SDG 8: Decent work and economic growth

8 DECENT WORK AND ECONOMIC GROWTH

4.4. SDG 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

SDG 8 calls for the world to rethink the character of economic growth. The long-term view of ensuring sustained economic development is enabled by the diversification of productive activities and stable financial investments. Such a strategy must also create inclusive economic growth by providing prosperity for all workers (regardless of gender) and, ultimately, fostering sustainable economic growth in line with the common responsibility to protect the environment (ILO 2019).

SDG target 8.4 firmly captures the link between SDG 8 and nature. It advocates for improved global resource efficiency in consumption and production and endeavours to decouple economic growth from environmental degradation. Despite increasing international efforts to reduce exploitation of environmental resources, material footprint and domestic material consumption (SDG targets 8.4) at the global level continue to rise (United Nations 2020).

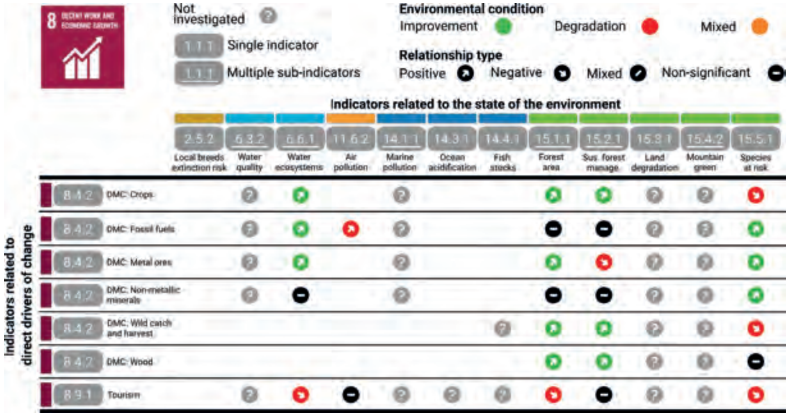
Statistics suggest that the global material footprint has grown from 73.2 billion metric tons in 2010 to 85.9 billion metric tons in 2017: a 17.4 per cent increase (United Nations 2020). Decoupling economic growth from resource use has been considered the key means to achieving sustainable consumption and production. However, in the context of increasing global consumption and economic growth, ‘relative decoupling’ (reduced environmental impact per unit of gross domestic product (GDP), usually achieved through efficiency gains) is unlikely to be sufficient and ‘absolute decoupling’ (reduced environmental impact in absolute terms) is required instead. However, absolute decoupling has proven to be far more difficult to achieve, since it requires that efficiency gains outweigh increases in consumption.

In addition, target 8.9 focuses on developing and implementing policies that promote sustainable tourism. Although target 8.9 has various dimensions, indicator 8.9.1 focuses on the economic contribution (proportion of total GDP) of all forms of tourism taking place at the national level. In 2018, international tourism expenditure represented 7 per cent of global exports and 29 per cent of global services exports (WTO 2019a). This is without including domestic tourism, which is estimated to be six times larger than international tourism in terms of total trips (WTO 2020a).

Tourism is a social, cultural and economic phenomenon that relies on – and has an impact on – the economy, the natural and built environment, the local population at the places visited, and visitors themselves (United Nations and World Tourism Organization 2010). It is a multidimensional sector with considerations related to national and local economies and the environmental and sociocultural resource base. The introduction of sustainable tourism since the early 1990s to englobe optimizing the “use of environmental resources and conserve natural resources and biodiversity” (WTO 2018a) while ensuring economic stability through employment has had a positive impact on the environment.

As SDG 8 crosscuts the social, economic and environmental dimension of sustainable development, it is inextricably connected to many other SDGs. Neglecting progress on SDG 8 will hinder the achievement of other SDGs, including poverty eradication (SDG 1), ensuring good health and well-being (SDG 3), gender equality (SDG 5), reducing inequalities (SDG 10) and fostering peace, justice and stable institutions (SDG 16).

Figure 4.4.1. Correlation analysis results for SDG 8 indicators



Domestic material consumption (DMC – SDG indicator 8.4.2/12.2.2) measures the total quantity of materials directly used within an economic system measured in tons (Eurostat 2018). The indicator is used to identify the raw materials that serve the consumption of a country (by excluding materials and products that are exported) as well as which material categories are the hotspots for DMC-related resource management measures. The indicator is a production-side measure that does not account for supply chain inputs.

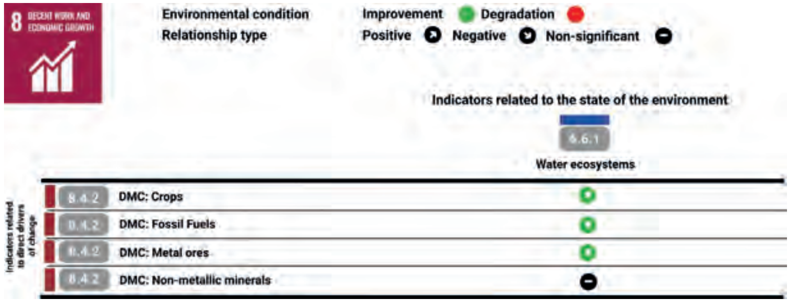
The use and consumption of raw materials is of specific relevance to nature as the extraction, processing, use and disposal of raw materials causes a series of environmental pressures and related impacts (IRP 2017). For instance, to extract raw materials, often virgin areas need to be modified or destroyed. During the process of extraction often emissions are produced, water and energy are used, water bodies are polluted, and so on. Similarly, emissions and air pollution occur in other phases of the life cycle of raw materials.

DMC equals the sum of raw materials extracted domestically, plus the mass of imported goods and raw materials and minus the mass of exports, making it an indicator of direct raw material use. A country can decrease its DMC by reducing domestic extraction or imports or increasing exports. The indicator does not include indirect flows – those raw materials that were extracted along the supply chains of the imported (and exported) goods. To account for these raw materials, analysts would need to use the 'material footprint', which is the second indicator used for targets 8.4 and 12.2. For monitoring within the SDG framework, DMC is reported for different types of raw materials including fossil fuels, metal ores, non-metallic minerals, crops, wild catch and harvest, and wood.

4.4.1. Water ecosystems (SDG indicator 6.6.1) and DMC (SDG indicator 8.4.2/12.2.2)

The analysis indicates a significant positive relationship between DMC of crops, fossil fuels and metal ores and the extent of water ecosystems. This is unexpected, as an increase in the harvest of crops as well as in the extraction of fossil fuels and metal ores most likely goes hand in hand with an increase in water use (Nair and Timms 2020). As a consequence, pressure on water ecosystems rises (Lutter *et al.* 2016). Excessive use of artificial fertilizers leading to eutrophication (Daniel, Sharpley and Lemunyon 1998) and mineral extraction through unknown fracking fluids (Howarth, Ingraffea and Engelder 2011) are the primary stressors of water ecosystems, both freshwater and marine. However, it is not only the use of water for the extraction processes, but also the expansion of extraction areas such as fields or mining sites, that come at the cost of other types of land cover, such as water ecosystems (Tost *et al.* 2018). A positive correlation would signify the contrary. The only scenario where this could be the case is when extraction is outsourced to other countries and more goods are imported, since fossil fuels and metal ores are not naturally available in all countries, as by that means less pressure is put on the domestic water resources. Interestingly, no correlation has been identified between water ecosystems and the DMC of non-metallic minerals. Non-metallic minerals are dominated by bulk materials such as sand and gravel, which require considerable area and often signify a considerable impact on the environment. Hence, a similar correlation as in the case of metals could have been expected.

Figure 4.4.2. Correlation analysis results for SDG sub-indicators of 6.6.1 and 8.4.2/12.2.2



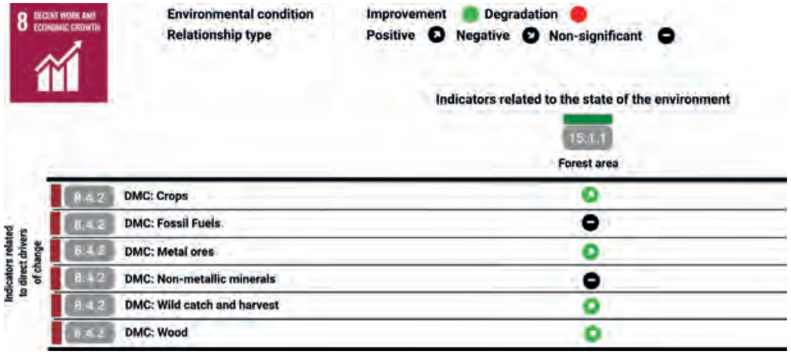
4.4.2. Air pollution (SDG indicator 11.6.2) and DMC (SDG indicator 8.4.2/12.2.2) ●

A significant positive correlation between DMC of fossil fuels and air pollution results from the analysis, which is almost self-explanatory. Fossil fuels are burned to produce energy. Apart from energy, other physical outputs of this process are CO_2 emissions and air pollutants (IEA 2018). When fossil fuels are burned, they release nitrogen oxides into the atmosphere, which contribute to the formation of smog and acid rain. It is hence only logical that an increase in DMC of fossil fuels also leads to an increase in air pollution. While there are differences among the specific types of fossil fuels regarding their impact on human health (indicator: disability-adjusted life year), it is clear that the goal to reduce the use of fossil fuels will also have positive effects on air pollution.

4.4.3. Forest area (SDG indicator 15.1.1) and DMC (SDG indicator 8.4.2/12.2.2)

The extraction of raw materials from the natural environment often involves substantial appropriations of land (Bruckner *et al.* 2015). For example, agriculture requires land to grow crops and process them in farms, while mining activities are normally very land intensive (Werner *et al.* 2020). In addition to the mining site itself, infrastructure to process the extracted material requires land. Hence, the extraction of this type of raw materials is always at the cost of other land uses or

Figure 4.4.3. Correlation analysis results for SDG sub-indicators of 15.1.1 and 8.4.2/12.2.2



		15.1.1 Forest area
8.4.2	DMC: Crops	🟢
8.4.2	DMC: Fossil Fuels	⊖
8.4.2	DMC: Metal ores	🟢
8.4.2	DMC: Non-metallic minerals	⊖
8.4.2	DMC: Wild catch and harvest	🟢
8.4.2	DMC: Wood	🟢

land covers, be it a natural environment, settlements or forest. Consequently, an increase in the DMC of crops, metal ores and wood often goes hand in hand with a reduction in the available forest area, which is in contrast with the obtained results. Hence, a positive correlation is rather surprising. Nevertheless, in cases where imports of these materials far exceed domestic extraction, it would be possible to see an increase in DMC while domestic forests are growing. In such a situation, the country of interest would be 'outsourcing' the extraction and related impacts to other countries (Bruckner *et al.* 2015).

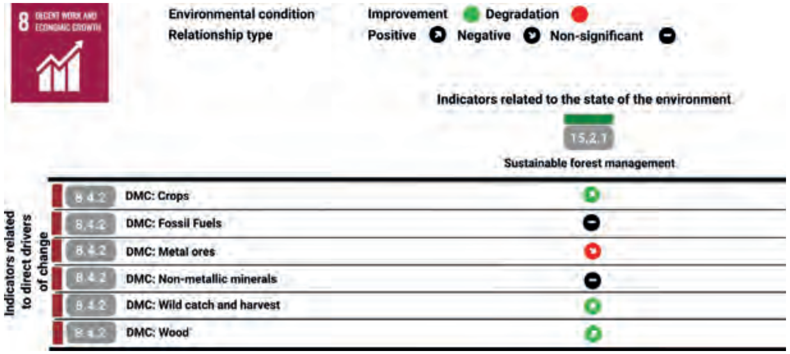
An interesting exception is the case of the DMC of wild catch and harvest. Here, an intensive use of a forest for the purpose of hunting, for instance, does not necessarily lead to an increase in forest area. On the contrary, the larger the forest, the larger the wild catch and harvest, which is explained by the significant positive correlation obtained in this analysis.

Interestingly, fossil fuels and non-metallic minerals show no significant relationship with forest area or sustainable land management. Apparently, these types of raw material uses do not necessarily take place in forest areas.

4.4.4. Sustainable forest management (SDG indicator 15.2.1) and DMC (SDG indicator 8.4.2/12.2.2)

The substantial appropriations of land cause land cover to change and, depending on the material extraction realized, cause above-ground biomass to be reduced. Hence, it is very likely that an increase in the DMC of metal ores goes hand in hand with a reduction in above-ground biomass (SDG sub-indicator of 15.2.1) (Austin *et al.* 2019), as the results of this analysis indicate. On the other hand, there are the unexpected results of positive correlations between the DMC of crops, wood, and wild catch and harvest and above-ground biomass, which might require in-depth research to analyse.

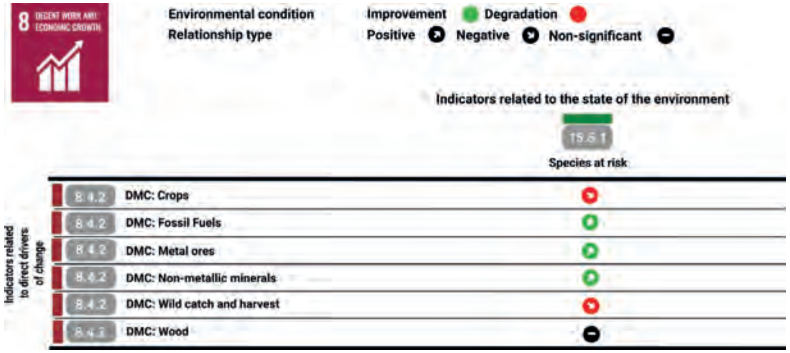
Figure 4.4.4. Correlation analysis results for SDG sub-indicators of 15.2.1 and 8.4.2/12.2.2



		15.2.1 Sustainable forest management
8.4.2	DMC: Crops	🟢
8.4.2	DMC: Fossil Fuels	⊖
8.4.2	DMC: Metal ores	🔴
8.4.2	DMC: Non-metallic minerals	⊖
8.4.2	DMC: Wild catch and harvest	🟢
8.4.2	DMC: Wood	🟢

4.4.5. Species at risk (SDG indicator 15.5.1) and DMC (SDG indicator 8.4.2/12.2.2)

Figure 4.4.5. Correlation analysis results for SDG sub-indicators of 15.5.1 and 8.4.2/12.2.2



		15.5.1 Species at risk
8.4.2	DMC: Crops	🔴
8.4.2	DMC: Fossil Fuels	🟢
8.4.2	DMC: Metal ores	🟢
8.4.2	DMC: Non-metallic minerals	🟢
8.4.2	DMC: Wild catch and harvest	🔴
8.4.2	DMC: Wood	⊖

An increase in material extraction destroys the potential habitats of different species. This holds true for all the different categories of raw materials. Agricultural areas normally do not provide the same habitat properties as natural vegetation (Emmerson *et al.* 2016), while the consumption of wild catch and harvest has a negative impact on habitats and biodiversity. This is reflected in the results, which suggest that an increase in the consumption of crops and wild animals and plants is accompanied by an increase in the extinction risk of wild species. In contrast, active mining sites are areas without vegetation. Hence, it is surprising to see a positive correlation with fossil fuels, metal ores and minerals, as it might be assumed that an increase in the DMC of these materials would be accompanied by an increase in the extinction risk of species. A non-significant relationship between DMC of wood and species extinction risk is surprising considering the detrimental impacts of deforestation on biodiversity.

4.4.6. Water ecosystems (SDG indicator 6.6.1) and tourism economic contribution (SDG indicator 8.9.1) 🔴

The analysis shows a weak negative relationship between tourism economic contribution and water ecosystems. In fact, as demand for water activities grows, improved infrastructure and services are needed to accommodate the influx of tourists to water-related sites. For instance, the tourism industry in the Republic of South Africa employs around 10 per cent of South Africans, yet freshwater ecosystems degradation is tangible. The relocation of local communities to the Inanda Dam/uMngeni River to settle down and provide tourism services is increasing river pollution (Houdet, Lewis and Browne 2020). Environmental awareness is limited in the Republic of South Africa which, coupled with a lack of implementation of the Water and Sanitation Master Plan on protecting and restoring ecological infrastructure, further degrades water ecosystems.

Swimming, boating and angling are all touristic activities that have a significant impact on water ecosystems, through the discharge of nutrients, fuel discharge through the increased number of commercial touristic boats, power boats or fishing boats, and the introduction of new fish species to attract tourists (Dokulil 2014). In the Socialist Republic of Viet Nam for instance, pollution from wastewater originating from tourist boats is contributing to 30 per cent of the pollution load from the local population in Ha Long Bay (WTO 2020b). Another study conducted in a small forested mountain catchment in the Black Forest in Germany has indicated that water quality in the uninhabited catchment has been contaminated by bacteria and turbidity, ammonium nitrogen and total nitrogen from the construction site of a new restaurant to serve tourists (Siegwald and de Jong 2020).

4.4.7. Air pollution (SDG indicator 11.6.2) and tourism economic contribution (SDG indicator 8.9.1) ●

Given the accessibility of travel and other factors that facilitate travelling (visa facilitation, low fuel costs, the emergence of low-cost travel options, a rising middle class in many emerging economies), whether domestically or internationally, tourism had been one of the fastest growing sectors and is expected to keep growing steadily (WTO 2019b). Transportation used for tourism is mostly fuel-based, which has an impact on air pollution. For instance, CO_2 emissions specific to tourism in Germany accounted for 12.3 per cent of the total economy emissions while tourism products for internal tourism consumption (air and water transport services) in Italy accounted for 5.9 per cent of greenhouse gas emissions in 2015 (WTO 2020b). However, the results of the analysis indicate a non-significant relationship between tourism economic contribution and air pollution, inciting more in-depth research and analysis.

4.4.8. Forest area (SDG indicator 15.1.1) and sustainable forest management (SDG indicator 15.2.1) and tourism economic contribution (SDG indicator 8.9.1)

Figure 4.4.6. Correlation analysis results for SDG sub-indicators of 15.1.1, 15.1.2 and 8.9.1

Several touristic activities are forest-oriented including hiking, biking, winter sports and camping. The increasing number of 'nature lovers' impacts the forest ecosystem. In the Federal Democratic Republic of Nepal, tourism was encouraged as an economic alternative to subsistence farming in rural areas. The tourism sector impacted forest size through tree-cutting to provide firewood for cooking and heating and timber for building accommodation. Moreover, a study indicated that the greater the distance from touristic villages, the less forest was removed (Chaplin and Brabyn 2013).

In addition, the growing popularity of winter sports impacts forests further through the clearing of terrains and the use of heavy machinery to level and prepare the terrain for ski runs. During the construction and management of winter sports sites, the spread of invasive and synanthropic species is very high, threatening the natural ecosystem, along with the development of roads by cutting trees (Kňazovičová *et al.* 2018). These are in line with the results obtained by the analysis, indicating a negative relationship between tourism economic contribution and forest area. However, the analysis also indicates a non-significant relationship between tourism economic contribution and above-ground biomass and forest area annual net change (SDG sub-indicators of 15.2.1), which incite future research on comparing alternative uses of land, including for tourism.

4.4.9. Species at risk (SDG indicator 15.5.1) and tourism economic contribution (SDG indicator 8.9.1) ●

The analysis indicates a negative relationship between tourism economic contribution and species at risk. Touristic areas are expanding at the expense of animal habitats, whether through the expansion of touristic facilities and services in ecosystems that were once inhabited by animal species, through the insertion of touristic activities into remote areas that were once inaccessible to humans, or through animal hunting. These pressures force animals into migrating and can cause animal species sizes to shrink. For instance, a study conducted on birds indicated that 63 critically endangered and endangered bird species of marine, coastal and aquatic birds were threatened by tourism in hotspots in Polynesia-Micronesia and the Mediterranean Basin (Steven and Castley 2013).

4.4.10. Conclusion

The future of tourism is shifting more towards sustainable tourism and conservation of nature and biodiversity, along with the prospects of having indicators that better depict the interlinkages between tourism and the environment, economy and society. Sustainable tourism projects have been implemented in several touristic areas, with results indicating that tourism's economic contribution and environmental conservation can grow together. For instance, a project implemented in the Republic of Rwanda provided revenues of USD 396,000 for the year 2016–2017, which the local community reinvested in agricultural production and agroforestry activities that help prevent soil erosion and forest degradation. The project allowed local communities to shift from their dependence on forest resources to conserving these natural resources, contributed to wildlife conservation in Gishwati Forest and Buhanga Forest for chimpanzees and serval cats respectively and promoted the development of ecotourism activities (WTO 2018b).

In the Republic of Cuba's Las Terrazas Complex, the first tourism-based sustainable rural development project was created in 1994 to rehabilitate and preserve the area's environment by reforesting terraces. The complex had generated USD 13 million by 2016, of which 16 per cent was reinvested in reforestation, landscaping, biodiversity management, renewable energy use and other activities (WTO 2018b).

The complexity and cross-cutting contribution of tourism to the economy, society and the environment along with limited data integration, comparability and availability have created grounds for the Measuring the Sustainability of Tourism (MST) programme. MST was launched by the United Nations World Tourism Organization (UNWTO) in partnership with the United Nations Statistics Division and leading countries, with the support of the United Nations Statistical Commission, to develop an internationally agreed statistical framework that integrates different data sets to support the production of internationally comparable data on tourism's water and energy use, waste and emissions generations and land use, as well as relevant biodiversity information and tourism from an ecosystems perspective (WTO n.d.). In order to measure and and analyse the impact of tourism on the environment holistically, it is necessary to develop indicators that reflect this and that can isolate the effect and dependencies of tourism on the environment from those of other activities.

On the other hand, SDGs 8 and 12 call for a more sustainable use of natural resources, which implies a more efficient use of resources, to achieve 'decoupling' (United Nations n.d.). 'Absolute decoupling' describes a state where the economy grows while resource use is decreasing. 'Relative decoupling' refers to a situation where both the economy and resource use increase, but the first increases more rapidly than the latter (IRP 2017). Achieving a reduction in resource use, or more specifically in raw material use, would reduce pressure on the environment. One important means to achieving decoupling is to transform the economic system into a circular economy, where materials remain in the system as long as possible by means of product design that allows repair and remanufacturing, as well as reuse and recycling of materials (IRP 2019a). A key tenet of circular economies is that materials stay at their highest possible value for as long as possible to increase their lifetime and keep them out of waste scenarios. Circularity requires the cooperation, innovation and creativity of everyone involved and is a way to achieve sustainable production and consumption (UNEP Circularity Platform 2021).

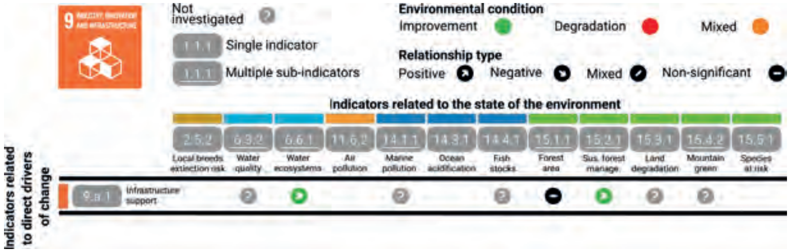
SDG 9: Industry, Innovation and Infrastructure

4.5. SDG 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

SDG 9 supports the need for industrial development to create dynamic and competitive economic performance that generates income and employment, facilitates international trade and increases resource efficiency, and is thus a major driver of poverty alleviation and shared prosperity (United Nations 2020).

SDG target 9.4 establishes the relationships between SDG 9 and nature. It promotes upgraded infrastructure and retrofitting of industries as part of a more sustainable approach. The goal demands increased resource efficiency and greater adoption of clean and environmentally sound technologies. Sustainable infrastructure plays a key role in conserving natural resources and addressing climate change impacts by reducing greenhouse gas emissions and environmental contamination and by managing natural capital (Murray 2019). Target 9.a facilitates resilient and sustainable infrastructure development through enhanced financial, technological and technical support for recipient countries. It provides essential services for societies including energy, waste management, transport and telecommunication. However, unsustainable infrastructure development can negatively affect ecosystems and the environment and thus increase human-induced burdens upon nature (Thacker *et al.* 2019). Progress in achieving SDG 9 in a gender-inclusive and sustainable manner enables governments and the private sector to provide services that contribute to individual livelihoods and economic growth, while improving the quality of life and human dignity (Murray 2019).

Figure 4.5.1. Correlation analysis results for SDG 9 indicators



4.5.1. Water ecosystems (SDG indicator 6.6.1) and total official development assistance for infrastructure (SDG indicator 9.a.1)

Conscious development of infrastructural support is necessary to ensure that water ecosystems are sustainable. Water-related ecosystems (including lakes, rivers, wetlands and groundwater) represent an essential resource for life on Earth. Their health and quantity impact humans and nature in various ways. Water-related ecosystems, as defined in the methodology of SDG indicator 6.6.1, include – in addition to the previously mentioned water ecosystems – artificial waterbodies, due to their significant freshwater storage capacity and the importance of measuring changes in their extent (UN-Water and UNEP 2020). On the other hand, official development assistance (ODA) for infrastructure includes projects related to hydropower and dam-building. Although the results of the analysis indicate a significant positive relationship between ODA for infrastructure and water body extent, threats to water-related ecosystems are driven by human activity (flood management and power generation, among others), which is a result of infrastructure projects (UN-Water and UNEP 2020).

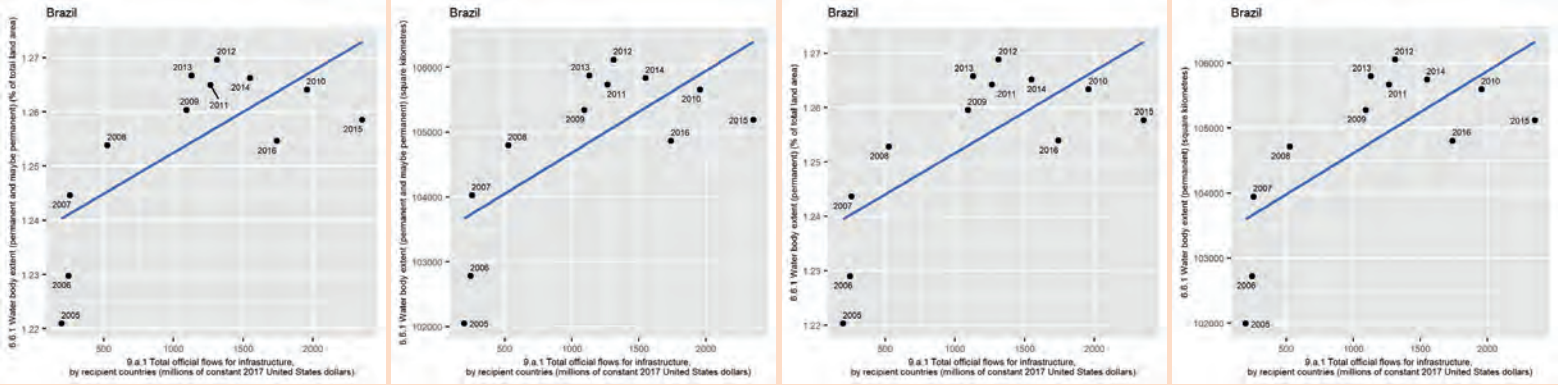
KEY NOTE 4. FEDERATIVE REPUBLIC OF BRAZIL – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS

The Federative Republic of Brazil emerges as a positive outlier in the correlation between official development assistance for infrastructure (SDG indicator 9.a.1) and water ecosystems (SDG indicator 6.6.1). The country is committed to conserving water ecosystems while developing infrastructure to aid in the growth of the energy sector and ensure urban water security. Robust population growth and the associated development of the agricultural and energy sectors have strained existing inland and marine water ecosystems. However, key policies that implement sustainable development have been established, providing avenues for conserving the country's water ecosystems.

In the case of in-land waters, developing dams and ensuring water supply for urban areas have required the construction of ecosystem-altering infrastructure. The Companhia de Gestão dos Recursos Hídricos (COGERH) was established in 1994 in order to support the growing infrastructures by "managing water resources and promoting access to water and contributing to sustainable development" in Ceará, Federative Republic of Brazil (COGERH n.d). Similarly, stemming from the country's water management goals, new policies, funding and projects have been rolled out in order to improve interdepartmental and interregional coordination around sustainable development of aquatic natural resources. These include the 1997 Brazilian National Water Resources Policy (Brazil, Porto 2000), the USD 66 billion received in 2018 in climate-related development finance for water and infrastructure in the form of grants and debt instruments (OECD 2018) and the World Bank-funded Federal Integrated Water Sector Project (World Bank 2020).

Critical development infrastructure is crucial for the growth of the nation's economy as well as improving the lifestyle of the Brazilian population. However, the country's aquatic ecosystems include key sites such as the Amazon basin and world heritage sites such as Pantanal and the Iguaçu National Park. Therefore, the Federative Republic of Brazil has created a great number of protected areas. Currently, official protection has been granted to 27 per cent of the Brazilian Amazon biome, 7 per cent of the Caatinga; 8 per cent of the Cerrado; 9 per cent of the Atlantic Forest; 5 per cent of the Pantanal; 4 per cent of the Pampas; and 3 per cent of the Brazilian Coastal and Marine zone (CBD n.d.a). Protection of these areas inhibits regional developmental in accordance with the country's 2020 Aichi Biodiversity Targets. Additionally, in regions beyond these protected areas, a strong conservation agenda is being relied upon in order to maintain aquatic ecosystems despite infrastructural development. Policies and projects such as the National Water Resources Policy and the Federal Integrated Water Sector Project enable stronger conservation efforts.

Figure 4.5.2. Brazil data for water body extent (SDG indicator 6.6.1) and official development assistance for infrastructure (SDG indicator 9.a.1)



Note: The blue line indicates the linear trend in the data.

4.5.2. Forest area (SDG indicator 15.1.1) and sustainable forest management (sub-indicator of 15.2.1) and total official development assistance for infrastructure (SDG indicator 9.a.1)

Figure 4.5.3. Correlation analysis results for SDG sub-indicators of 15.1.1, 15.2.1 and 9.a.1

Total ODA for infrastructure includes transport and storage, communications equipment, energy generation and distribution, banking and financial services, and business and other services (OECD n.d.). According to the OECD Creditor Reporting System, total ODA amounts have been increasing for all regions since 2000, with the highest increase in Africa. Moreover, climate-related development finance activities are published, covering 2008 onwards, to reflect on the ODA commitments for infrastructure projects within the aid activities targeting global environment objectives, covering climate change mitigation, climate change adaptation, biodiversity and combating desertification (OECD 2018).

On the other hand, the above-ground biomass in forests is a sub-indicator of sustainable forest management. Although the above-ground biomass expressed as tons per hectare has shown an increase since the year 2000, the global biomass stock decreased between 1990 and 2020, with the largest decreases in Africa and South America[24] (FAO 2020d). The statistical analysis indicates a weak positive relationship between infrastructure ODA and above-ground biomass in forests. However, infrastructure projects in forests, such as transportation or power-generation projects, enable population movements and agricultural expansion into the forest (Bebbington *et al.* 2018), hence they negatively impact the above-ground biomass in forests.

Global forest area (SDG indicator 15.1.1) decreased between 1990 and 2020. Although the decrease in forest area has slowed over the past decade, forest area loss is attributed to a shift in land use (cropping and grazing), insects, disease, severe weather and fires (FAO 2020b; FAO 2019a). The statistical analysis indicates a non-significant relationship between forest area and infrastructure ODA. Forest covers are minimally impacted by infrastructure projects such as roads. However, roads create indirect impact by improving access to forests that were not previously accessible and they can introduce additional pressures such as mining, hunting, logging and deforestation for agriculture (Laurance *et al.* 2017). This indirect impact can be mitigated through appropriate forest management that would address the additional pressures, especially an increase in the area of forest under management plans in all the regions and an increase in environmentally targeted aid commitments (FAO 2020b; OECD 2018).

4.5.3. Conclusion

The relationship between ODA for infrastructure and nature has shown improvement, based on the statistical analysis conducted, which hints that by fostering sustainable manufacturing, industrialization does not necessarily have to pose environmental concerns. New technologies and modernized production processes can allow for less resource-intensive utilization of inputs (UNIDO 2019). The recognition of new opportunities coming from sustainable industrialization and infrastructure has driven rapid progress in developing cleaner and more energy-efficient technologies and decarbonized transportation options (UNEP 2019b).

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[24] Regional grouping follows the Food and Agriculture Organization classification. For more information, please see http://www.fao.org/unfao/govbodies/gsbhome/council/council-election/en/

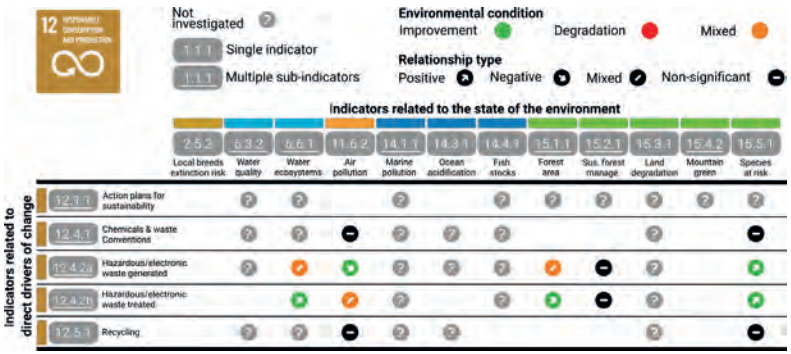
SDG 12: Sustainable consumption and production

4.6. SDG 12 Ensure sustainable consumption and production patterns

SDG 12 promotes social and economic development within the carrying capacity of ecosystems and decoupling economic growth from negative environmental impacts (Akenji and Bengtsson 2014). This originates from the fact that increasing demand for energy, food, water and other resources has resulted in resource depletion, pollution, environmental degradation and climate change. The links between SDG 12 and nature are firmly captured in the notion that the world is reliant on natural resources for growth and development. A measure of this reliance is the amount of primary material required to meet the basic needs for food, clothing, water, shelter, infrastructure, sanitation, energy and other aspects of life (United Nations 2020).

SDG 12 acknowledges the need to reduce natural resource exploitation and preserve the Earth's life-supporting ecosystems by realizing essential trade-offs between the growth and environment-related targets. Industrialization and globalization have led to increasing consumption patterns that generate vast amounts of waste and various pollutants that further harm the environment (ILO 2019). There is an urgent call to decrease society's reliance on virgin materials, increase recycling and promote 'circular economy' approaches to reduce environmental pressure and impacts.

Figure 4.6.1. Correlation analysis results for SDG 12 indicators

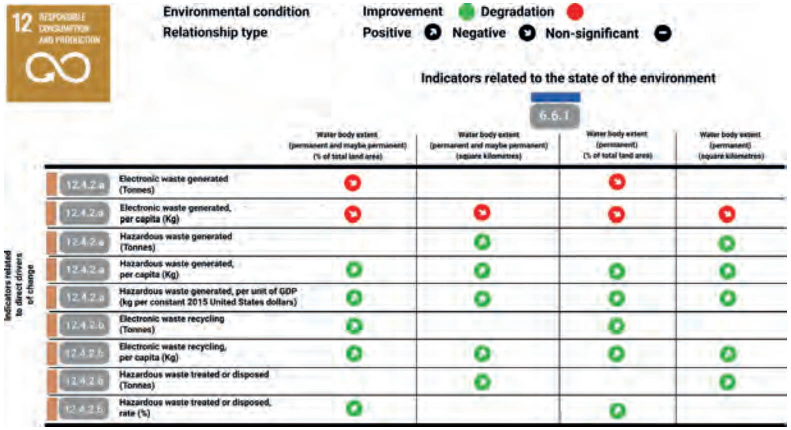


4.6.1. Air pollution (SDG indicator 11.6.2) and species at risk (SDG indicator 15.5.1) and chemicals and waste conventions (SDG indicator 12.4.1) ⊖

SDG indicator 12.4.1 on chemicals and waste conventions relates to the sharing of information between countries and the Secretariat of five multilateral environmental agreements (Basel Convention, Rotterdam Convention, Stockholm Convention, Montreal Protocol and Minamata Convention). The values of this indicator refer to the number of Parties that meet reporting commitments (parties to international multilateral environmental agreements on hazardous waste and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement). The values themselves do not represent any progress related to the implementation or not of any of the terms of the conventions. Hence, the correlation between this indicator and state of the environment indicators, namely air pollution (11.6.2) and species at risk (15.5.1), is non-significant.

4.6.2. Water ecosystems (SDG indicator 6.6.1) and hazardous and electronic waste generated (SDG indicator 12.4.2.a) and hazardous and electronic waste treated (SDG indicator 12.4.2.b)

Figure 4.6.2. Correlation analysis results for SDG sub-indicators of 6.6.1 and 12.4.2.a, 12.4.2.b



The unlawful discharge of untreated hazardous waste (sub-indicator 12.4.2.a) from various sources is a major threat to water-related ecosystems, causing adverse deleterious impacts. In developing countries, hazardous chemicals from fertilizers and pesticides used in agricultural activities present a significant source of water pollution. Results suggest a mixed relationship between the SDG 12.4.2.a and SDG 6.6.1 indicators (water body extent – permanent and maybe permanent in km^2 and percentage of total land area, water body extent – permanent in km^2) (Annex C). This can be attributed to the fact that hazardous waste is being generated and disposed of into the environment at rates greater than they can be safely managed, leading to the release of toxic substances that end up in water streams. Examples include the disposal of inorganic fluorine compounds used in a variety of industrial and manufacturing processes which can cause a decrease in the pH of ecosystems for extended periods of time, and the discharge of some acidic solutions used in the metal industry which, when exceeding a certain threshold, can also impact the pH level of aquatic ecosystems (Ascend Waste and Environment 2015).

On the other hand, increased use of recycled material in the production of electronic products has positively impacted the generation of hazardous waste. For instance in India, 95 per cent of e-waste collected has been recycled in the informal sector (ILO 2014), while Apple Inc. sourced 100 per cent recycled aluminium by using post-industrial aluminium waste generated during the manufacturing of their products in 2019 (Apple Inc. 2020).

Nevertheless, global production of e-waste (sub-indicator 12.4.2.a) is on the rise, with an estimated 53.6 million metric tons produced in 2019, which is equivalent to 7.3 kg per capita. This is expected to rise to 74.7 million metric tons or 9 kg per capita by 2030 (Forti *et al.* 2020). The proportion of hazardous waste treated to environmentally sound standards varies widely, with emerging economies struggling to meet the financial and technical demands needed to address hazardous waste production (UNEP 2016). The availability, affordability and innovations in electrical and electronic equipment encourages users to adopt a consumptive behaviour based on the need to upgrade to the latest innovations. This behaviour is detrimental, leading to an increase in e-waste. In 2019, the proportion of e-waste that was properly collected and recycled amounted to 17.4 per cent, while 7-20 per cent was exported to developing countries for second-hand usage (Forti *et al.* 2020). On the other hand, an increase in recycling rates of e-waste over time and proper handling and disposal can help minimize resource extraction by re-introducing the recycled products into the market, and reducing the disposal of contaminated material into water streams. This is explained by the positive relationship resulting from the statistical analysis between e-waste and water ecosystems (SDG indicator 6.6.1).

4.6.3. Air pollution (SDG indicator 11.6.2) and hazardous and electronic waste generated (SDG indicator 12.4.2.a) and hazardous and electronic waste treated (SDG indicator 12.4.2.b)

Figure 4.6.3. Correlation analysis results for SDG indicators of 11.6.2 and 12.4.2.a, 12.4.2.b

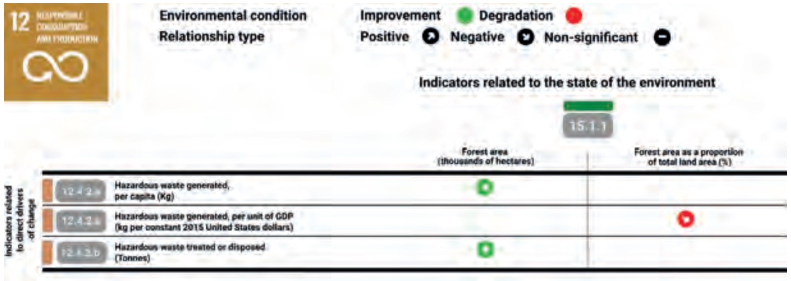
The increase in the world's population along with urbanization is contributing to air pollution. In lower income areas, indoor cooking and heating of homes with fuel sources such as wood, coal and kerosene produce high levels of fine particulate matter, carbon monoxide and other toxic pollutants. The correlation results (Annex C) highlight a mixed relationship between indicator 12.4.2 and the annual mean levels of particulate matter. The results also indicate a mixed correlation between hazardous waste treatment or disposal (sub-indicator 12.4.2.b) and the annual mean levels of particulate matter. The negative correlation could be attributed to the sound environmental disposal or treatment of hazardous waste, which then leads to decreased levels of particulate matter in the air. However, hazardous waste can cause an increase in particulate matter due to its radioactive and flammable properties when it is dumped, disposed of or processed inappropriately (United Nations 2010).

On the other hand, hazardous waste generated (sub-indicator 12.4.2.a) indicates a negative correlation with annual mean levels of particulate matter. It may be expected that as hazardous waste generation increases, air pollution would increase, yet this was not the case from the results. This might be related to the collection and disposal facilities for hazardous waste that are usually located outside urban areas, making the impact on urban particulate matter levels rather limited.

4.6.4. Forest area (SDG indicator 15.1.1) and hazardous and electronic waste generated (SDG indicator 12.4.2.a) and hazardous and electronic waste treated (SDG indicator 12.4.2.b)

Forests are important ecosystems carrying out important functions that enhance air quality. Trees can improve public health greatly by catching dust, ash, pollen and smoke on their leaves. However, from 2015 to 2020, the annual rate of deforestation was estimated at 10 million hectares, down from 12 million hectares between 2010 and 2015. The proportion of forest area globally declined from 31.9 per cent in 2000 to 31.2 per cent in 2020 (United Nations 2020).

Figure 4.6.4. Correlation analysis results for SDG sub-indicators of 15.1.1 and 12.4.2.a, 12.4.2.b



These losses in forest areas are mirrored in the disappearance of livelihoods in rural communities, increased carbon emissions, diminished biodiversity and the degradation of land (United Nations 2020). Results suggest a mixed relationship between hazardous waste generation (sub-indicator 12.4.2.a) and forest areas and a positive relationship between the treatment of hazardous waste (sub-indicator 12.4.2.b) and forest areas (Annex C). Air pollutants stemming from hazardous pollutants have been shown to cause changes in tree conditions, tree physiology and biogeochemical cycling which affect a tree's vulnerability to biological and environmental stressors. Forests are also susceptible to acid rain, which weakens trees by damaging their leaves and limiting nutrient availability. On the other hand, hazardous waste and more specifically e-waste contain hazardous substances such as lead, cadmium, mercury, persistent organic pollutants (POPs), asbestos and chlorofluorocarbons (CFCs) (UNEP 2019c). The capacity for environmentally sound management of such hazardous waste is still lacking in many developing countries and countries with economies in transition (UNEP 2019c).

4.6.5. Sustainable forest management (SDG indicator 15.2.1) and hazardous waste generation (SDG indicator 12.4.2.a) ⊖

Hazardous waste generation includes hazardous waste collected through municipal services or private companies, hazardous waste given by generators to treatment or disposal facilities, and an estimation of hazardous waste unaccounted for (UNSD 2020a). Although hazardous waste disposal impacts forests through leachate seeping into water streams or soil contamination through dumping, the results indicate a non-significant relationship between hazardous waste generated and disposed of (sub-indicator 12.4.2.a) and above-ground biomass (sub-indicator 15.2.1).

4.6.6. Species at risk (SDG indicator 15.5.1) and hazardous and electronic waste generated (SDG indicator 12.4.2.a) and hazardous and electronic waste treated (SDG indicator 12.4.2.b) ↗

The release of hazardous waste into the environment continues to have a significant role in its deterioration. Widespread use of pesticides significantly affects all species as they move along food chains and are biomagnified as they transfer from one species to the next. The contamination of polar bears in the Arctic is an example. Pesticides approved for use in the United States of America end up in the Arctic, transported along atmospheric oceanic and biological pathways and endangering the entire health of the Arctic ecosystems (Center for Biological Diversity n.d.). The hazardous chemicals in pesticides have the ability to result in suppressed immune function, endocrine disruption, reproduction-organ shrinkage, hermaphroditism and increased death in young of all species (Center for Biological Diversity n.d.). The results obtained draw a positive relationship where the increase in hazardous waste and e-waste generation (sub-indicators 12.4.2.a) is matched by a decrease in the extent of threat to species, which is generally not the case unless hazardous waste is generated in a different country. On the other hand, the results show a positive relationship between hazardous waste and e-waste treatment and recycling (sub-indicators 12.4.2), where an increase in treatment and recycling is matched with a decrease in threat to species at risk. This is somewhat self-explanatory, where appropriate treatment and recycling leads to reduced quantities of hazardous and e-waste dumped in nature that pose a threat to species.

4.6.7. Air pollution (SDG indicator 11.6.2) and species at risk (SDG indicator 15.5.1) and recycling rate (SDG indicator 12.5.1) ⊖

Recycling is based on the process of collecting used material and remanufacturing it into similar or other products for consumption. Recycling waste has positive impacts on the environment as it reduces the quantities of waste disposed of in landfills, incinerated or dumped in the environment. A study in Massachusetts in 2014 indicated a negative relationship between recycling rate and air pollution, where an increase in the recycling rate is matched by a decrease in air pollution, especially since waste that is recycled does not get incinerated or sent to landfill, which causes pollutants to be released into the air (Giovanis 2015). However, the results of the analysis indicate a non-significant relationship between the two indicators.

At the same time, the effect of recycling on species at risk is expected to be positive, especially since recycling has an impact on the quantities of waste being disposed of in various ecosystems. For instance, in 2014 a study of skin biopsies of endangered whale sharks revealed the extent of ingestion of micro- and macroplastics and the toxicity levels caused by plastic pollution in the Gulf of California (Fossi *et al.* 2017). Yet, the results of the analysis here indicate a non-significant relationship between species at risk and recycling rate. This could be linked to the availability and nature of the data that relate to the recycling of e-waste only, or it may be related to the unavailability of recycling rates for other products (UNSD 2020a). In addition, as waste is disposed of in various ecosystems, a more focused Red List Index aggregated by ecosystem type could provide a better understanding of the relationship between recycling rate and species at risk.

4.6.8. Conclusion

The mixed relationships assessed in this section affirm that although some drivers have been leading to environmental improvement, some are still causing environmental degradation. This highlights the need to improve the management of chemicals and waste to limit their interactions with nature. The rise in sound waste treatment that considers the human dimension and gender inequalities (for example in informal waste picking and household waste management and recycling, including e-waste) suggests there will be further improvements in reducing the impact of waste on nature and human health.

On the other hand, due to limited data availability, only a partial assessment of solid and hazardous waste impact on certain aspects of nature was presented. As more potential synergies have been identified in the methodology, the need for improved data availability on solid and hazardous waste, including e-waste, is imperative to provide a full assessment of the impact of chemicals and waste on nature.

SDG 14: Oceans

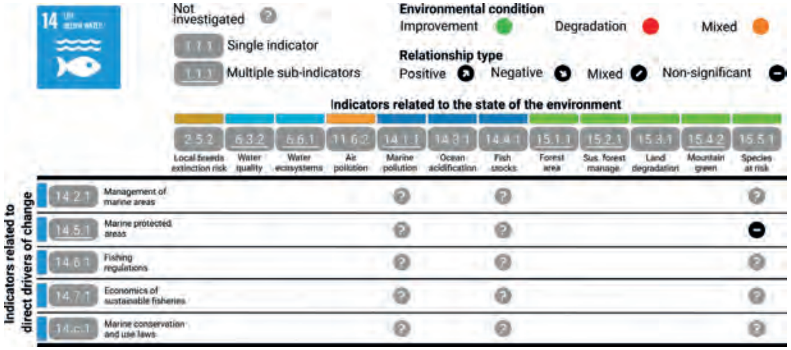
4.7. SDG 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Life below water (SDG 14) is one of the core SDGs on the state of the environment. SDG 14 is linked to all the other SDGs, with positive relationships (synergies) or potentially negative relationships (trade-offs) expected between particular targets. Achieving the targets of SDG 14 would yield many co-benefits for the achievement of other SDGs, particularly SDG 1 on poverty and SDG 2 on hunger as a result of sustainable use of marine resources (Singh *et al.* 2018; Ntona and Morgera 2018). The empowerment of women and promoting gender equality in coastal communities would greatly benefit the achievement of SDG 5 on gender equality. Trade-offs include the potential for expansion of marine protected areas (SDG target 14.5) to increase inequalities (SDG 10), if implemented without adequate social safeguards.

The 10 targets of SDG 14 are associated with maintaining and improving the health and productivity of the oceans and life within them. Some of the indicators measuring progress towards achieving these targets focus on the state of the environment, including fish stocks (SDG indicator 14.4.1), while others focus on responses, such as marine protected areas (SDG indicator 14.5.1). Others focus on the intensity of pressures impacting the marine environment, including for example coastal eutrophication potential (nitrogen and phosphorous loading) (SDG indicator 14.1.1).

Achieving all targets and indicators within SDG 14 could have many possible impacts on nature, either directly within the oceans or indirectly on other environment-related SDGs (IOC-UNESCO 2020). Direct relationships include biogeochemical cycles that influence carbon sequestration, interactions with the atmosphere that provide climate regulation, or interactions at the interface between marine and land ecosystems, for example through movements of animals (e.g. seabirds), salinization of aquifers and modifications of coastal ecosystems due to extreme events and sea-level rise. While none of these dynamics are captured by the SDG indicators, they are relevant to other environment-related SDGs: SDG 6 (clean water and sanitation), SDG 13 (climate action) and SDG 15 (life on land). Indirect relationships include the provision of marine and terrestrial food and resources, such as the relationship between fish supply and bushmeat hunting pressure (Brashares *et al.* 2004), which can thus indirectly impact terrestrial wildlife (SDG 15) as well as food security (SDG 2).

Figure 4.7.1. Correlation analysis results for SDG 14 indicators



4.7.1. Species at risk (SDG indicator 15.5.1) and marine protected areas (SDG indicator 14.5.1) ⊖

For all but one of the relationships that have been pre-identified as possible synergies, there is a lack of data to conduct the statistical analysis. Only marine protected areas (SDG indicator 14.5.1) possesses data that are available for most countries and for at least two years. The lack of data for the other indicators considered is either due to a lack of any national data for many sub-indicators, especially on fisheries, or a lack of time series.

In the first case, data sets exist at the global and regional levels, but fisheries data have not yet been reported at (or downscaled to) the country level for the reporting of fish stocks (SDG indicator 14.4.1). In the second case, there are at present no time series data for international instruments to combat illegal, unreported and unregulated fishing (SDG indicator 14.6.1).

The relationship between indicators 14.5.1 and 15.5.1 is not statistically significant. This was indeed expected as the Red List Index, used for indicator 15.5.1, contains species across realms, rather than specifically from the marine realm. It could therefore be interesting for future work to pull out marine groups within the Red List Index to identify possible synergies with the indicators pertaining to SDG 14 specifically.

4.7.2. Conclusion

Given the scope of the results for SDG 14, the main conclusions that can be drawn relate to the inadequate availability of data sets reported to test relationships between SDG 14 and other goals on nature, and that custodian agencies should strengthen both data collection and data-sharing at the country level.

Furthermore, there are plausible relationships not explored using the synergies matrix provided here, particularly with SDG 6 and within SDG 14. Given the interactions between watersheds and coastal water quality, synergies between SDG 6 and SDG 14 should be investigated in the future (IPBES 2019a).

SDG 15: Land and biodiversity

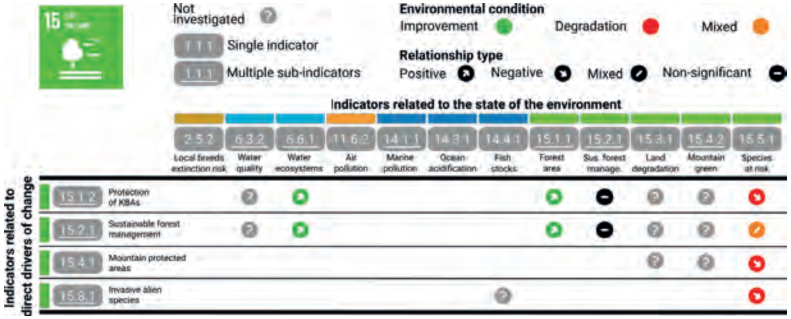
15 LIFE ON LAND

4.8. SDG 15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

The interrelationships between the environmentally related SDGs and their socioeconomic counterparts are powerful and ubiquitous but, frequently, also complex (Pradhan *et al.* 2017; Scharlemann *et al.* 2020). Both IPBES (2019a) and the Secretariat of the Convention on Biological Diversity (CBD) (2020a) mapped out suites of anticipated relationships between SDG 15 and other goals in this light. Here, the analysis considers the relationships generated by four anticipated direct drivers of positive trends upon the state of the environment: two related to protected area coverage of key biodiversity areas (SDG indicators 15.1.2 on protection of key biodiversity areas and 15.4.1 on protection of mountain key biodiversity areas) plus SDG indicator 15.2.1 on sustainable forest management and SDG indicator 15.8.1 on invasive alien species policy response.

This analysis evaluates the statistical relationships between these four indicators of direct drivers and five state of the environment indicators, the latter drawn from across three SDGs. These were SDG 2 (indicator 2.5.2 on local breeds), SDG 6 (indicator 6.6.1 on water ecosystems) and SDG 15 (indicators 15.1.1 on forest area, 15.4.2 on the Mountain Green Cover Index, and 15.5.1 on species extinction risk). Relationships were also considered for SDG indicators 6.3.2 on water quality, 15.2.1 on sustainable forest management and 15.3.1 on land degradation, but as they did not meet the requirement of having at least two data points per country since the year 2000, they were not analysed further.

Figure 4.8.1. Correlation analysis results for SDG 15 indicators



4.8.1. Water ecosystems (SDG indicator 6.6.1), forest area (SDG indicator 15.1.1), sustainable forest management (SDG indicator 15.2.1) and species at risk (SDG indicator 15.5.1) and protected area coverage of key biodiversity areas (SDG indicators 15.1.2 and 15.4.1)

Figure 4.8.2. Correlation analysis results for SDG sub-indicators of 6.6.1, 15.1.1, 15.2.1, 15.5.1 and 15.1.2, 15.4.1

Key biodiversity areas are "sites contributing significantly to the global persistence of biodiversity" (IUCN 2016). More than 16,000 such sites have been identified through national processes around the world (BirdLife International 2020). The identification of a site as a key biodiversity area has no necessary implication as to how that site should be managed, other than its management should be consistent with maintaining the biodiversity for which the site is significant (Smith *et al.* 2019). In practice, this means that such sites should be managed to maintain their biodiversity value through protected areas or through other effective area-based conservation measures.

A protected area is "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" (Dudley 2008), while another effective area-based conservation measure is "a geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity with associated ecosystem functions and services and where applicable, cultural, spiritual, socioeconomic, and other locally relevant values" (International Union for Conservation of Nature–World Commission on Protected Areas [IUCN-WCPA] Task Force on OECMs 2019). While documentation of the latter is just beginning, the former have been documented for many decades and there are now more than 240,000 protected areas worldwide (UNEP-WCMC and IUCN 2020). On average, approximately 45 per cent of the area of key biodiversity areas is now covered by protected areas (United Nations 2020).

Given the critical role of safeguarding important sites as the cornerstone of nature conservation efforts (Maxwell *et al.* 2020), it is perhaps unsurprising that this analysis revealed a number of positive relationships between protected area coverage of key biodiversity areas and state of the environment indicators.

Two of these are related to the extent of specific habitat types. The importance of biodiversity to both forests (Gibson *et al.* 2011) and wetlands (Ramsar Convention on Wetlands 2018) is well known, so the preponderance of forest and wetland habitats within key biodiversity areas is to be expected. Moreover, as protected areas have a demonstrated impact in reducing deforestation (Andam *et al.* 2008; Geldmann *et al.* 2013), countries with higher proportions of protected area coverage of key biodiversity areas should in turn, all else being equal, also have both more forest in absolute terms and more forest relative to their land area. While the benefits of protected area coverage for wetlands are less comprehensively demonstrated (Reis *et al.* 2017), a reasonable expectation would again be that countries with higher proportions of protected area coverage of key biodiversity areas should in turn also retain more wetlands. This analysis supports all of these expectations, revealing positive relationships between protected area coverage of both freshwater and terrestrial key biodiversity areas, absolute forest and wetland extent, and forest cover relative to national area.

Some countries emerge as positive outliers in the correlations between protected area coverage of key biodiversity areas and forest area, notably the Gabonese Republic, the Dominican Republic, the Republic of Cuba, the Kingdom of Bhutan, the Socialist Republic of Viet Nam, the People's Republic of China, most of the Eastern European group of Member States, the Hellenic Republic (Greece), the French Republic (France) and the Republic of Italy. These countries have both disproportionately high protected area coverage of key biodiversity areas and also disproportionally high forest cover. While such coarse-scale correlation analysis cannot reveal the impacts of specific national policy drivers in determining these results, and certainly many gaps remain in the protected area coverage of biodiversity even in these countries (Butchart *et al.* 2015), these outliers do reveal the feasibility of national-level high performance across multiple environmental indicators and across both high- and low- income countries.

Protected area coverage of key biodiversity areas is also well documented to provide benefits in reducing species extinction risk: species for which important sites are well covered by protected areas are declining towards extinction at only half the rate of those that are poorly covered (Butchart *et al.* 2012). It is therefore counter-intuitive that these analyses reveal a weak negative correlation between protected area coverage of terrestrial, freshwater and mountain key biodiversity areas, and the Red List Index, which tracks change in aggregate extinction risk over time (Butchart *et al.* 2007). This reveals the limitations of correlation analyses of data aggregated to the national level, where the benefits of individual protected areas are overwhelmed by coarse-scale variation between tropical and temperate countries. This coarse-scale variation is driven by both underlying biogeography (many more vulnerable species live at low latitudes, especially in island nations) and socioeconomic capacity (much more conservation action and investment occurs in high latitude countries) (Balmford *et al.* 2003).

4.8.2. Water ecosystems (SDG indicator 6.6.1), forest area (SDG indicator 15.1.1), sustainable forest management (SDG indicator 15.2.1) and species at risk (SDG indicator 15.5.1) and sustainable forest management (SDG indicator 15.2.1)

Figure 4.8.3. Correlation analysis results for SDG sub-indicators of 6.6.1, 15.1.1, 15.2.1, 15.5.1 and 15.2.1

Forests provide valuable economic and ecosystem services, as a source of timber and non-timber forest products and in the provision of a range of ecological and social benefits. From an ecological perspective, forests store carbon, purify the atmosphere and water, cycle key nutrients and provide habitats for species. Forests also play a key role in recreation and human well-being and are important cultural resources for indigenous peoples, whose relationship with the forest is based on a long history of traditional knowledge, passed down through generations (Parrotta, Yeo-Chang and Camacho 2016; Brockerhoff *et al.* 2017). Forests not only support biodiversity, but depend on it – in particular forest species – for ecosystem function, resilience and delivery of all these ecosystem services (Kümpel *et al.* 2016; Green *et al.* 2020).

Recognizing the importance of conserving the world's forests, the Statement of Forest Principles was developed at the Earth Summit in Rio de Janeiro in 1992. Since then, other criteria and indicators for monitoring the sustainable use of forests have been developed for temperate and boreal forests (Montréal Process), for forests in Europe (Helsinki Process) and for tropical forests (guidelines developed by the International Tropical Timber Organization (Siry, Cubbage and Ahmed 2005). Most recently, and building on the 2030 Agenda for Sustainable Development, the United Nations Strategic Plan for Forests 2017–2030 has been developed, containing six Global Forest Goals and 26 associated targets to be achieved by 2030, which are voluntary and universal (DESA 2017).

Sustainable forest management is the focus of SDG target 15.2 and is defined by the United Nations General Assembly (A/RES/62/98) as a "dynamic and evolving concept [that] aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations", and includes five sub-indicators, as previously stated in Chapter 2.

From the analysis undertaken here, sub-indicator (v) of 15.2.1, on forest area certified under an independently verified certification scheme, was found to be positively correlated with several predicted state of the environment indicators: both sub-indicators of 6.6.1 on permanent water body extent, indicator 15.1.1 on forest area and indicator 15.5.1 on species extinction risk. In contrast, sub-indicator (iv) of 15.2.1, on proportion of forest area under a long-term management plan, was negatively correlated with indicator 15.5.1 on species extinction risk.

Forest certification would also be expected to influence not only forest extent but also water extent. This would be both directly, as water management is a criterion in such schemes (e.g. Forest Stewardship Council 2015), and indirectly, where this is related to greater forest area, leading to higher water retention and therefore contributing to an increase in water body extent. In an EU-wide study (EEA 2015), water retention was 25 per cent and 50 per cent higher in catchments that had 30 per cent and 70 per cent forest cover, respectively, compared with a catchment with only 10 per cent forest cover. Moreover, catchments with any forest cover had 25 per cent greater water retention in the summer compared with the winter.

The first criterion of the Montréal Process for assessing sustainable forest management is the conservation of biological diversity (Siry, Cubbage and Ahmed 2005), recognizing the importance of forests in providing habitats for species. Accordingly, sub-indicator (v) of 15.2.1 on forest management certification schemes was shown to be positively correlated with the Red List Index (SDG indicator 15.5.1). However, surprisingly, 15.2.1 sub-indicators (iv) on implementation of long-term forest management plans and (iii) on proportion of forest area located within legally established protected areas were apparently negatively correlated with the Red List Index (SDG indicator 15.5.1), contrary to what would be expected. The FAO Global Forest Resources Assessment has shown a steady increase in the proportion of forests in protected areas between 1990 and 2015, across all continents and globally (Morales-Hidalgo, Oswalt and Somanathan 2015). Hence, one would have expected to see a positive effect on threatened species. These results may be spurious correlations resulting from co-variation with coarse-scale factors, and it should be noted that all the correlations with indicator 15.5.1 were relatively weak and the model r-squared values were relatively low (between 0.25 and 0.35). Moreover, the Red List Index is driven by changes in extinction risk for species in all environments, not just forests. That said, the performance of protected areas in terms of biodiversity outcomes is influenced by a range of local and national factors such as location, deforestation pressure and enforcement. While there is strong evidence of benefits under certain governance regimes for the conservation of forest cover, this does not necessarily conserve the full range of forest species (FAO and UNEP 2020).

Looking at the results of the analysis as a whole, it is likely that the coarse-scale nature of the indicators – some of which mask variation at the national, taxonomic or ecosystem levels – may be causing some of these unexpected results. For example, it would be useful to check for correlations between sustainable forest management or protected area coverage of forest key biodiversity areas and a subset of the Red List Index relating to forest species, or forest area by forest type (e.g. primary, secondary or plantation forest as reported by the FAO), to gain a better understanding of the relationship between conservation action and conservation outcome in the forest context. More fundamentally, demonstrating genuine impact of drivers on state indicators requires robust counterfactual techniques be applied at the level of the individual interventions (Ferraro and Pattanayak 2006). Unfortunately, such data sets are not yet available at the level of most countries in order to allow these analyses; their development is an important activity in support of the 2030 Agenda for Sustainable Development over the coming decade.

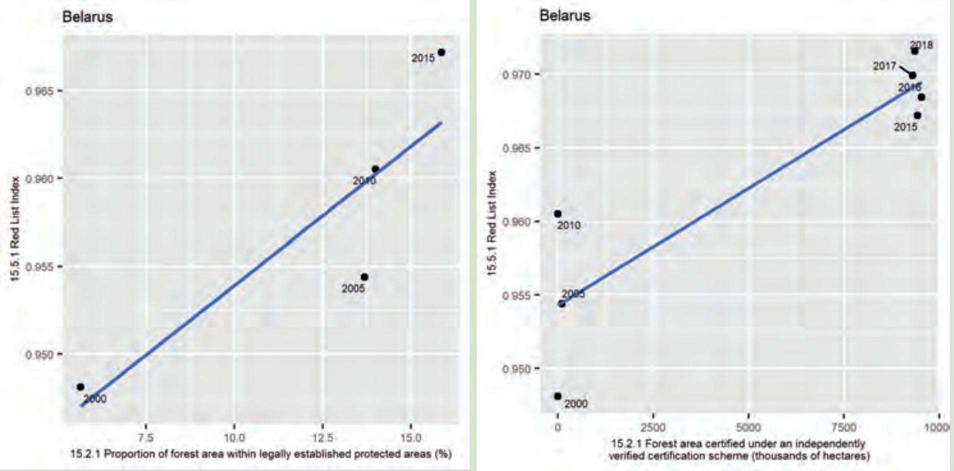
KEY NOTE 5. REPUBLIC OF BELARUS – EXAMPLE OF POSITIVE RELATIONSHIPS AMONG SDG INDICATORS

The Republic of Belarus emerges as a positive outlier in the correlation between sustainable forest management (15.2.1) and species extinction risk (15.5.1). The country is home to substantial temperate and boreal forest ecosystems, including one World Heritage Site and two UNESCO Biosphere Reserves (Republic of Belarus, Ministry of Natural Resources and Environmental Protection of Belarus n.d.). Several species have been successfully protected and some removed from the Red Data Book as the result of a number of conservation projects (CBD n.d.b) and it is one of the few countries reporting decreasing biodiversity extinction risk measured by 15.5.1 (Red List Index) and progress towards achieving Aichi Biodiversity Target 12 regarding species extinction prevention (Buchanan et al. 2020).

Particularly notable has been the reduction of extinction risk facing the European Bison (Bison bonasus), assessed as Vulnerable in 2008 but re-assessed as Near Threatened in 2020 (Plumb et al. 2020). Biodiversity concerns in the Republic of Belarus are addressed to a considerable degree by the national system of protected areas (UNDP Belarus n.d.), established as part of the national biodiversity action plan (2011–2020) (CBD n.d.b). The proportion of forest areas that are legally protected has more than doubled since 2000, measured by 15.2.1 proportion of forest area within legally established protected areas (percentage). In addition, state forestry regulations increased the forest cover that is sustainably managed under a certification scheme from none in 2010 to almost 10 million hectares in 2018, measured by 15.2.1 forest area certified under an independently verified certification scheme (thousands of hectares).

The country has a well-established legislative framework in relation to environmental protection. The Law on Protection of the Environment (2002) and the Law on Specially Protected Areas (2000) related directly to the protection and sustainable management of forests and biodiversity conservation (CBD n.d.b). More recently, key national strategies have been implemented to further develop biodiversity conservation efforts in the country. The National Strategy for the Development of the Network of Specially Protected Natural Areas is a political effort to regulate the use of natural resources by strengthening interdepartmental relations, promoting public-private sector conservation efforts, implementing scientifically sound planning and improving conservation education in the country (Republic of Belarus, Council of Ministers 2015). Another key priority is reflected through the National Strategy for the Conservation and Sustainable Use of Biological Diversity in the Republic of Belarus (Republic of Belarus, Council of Ministers n.d), although it omits the role women can play in protecting biological diversity. Through this strategy, Belarus aims to identify natural areas in need and then monitor and manage the biodiversity in the region. Through such strategies that aim to re-enforce the country's conservation goals, critical projects are being developed, leading to natural areas being prioritized over economic development. The Forestry Development Project and the Global Environmental Facility funded Wetlands project are just two of many examples that follow the conservation strategy while not inhibiting economic development.

Figure 4.8.4. Country data for the Republic of Belarus for SDG indicators 15.2.1 and 15.5.1



Note: The blue lines indicate the linear trend in the data.

4.8.3. Species at risk (SDG indicator 15.5.1) and invasive alien species policy response (SDG indicator 15.8.1)

Invasive alien species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity (CBD n.d.c). IAS can have serious negative consequences on the environment by driving biodiversity loss and species extinction through outcompeting or preying on native species, acting as vectors of disease or changing ecosystems (Clavero and García-Berthou 2005; IUCN n.d.b). As examples, Rinderpest virus (now eradicated) and the aquatic fern *Salivinia molesta* have been ranked by experts in the past as the worst IAS (Courchamp 2013) and are among the 100 worst global IAS compiled by the Global Invasive Species Database (Invasive Species Specialist Group [ISSG] n.d.).

The costs associated with managing IAS are high, with estimates ranging from EUR 12 billion to 20 billion in the EU (Institute for European Environmental Policy [IEEP] n.d.), USD 40 billion in the United States of America (Nuwer 2016) and AUD 13.6 billion in Australia (Hoffmann and Broadhurst 2016). SDG indicator 15.8.1 measures the proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species. Based on data from the IUCN Red List Index (which also underpins SDG indicator 15.5.1), IAS are a major driving factor in the decline of 16.6 per cent of species in the extinct or threatened categories (McClure *et al.* 2018). Hence, one would expect that countries that have introduced legislation and adequately resourced the prevention and control of IAS should see a reduction in species at risk of extinction.

The analyses undertaken here, however, seem to reveal a negative relationship. This counter-intuitive finding may be the result of a spurious correlation arising from co-variation with coarse-scale factors, or because the indicator for 15.8.1 is based on a binomial (yes/no) measure for each country, thus limiting the appropriateness of a correlation-based analysis. Alternatively or additionally, it may be due to ecological time lags in the policy response. Watts *et al.* (2020) acknowledge the challenge of taking the effect of time lags into account when evaluating the effectiveness of conservation actions or when developing indicators and setting targets for biodiversity (Watts *et al.* 2020). They differentiate between generalist, specialist and sensitive species, each of which may react differently to the same intervention over different time periods. Using the woodland bird indicator in the United Kingdom of Great Britain and Northern Ireland as an example, they showed that it took more than a decade to see the positive effects of woodland creation on generalist species numbers, while the effect on specialist species was not yet visible in their time series. Hence, the positive effects of introducing legislation and resourcing for IAS may simply need a longer time frame to emerge than the time frame currently used in the analyses undertaken here. This explanation may also apply to other anticipated positive correlations that were not supported by analyses.

A final potential explanation could be the fact that legislation aimed at IAS control is often only brought in at the point where IAS have become a threat, which would make consequent trends in extinction risk extremely challenging to reverse. Many countries either already had IAS legislation in place in 2000, or still had none in place in 2018, so the indicator remained unchanged in both cases. However, it is unclear whether this was because IAS are a long-established threat or, conversely, not yet a threat in these countries. Additional analysis to understand the impact of IAS in a country over time in relation to the timing of IAS legislation, as well as trends in IAS enforcement or funding over time, could provide further illumination on this point.

4.8.4. Conclusion

It is of no surprise that SDG 15 indicators focusing on life on land have an impact on the state of the environment, as these indicators are directly related to biodiversity. The realization of SDG 15 requires the effort and commitment of countries to conserving biodiversity and investing in expanding protected areas and reducing the impact of IAS. In addition, the current data coverage, coarse-scale nature of data, unavailability of some indicators and absence of country-level data aggregation to ecosystems types or the species level hinder the integrated assessment to demonstrate the genuine impact.

Chapter 5: Correlations between the state of society and the state of the environment

Although direct drivers of change have primary impact on the state of the environment, their secondary impact on the state of society has also been identified within the SDG global framework. These indicators are found in SDG 1 on ending poverty in all its forms everywhere, SDG 11 on making cities and human settlements inclusive, safe, resilient and sustainable, SDG 4 on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all, SDG 6 on ensuring availability and sustainable management of water and sanitation for all and SDG 7 on ensuring access to affordable, reliable, sustainable and modern energy for all. The interlinkages of state of society indicators and the state of the environment indicators are presented in detail in this chapter.

SDG 1: End Poverty

1 NO POVERTY

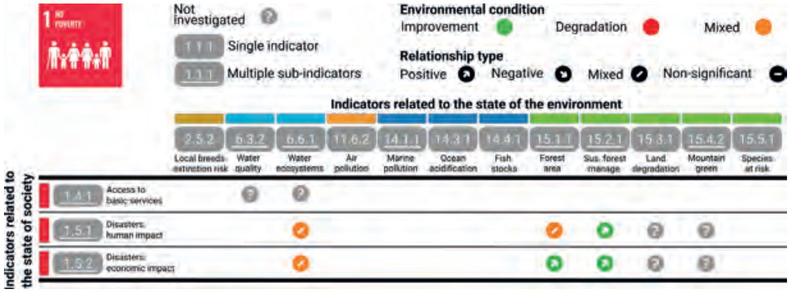
5.1. SDG 1 End poverty in all its forms everywhere

SDG 11 Make cities and human settlements inclusive, safe, resilient and sustainable

SDGs related to no poverty (SDG 1) and sustainable cities and communities (SDG 11) have strong and complex relationships with nature as the latter encompasses the quality of the air, fresh water and soils on which humanity depends, as well as climate variability that may lead to disasters (IPBES 2019a). Drastic changes in the natural environment can disrupt the human living environment, potentially resulting in casualties, economic losses that can exacerbate poverty, and damage to critical infrastructure. The world's cities occupy just 3 per cent of the Earth's land, but account for 60–80 per cent of energy consumption and 75 per cent of carbon emissions. Due to the high concentration of people, infrastructure, housing and economic activities, cities are particularly vulnerable to environmental extremes and long-term changes. This will only increase with the continued rise in urbanization that is predicted by 2050, with more than two-thirds of the world's population expected to live in urban areas (DESA, Population Division 2019).

The analysis identified two disaster-loss SDG indicators from SDGs 1/11 (1.5.1/11.5.1/13.1.1 on human impact and 1.5.2/11.5.2 on economic impact of disasters) to understand their potential correlation with state of the environment indicators. On the one hand, environmental extremes often have differential effects on populations and disrupt infrastructure, natural resources and other aspects of human settlements that could impact their sustainability. Vulnerable groups in many communities, including those suffering from poverty, have limited ability to deal with extreme events or to adapt to the long-term impact of changes in the natural environment. On the other hand, poor management of water, forests and other natural resources could increase the vulnerability of these systems to extreme climatic and other events, potentially reducing the ecosystem services they provide — including protection from environmental extremes.

Figure 5.1.1. Correlation analysis results for SDG 1/ SDG 11 indicators



5.1.1. Water ecosystems (SDG indicator 6.6.1) and number of deaths due to disasters (sub-indicator of 1.5.1/11.5.1/13.1.1) ●

In total, the number of deaths due to disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) is decreasing in absolute and relative terms based on the data gathered for those countries participating in the Sendai Framework monitoring process, as well as other global data sets (UNDRR 2019). The significantly negative relationship observed between the above indicators may reflect that most countries are better at reducing deaths in water-related disasters than other types of disasters. In fact, deaths from water-related disasters (such as flooding and drought) have decreased over the last two decades (Ritchie and Roser 2014), whereas earthquakes and extreme weather events (storms and extreme temperatures) are the main types of disasters currently responsible for loss of human life. Between 1998 and 2017, climate-related and geophysical disasters killed 1.3 million people globally (Wallemacq and House 2017). More specifically, low and lower-middle income countries were more greatly impacted by disaster deaths in the last 20 years than other income bracket (Wallemacq and House 2017).

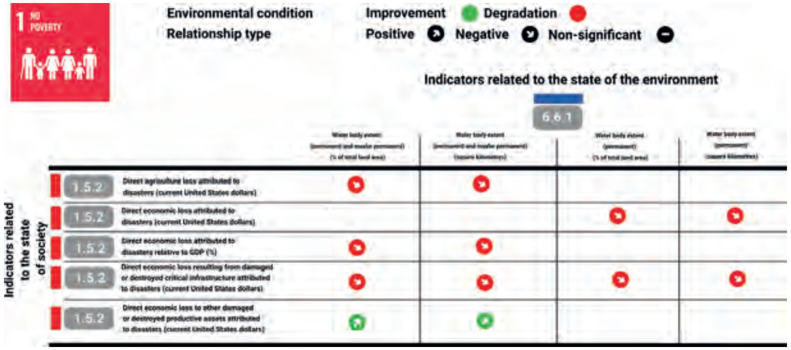
5.1.2. Water ecosystems (SDG indicator 6.6.1) and number of people whose livelihoods were disrupted or destroyed by disasters (sub-indicator of 1.5.1/11.5.1/13.1.1) ●

Water-related disasters or hydro-disasters are the result of complex interactions in the ocean atmosphere–land process cascade. Floods and droughts are expected to increase due to global warming (UNESCO n.d.). Humans are prone to living and working in water-rich areas, which leads to higher human exposure to water-related disasters. According to UN-Water, around 74 per cent of all natural disasters between 2001 and 2018 were water-related, and during the past 20 years floods and droughts affected over 3 billion people (UNESCO and UN-Water 2020). Although governments and communities may have developed various measures to reduce or avoid deaths caused by these disasters – such as through improved early warning systems – people's livelihoods might be disrupted or destroyed to a greater extent in the future, with higher human exposure to water-related disasters than other kinds of disasters. This may explain why a significantly positive relationship was observed with respect to economic impacts, but a negative one was apparent with respect to mortality.

These results underscore the need to pay attention not only to reducing casualties, but also to water resources management to avoid human livelihoods being disrupted or destroyed by disasters. The United Nations Educational, Scientific and Cultural Organization (UNESCO) estimated that by 2050, population growth in flood-prone lands, climate change, deforestation, loss of wetlands and rising sea levels would increase the number of people vulnerable to flood disaster to 2 billion (WWAP 2012). UN-Water lists several disaster risk reduction strategies including enhanced water storage, climate-proof infrastructure, crop resilience improvements through the introduction of flood- and drought-resistant crop varieties, flood and drought insurance, forecasting and early warning systems, land-use planning, and capacity-building (education and awareness) (UNESCO and UN-Water 2020).

5.1.3. Water ecosystems (SDG indicator 6.6.1) and economic loss (SDG indicator 1.5.2/11.5.2)

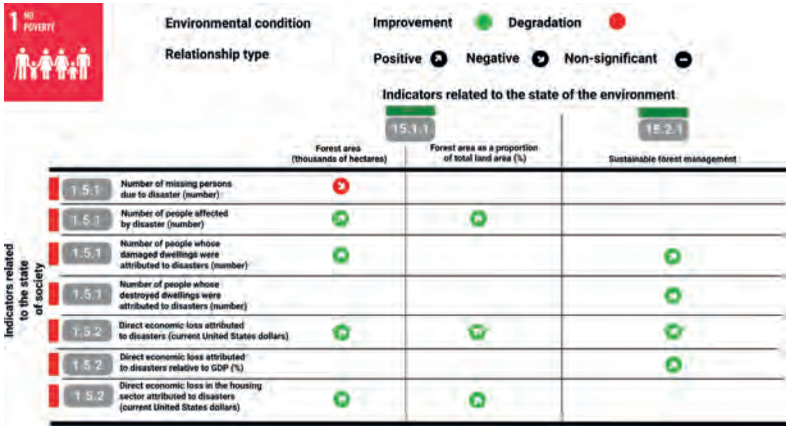
Figure 5.1.2. Correlation analysis results for SDG sub-indicators of 6.6.1 and 1.5.2/11.5.2



Here, water body extent is the sub-indicator used for 6.6.1 and the analysis indicates a mixed relationship between the pair of indicators. The significant negative relationship that was observed between economic loss (both direct economic loss and direct agriculture loss) due to disasters and water body extent suggests that economic development may be more susceptible to disasters in areas where water resources are not abundant, such as in sub-Saharan Africa where climate variability is associated with higher vulnerability to drought (Shiferaw *et al.* 2014). In these areas, it may make sense to give more attention to disaster risk reduction and prevention strategies related to drought, for example by adapting existing modes of production to address a higher incidence of water scarcity and by protecting limited water resources. For instance, integrated water management at the basin level can reduce disaster risks and its economic impact, through adopting measures and building infrastructure to retain water surplus. Retaining water surplus helps avoid flooding and can be used during drought periods (UNECE and UNISDR 2018). UN-Water (UNESCO and UN-Water 2020) suggests climate-smart agriculture (CSA) practices that could reduce the impact of disasters. Meanwhile, the relationship between water body extent and direct economic loss to other damaged or destroyed productive assets was observed to be positive. This may be due to the fact that productive assets are prone to be located near to water-abundant areas to reduce production costs.

5.1.4. Forest ecosystems (SDG indicators 15.1.1 and 15.2.1) and human and economic impact of disasters (sub-indicator of 1.5.1/11.5.1/13.1.1 and 1.5.2/11.5.2)

Figure 5.1.3. Correlation analysis results for SDG sub-indicators of 15.1.1, 15.2.1 and 1.5.1/11.5.1/13.1.1, 1.5.2/11.5.2



With growing population and infrastructure, the world's exposure to natural hazards is likely to increase. Often, land remaining available for urban growth is more risk-prone, for instance floodplains or steep slopes subject to landslides. Urban development may increase the area of impervious surfaces and reduce natural vegetative cover, with consequent effects on run-off and flood risk. Investments in flood control infrastructure often lag behind expansion of urban boundaries, especially in slums and informal settlements.

Ecosystem-based disaster risk reduction (Eco-DRR) – the sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience – has been embraced by a number of countries and organizations (Estrella and Saalismaa 2013). Forests sustain water supplies, protect the soils of watersheds and ameliorate the effects of natural hazards such as floods and landslides. More broadly, the ecosystem services derived from trees and forests provide a range of benefits to people, society and the economy at large. When effectively managed, ecosystem services can help reduce the vulnerability of communities to disasters, both in terms of reducing their physical exposure to natural hazards and providing them with the livelihood resources to withstand and recover from crises. However, forests themselves are increasingly exposed to the risk and impact of disasters, such as windstorms and wildfires. Forest-abundant countries generally have higher disaster vulnerabilities and intensities, due to their geo-location.

From the analyses undertaken here, the apparent relationships between human impact of disasters (sub-indicator of 1.5.1/11.5.1/13.1.1) and forest area (SDG indicator 15.1.1) or sustainable forest management sub-indicators (SDG indicator 15.2.1) at the national scale are subject to these interdependent processes.

Significant positive relationships were found between direct economic loss attributed to disasters (sub-indicator of 1.5.2/11.5.2) and forest area (absolute and percentage, SDG indicator of 15.1.1) and above-ground biomass in forests per hectare (SDG sub-indicator of 15.2.1). Countries with greater forest area or above-ground biomass per hectare coincide with tropical areas where there are greater numbers of disasters and higher direct economic losses attributed to disasters. This apparent relationship does not necessarily reflect the effects of sustainable forest management on the reduction of disaster impacts, but may represent the differential disaster vulnerability of different forest areas spatially. This could also help explain the positive relationships between (i) forest area (absolute and percentage, SDG indicator 15.1.1) and the number of people affected by disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) and the number of people whose damaged dwellings were attributed to disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1), and (ii) above-ground biomass in forests per hectare (SDG sub-indicator of 15.2.1) and both the number of people whose damaged dwellings were attributed to disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) and the number of people whose destroyed dwellings were attributed to disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1).

The negative relationship between forest area (sub-indicator of 15.1.1) and the number of missing persons due to disaster (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) contrasts with the finding that the number of people affected by disaster is positively correlated with forest area. The number of missing persons from natural disasters can be highly variable from year to year, which is dependent on low-frequency, high-impact events. The world has seen a significant reduction in numbers of missing persons through timelier predictions, more resilient infrastructure, emergency preparedness, and response systems. However, as forest area is declining globally, it cannot be an effective indicator for interpreting the reduction in numbers of missing persons due to disasters in general.

5.1.5. Conclusion

Many correlations appear significant but suggest complex relationships between national environmental and resource conditions and management approaches, and the observed impacts of natural disasters in different countries.

The statistical analysis shows that the water ecosystems indicator (SDG indicator 6.6.1) was significantly negatively correlated with the number of deaths due to disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) and positively correlated with the number of people whose livelihoods were disrupted or destroyed by disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1), but it has mixed correlation with indicators of economic loss (SDG indicator 1.5.2/11.5.2). Forest-related indicators (15.1.1 and 15.2.1) were significantly positively correlated with the number of people affected by disasters (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) and indicators of economic loss (SDG indicator 1.5.2/11.5.2) at the national scale, while the number of missing persons due to disaster (SDG sub-indicator of 1.5.1/11.5.1/13.1.1) was found to be negatively correlated with the total forest area.

Based on countries' current data availability, it is not possible to conclude that changes in water ecosystems or forest indicators would necessarily lead to changes in disaster outcomes — or the reverse, that reduced disaster impacts could lead to improved water ecosystems and forest management. In addition to income levels and population, the multivariate time series analysis should be extended to include, among other things, control for other potential common drivers of national differences, such as ecological or climatic factors, in order to further assess the direction and mechanisms of causality.

The Sendai Framework for Disaster Risk Reduction calls for stronger women's leadership and participation in disaster risk reduction and the integration of gender, age, disability and cultural perspectives into policies and practices (United Nations 2015). In addition, and in line with the suggestion by the United Nations Office for Disaster Risk Reduction (UNDRR), data in the disaster-loss databases should be disaggregated by event, hazard and geographic area, which should allow for more in-depth analysis in the future. Nevertheless, the observed correlations do support the premise that there are important linkages between the indicators and systems associated with SDGs 1, 6, 11 and 15 that need to be taken into account as countries work towards achieving the SDGs.

SDG 2: Food security

2 ZERO HUNGER

5.2. SDG 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture

The state of the environment is crucial to achieving SDG 2. Land, water, biological resources, and climate, among others, are key elements from nature that impact food provision and, consequently, nutrition and food security.

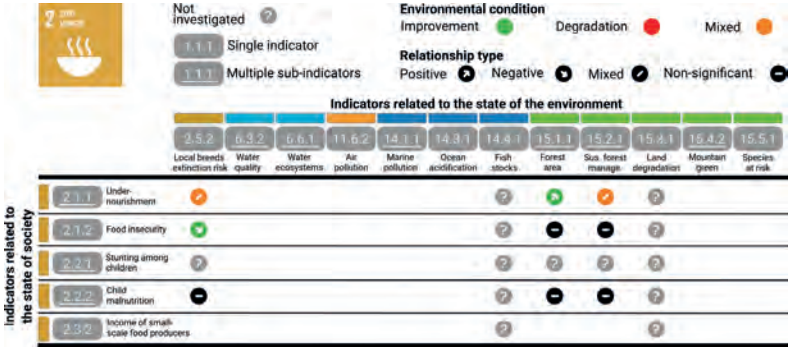
It is important to highlight the role that land plays and the important link between SDG 2 and SDG target 15.3 (land degradation neutrality). The indicator associated with the latter measures the proportion of land that is degraded over total land area. The connection between land, agriculture and nutrition is a direct one, as land-use change, conventional agricultural practices, and pesticide use can impact negatively on the health and diversity of pollinators (International Council for Science 2017). Many of the world's most important cash crops are pollinator-dependent crops such as coffee and cocoa in developing countries or almonds in developed countries (IPBES 2016). Also, many people depend on food gathered from natural ecosystems, such as forests, grasslands, oceans and rivers. Products supplied from nature are an important source of nutrition and thus contribute to household food security.

Genetic diversity in agriculture is one key element of food security. It helps ensure the evolution of species that can adapt to changing environmental conditions and gain resistance to diseases, pests and parasites. This diversity has been managed or influenced by farmers, livestock keepers and pastoralists, forest dwellers and fisherfolk for hundreds of generations and reflects the diversity of both human activities and natural processes. It can also reduce farmers' vulnerability to climate change. Further, it can provide diverse foods with multiple nutritional benefits (CBD 2020a).

A growing body of scientific evidence reveals how the way in which humans produce and consume food is taking a toll on the natural resource base and contributing to greenhouse gas emissions (FAO *et al.* 2020). It seems that economic gains are being prioritized over ecosystem health. The IPBES found that the value of agricultural crop production (USD 2.6 trillion in 2016) has increased approximately threefold since 1970. However, indicators of regulating contributions (such as soil organic carbon and pollinator diversity) have declined, indicating that gains in material contributions are often not sustainable. Furthermore, land degradation has reduced productivity in 23 per cent of the global terrestrial area (IPBES 2019a), which is posing a serious threat to food security around the world.

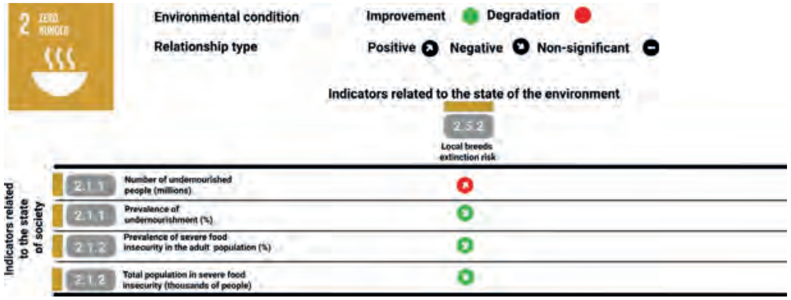
The use of sustainable approaches to agriculture offers opportunities to meet growing food demands while reducing adverse impacts on the natural resources that underpin the sector's long-term viability. In addition, traditional knowledge and practices inherited over generations by indigenous and local communities can often provide invaluable and proven measures of conservation and sustainable use of plant species and animal breeds (FAO 2020d).

Figure 5.2.1. Correlation analysis results for SDG 2 indicators



5.2.1. Local breeds extinction risk (SDG indicator 2.5.2) and undernourishment (SDG indicator 2.1.1) and food insecurity (SDG indicator 2.1.2)

Figure 5.2.2. Correlation analysis results for SDG sub-indicators of 2.1.1 and 2.1.2



There are four broad subforms of undernutrition: wasting, stunting, underweight and deficiencies in vitamins and minerals (WHO 2020). Countries and communities that maintain their indigenous food systems are better able to conserve local breeds and experience less undernutrition and fewer diet-related diseases (FAO 2010). Undernutrition makes children much more vulnerable to disease and death: in 2016, it was estimated that around 45 per cent of deaths among children under 5 years of age were linked to undernutrition, mostly in low- and middle-income countries (WHO 2020). Among adults, undernourishment derives from both a lack of quantity and quality of food sourced for consumption. In 2019, about 750 million people, including adults, were exposed to severe levels of food insecurity (FAO *et al.* 2020).

Local breeds include plant, animal, fungal and bacterial life associated with a particular area. Wheat, maize, rice (known as the 'mega crops') and other staples (such as plantains, lentils and groundnuts) are examples of the 150 or more species of plants upon which the world depends for food – a number that has decreased over time (Mbow *et al.* 2019). Half of the breeds of the world's domesticated species have been lost (Mbow *et al.* 2019). Such species have been used for human consumption for thousands of years (FAO 2010). However, biodiversity loss through anthropogenic drivers of change including urbanization, climate change and the simplification of food consumption (such as diets comprising of commercially processed products) is threatening food security, health and nutrition. This occurs not only through the loss of species but also through the loss in quality of local breeds consumed by communities, leading to negative health impacts, including undernutrition. The significant positive correlation between extinction risk of local breeds (SDG indicator 2.5.2) and the number of undernourished people (SDG sub-indicator of 2.1.1) is in line with these global trends, as it suggests that the number of undernourished people in a country increases in tandem with increases in the proportion of local breeds at risk of extinction. In contrast, the significant negative correlation between extinction risk of local breeds (SDG indicator 2.5.2), food insecurity (SDG indicator 2.1.2) and the prevalence of undernourishment (SDG sub-indicator of 2.1.1) are unexpected results that are difficult to explain.

5.2.2. Forest area (SDG indicator 15.1.1) and sustainable forest management (SDG indicator 15.2.1) undernourishment (SDG indicator 2.1.1)

For decades, deforestation has played a critical role in boosting food production. Agriculture accounted for around 80 per cent of deforestation worldwide (Hosonuma *et al.* 2012). Large-scale commercial agriculture (primarily cattle ranching and cultivation of soya bean and oil palm) accounted for 40 per cent of tropical deforestation between 2000 and 2010, and local subsistence agriculture for another 33 per cent (FAO and UNEP 2020). Especially in Latin America, the development of the local economy through harvesting of both wood and crops can help local people overcome poverty, thus leading to reduced prevalence of undernourishment (Sharma, Dwivedi and Singh 2016). Indeed, the significant positive correlations between undernourishment (SDG indicator 2.1.1) and forest area (SDG indicator 15.1.1) and forest above-ground biomass (SDG sub-indicator of 15.2.1) suggest that decreasing undernourishment is coupled with decreasing forest cover and forest biomass.

Figure 5.2.3. Correlation analysis results for SDG sub-indicators of 15.1.1, 15.2.1 and 2.1.1

However, it must be cautioned that the relationship between undernourishment and forests is indirect and dependent on many other factors. For instance, deforestation and undernourishment are presenting negative progress in terms of world trends, but more deforestation – to increase agricultural productivity – does not equate to less undernourishment, as the latter also reflects the quality of food, not just the quantity. Having constant access to quality and nutritious food is also dependent on other factors, including purchasing capacity.

In relation to indicator 2.1.1, the trends show a prevalence of undernourishment, which the IPBES considers as pointing to failed progress (IPBES 2019a). The 2019 Global Assessment Report on Biodiversity and Ecosystem Services clarifies that beyond hunger, a growing number of people have been forced to compromise on the quality and/or quantity of the food they consume, as reflected in the increase in moderate or severe food insecurity since 2014 (IPBES 2019a). Furthermore, even without considering the potential impact of COVID-19, projections for 2030 serve as a warning that the current level of effort is not enough to reach zero hunger 10 years from now (FAO *et al.* 2020).

The trends described here could change if there was a shift in agriculture systems. Sustainable agriculture and forestry address the supply of sufficient food, feed, biomass and other raw materials, while protecting natural resources. Halting deforestation is also essential for the sustainable transformation of food systems, through legal and sustainable forest value chains (FAO 2020e). Evidence suggests that enough food is produced globally and food scarcity mainly results from inadequate distribution, a lack of purchasing power, food waste and so on (FAO 2019c). This indicates the need for changes in food systems and transforming eating habits, which could help reduce undernourishment while increasing forest area and recovering forest from degradation.

5.2.3. Conclusion

The further negative development of the trends presented in this section would seriously hinder progress towards the SDGs. The situation is likely to deteriorate due to economic slowdowns and disruptions caused by the COVID-19 pandemic-triggered recession (Filho *et al.* 2020).

Given that forests and wild-animal-based diets are of great importance to nutrient security, providing diverse micronutrients (Friant *et al.* 2019), reforestation and proper forest management could help reduce the prevalence of undernourishment.

It would also be desirable to consider the role of diversification in strategies to improve production, productivity, employment, income, nutrition and sustainability, as well as its capacity to reduce risks associated with market volatility, climate change and natural disasters. As women's economic empowerment is linked to ending hunger, strategies that support the gender dimension for small-scale food producers must be developed.

Finally, it will be necessary to strengthen management of the relationships between these indicators via national, regional and international governance. This requires a co-design and co-development of mechanisms to mitigate the negative interactions and target particular resiliency needs by ensuring that poor and small-scale food producers' interests are fully addressed.

SDG 4: Quality Education

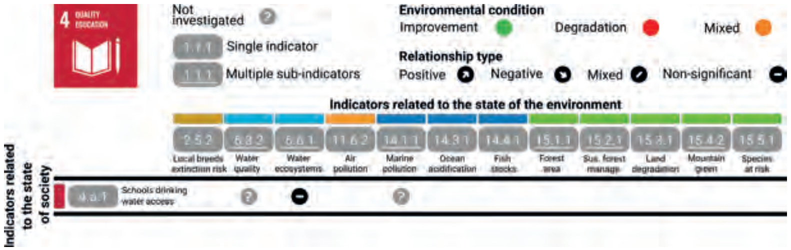
4 QUALITY EDUCATION

5.3. SDG 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

SDG 4 targets equitable quality education for all, through ensuring accessibility, affordability and equal rights for women and men to access primary, secondary, technical, vocational and tertiary education. Target 4.a focuses on education facilities and services provided within these facilities. Indicator 4.a.1 aims to build and upgrade education facilities that are child-, disability- and gender-sensitive and provide safe, non-violent, inclusive and effective learning environments for all.

Measuring schools offering key basic services, indicator 4.a.1 defines access to basic drinking water as having a functional drinking water source on or near the premises and having water points accessible to all users during school hours (UNSD 2020a). Lack of drinking water impacts a student's health and academic performance (UNICEF and WHO 2018). It also impacts school attendance, for example, if schoolchildren in some low- and middle-income countries no longer need to gather water, it frees them up to attend school. In 2016, nearly 570 million children lacked a basic drinking water service at their school and just one in 10 young people are on track to gain basic secondary skills by 2030 (UNICEF and WHO 2018).

Figure 5.3.1. Correlation analysis results for SDG 4 indicators



5.3.1. Water ecosystems (SDG indicator 6.6.1) and school drinking water access (SDG indicator 4.a.1) ⊖

Water-related ecosystems provide clean water for human consumption with respect to subsistence, agriculture, energy generation and other activities. Secure water supplies are needed to sustain healthy water-related ecosystems. Threats to water supplies include deforestation, change in land use and climate change (WHO n.d.a), leading to water scarcity (IUCN n.d.c). Increasing water use efficiency reduces the risk of water stress, reinforcing both economic and environmental resilience. Although globally, water stress remains at a 'safe' 17 per cent, this overall value masks regional variations. Northern Africa and Central and Southern Asia[25] register water stress levels above 70 per cent, followed by Western Asia and Eastern Asia with water stress levels of 45 per cent and 55 per cent, respectively (United Nations 2020).

Potential synergies between the indicators 6.6.1 (change in the extent of water-related ecosystems over time) and indicator 4.a.1 (proportion of schools with drinking water access) were deemed worth exploring a priori. The potential synergies between these indicators stemmed from the assumption that the change in extent of (i.e. increasing) water-related ecosystems over time could be positively related to access to water for drinking/sanitation purposes. However, no statistically significant relationship was identified between indicators 6.6.1 and 4.a.1. Without access to drinking water, SDG 4 cannot be achieved. For schools (and communities), obtaining safely managed drinking water services and sanitation requires infrastructure (for example piped water supply and water treatment works), human capacity and finances to get the drinkable water to the school (or community). For many low- and middle-income countries, these services are not available yet, especially in rural areas where people walk to water bodies and haul water to places where it is used (Desphande *et al.* 2020).

Clean water and sanitation cannot be provided to schools and communities if the extent of water-related ecosystems that supply water has decreased or shifted geographically. However, there are pathways that obscure a direct relation between the two (hence the non-significant findings). Many people living in rural areas extract water from water-related ecosystems. Since these ecosystems are also the drinking holes for livestock and may be located downhill from pit latrines, they can be polluted with contaminants that can cause life-threatening illnesses such as diarrhoea, cholera, dysentery and hepatitis (WHO n.d.b). If these polluted water-related ecosystems are used to supply water to schools and communities, there may be health-related consequences.

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[25] Regions and sub-regions are based on the SDG regional grouping detailed in Annex B and accessed from https://unstats.un.org/unsd/methodology/m49

5.3.2. Conclusion

A growing population increases the demand for water, for example in low- and middle-income countries, where reliance on surface water persists (UNEP 2019a). Globally, the water, sanitation and hygiene (WASH) programme is promoted to encourage personal hygiene practices and safe drinking water, thereby improving sustainable livelihoods and including adaptation interventions that work with nature to conserve water. Integrated water resource management, including WASH, remains essential.

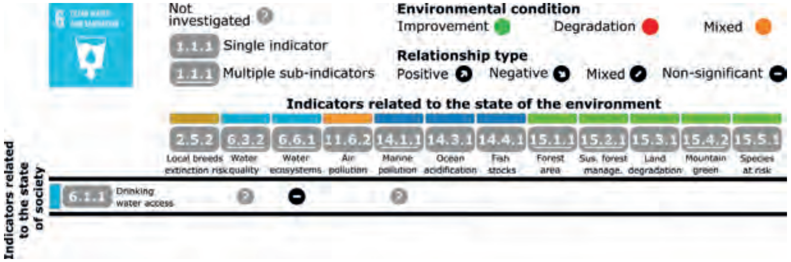
SDG 6: Water

5.4. SDG 6 Ensure availability and sustainable management of water and sanitation for all

Water is a natural resource upon which all life depends. The Earth's ecosystems are linked and maintained by water. SDG 6 focuses on drinking water and basic sanitation and includes the sustainable management of water, wastewater and ecosystems, with the purpose of addressing challenges linked to water scarcity, water pollution, degraded water-related ecosystems and cooperation over transboundary water basins (UNEP 2018b; United Nations 2020). Key actions include valuing the benefits and co-benefits provided by water-related ecosystem services; understanding and addressing land-use change impacts on water-related ecosystems; and prioritizing restoration and protection of source watersheds such as forests and critical basins (UN-Water 2018).

The link between SDG 6 and nature is firmly captured in target 6.6 which highlights the protection and restoration of water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. Such ecosystems play an important role in the global hydrological, carbon and nutrient cycles (UNEP 2018b). In addition, water-related ecosystems support water security, provide fresh water, regulate flow and extreme conditions, purify water and replenish groundwater (UNEP 2018b). Humans depend on water-related ecosystems to provide goods and services such as purified water for drinking purposes (WWAP 2018) for hygiene practices, to support agriculture, as well as energy generation, recreation and tourism. Water-related ecosystems underpin and depend on other SDGs, specifically those related to food (SDG 2), energy (SDG 7) and biodiversity (SDGs 14 and 15).

Figure 5.4.1. Correlation analysis results for SDG 6 indicators



5.4.1. Water quality (SDG indicator 6.3.2) and drinking water access (SDG indicator 6.1.1) ⊖

Water-related ecosystems comprise five categories: vegetated wetlands, rivers and estuaries, lakes, aquifers and artificial water bodies (UNEP 2018b). The latter include open water bodies created by humans, such as dams, reservoirs, canals, mines, quarries and rice paddies (UNEP 2018b). Although artificial water bodies are not traditional water ecosystems that necessarily need to be protected and restored, in some countries they hold significant amounts of fresh water and are therefore included as a water-related ecosystem category that should be monitored (UNEP 2018b).

Vegetated wetlands, which include swamps, fens, peatlands, marshes and mangroves, are critical water ecosystems that serve multiple purposes such as provision of food and water, regulation of flows of water, unique habitats for endangered species (IPBES 2018) and recycling of nutrients and waste. Over time, changes in the global extent of water-related ecosystems, including wetlands, have been difficult to assess due to a lack of data (United Nations 2020). Some evidence (UNEP 2019a) suggests that previously, the wetland extent trend index showed a negative trend, expressing both loss of natural wetland extent and significant loss of freshwater species. There is still a need for commitment to the Ramsar Convention (UNEP 2019a) to conserve wetlands. Potential synergies between indicators 6.6.1 (change in the extent of water-related ecosystems over time) and 6.1.1 (the proportion of the population using safely managed drinking water services) stemmed from the assumption that the change in extent of (i.e. increasing) water-related ecosystems over time could be positively related to access to water for drinking/sanitation purposes. However, no statistically significant relationship was identified between this pair of indicators.

5.4.2. Conclusion

While there are positive impacts from conserving water ecosystems where the preservation of water resources benefits nature and humans and helps to preserve forests and species at risk, water stress in many regions threatens progress to sustainable development. Lack of fresh water of adequate quality in low- and middle-income countries is increasing water scarcity. To date, funding for SDG 6 targets has been deemed insufficient and the global framework for water resources management shows a poor record of implementation (United Nations 2020; IPBES 2018). Unless significant progress is made, it is envisaged that SDG 6 targets will not be met by 2030, which in turn has impacts on the other SDGs (United Nations 2020).

SDG 7: Energy

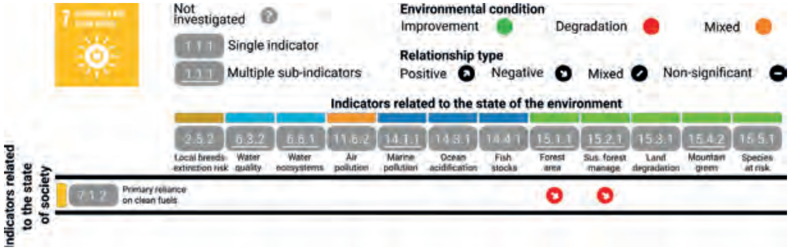
5.5. SDG 7 Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 7 aims to increase universal access to reliable energy, to increase the share of the renewable energy in the global energy mix, to double the global rate of improvement of energy efficiency, to enhance international cooperation to facilitate access to clean energy research and technology and to expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all.

Access to affordable, reliable, sustainable and modern energy is a pre-requisite for healthy lives and sustainable livelihoods across the globe. A lack of access to such energy sources poses significant economic, environmental and social challenges (ESCAP n.d.a). Modern energy access underpins socioeconomic development by enabling advancements in education, transport, communication and industrialization. Its connection to climate change adaptation and mitigation is of particular importance as global economic growth is strongly coupled with energy use (UNSD 2016). Recently, the urgent need for affordable and reliable energy for health facilities during the COVID-19 pandemic has been highlighted as well as the need for energy to deliver clean water to people to perform basic hygiene practices, such as handwashing (United Nations 2020).

5.5.1. Forest area (SDG indicator 15.1.1) and sustainable forest management (SDG indicator 15.2.1) and primary reliance on clean fuels (SDG indicator 7.1.2)

Figure 5.5.1. Correlation analysis results for SDG 7 indicators



Forests are key areas for conservation in SDG 15, aiming at ensuring conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements. The above-ground biomass stock in forests, as measured by indicator 15.2.1, indicates that the gains in biomass due to forest growth (due to natural expansion or anthropogenic activities) and losses due to wood removals and natural losses are interlinked. Sustainably managed forest areas could see increases in both forest areas and biomass stock (in tons per hectare), while unsustainable management practices could lead to the opposite (UNSD 2020).

In the results presented in Annex C, there is a weak negative relationship between indicators 7.1.2 and 15.1.1 and 15.2.1. One possible reason for this could be that, though there is a positive trend in the proportion of a population with primary reliance on clean fuels, the relative proportion of reliance on biomass fuels or non-renewable resources (especially in low- and middle-income countries) is still larger (International Institute for Sustainable Development [IISD] 2017), leading to a decrease in forest area and above-ground biomass in forest per hectare (tons per hectare). As this reliance on biomass fuels persists, forests are threatened by inefficient and unsustainable wood collection practices (FAO and UNEP 2020). Promoting sustainable wood/biomass harvesting practices therefore remains essential in order to conserve forests while aiming for a just transition to sustainable clean fuels using renewable energy sources.

5.5.2. Conclusion

Achieving universal access to clean fuel through affordable and sustainable energy sources requires populations, and more specifically women, to shift from unsustainable energy consumption practices for cooking, cleaning and lighting. Governments are encouraged to increase their investment to include renewable energy in the country's energy mix. This reduces the impact of using fuel-based sources and will lead to environmental improvement.

Chapter 6: Measuring progress towards the SDGs and strong environmental sustainability in Viet Nam and Kenya

6.1. Introduction

There are 92 environmental SDG indicators,[26] but only 12 indicators focus on the state of the environment or the pressures on it. Yet it is the pressures on the environment, or its increasingly degraded state, that will determine whether it can continue to function and contribute to the economy, health and welfare of human societies to the extent required, or desired, for societies to prosper and develop.

There are four core sets of environmental functions that human societies need: provision of resources (source functions), absorption of wastes (sink functions), maintenance of the biosphere (life-support functions), and provision of other contributions to human well-being (human health and welfare functions). The strong sustainability approach starts from the perception that these functions can very often not be provided by means other than the environment, i.e. by other forms of assets. Maintaining these functions, and the states of the environment that produce them, then becomes an important component of sustainable development, but one that is currently very imperfectly reflected in the environmental SDG indicators.

There are now significant concerns, clearly articulated in UNEP's sixth Global Environment Outlook (GEO-6) (UNEP 2019b), that natural assets are not in fact being sustained at the requisite level to deliver critical environmental functions, and will require restoration to do so. To give insights into efforts to improve this situation, there would seem to be a case for complementing the environmental indicators of the SDGs with a set of environmental indicators related to science-based standards that indicate the quantity or quality of natural assets required to perform essential environmental functions. The Environmental Sustainability Gap (ESGAP) framework of indicators and the associated Strong Environmental Sustainability (SES) index have been developed to meet this need, as described in the next section.

6.2. Towards an index of strong sustainability

UNEP and the Agence Française de Développement have been working with UCL to develop a set of indicators that will complement the environmental SDGs, based on a distance-to-target methodology that computes the environmental sustainability gap between current environmental conditions across a range of issues and science-based standards (Andersen *et al.* 2020) on those issues that would indicate that environmental functions were indeed being maintained at a sustainable level. This set of indicators could then be aggregated into the SES index to show the extent to which environmental sustainability, as defined by the standards, was being achieved in the country and, if computed on an annual basis, progress towards it over time.

The approach to developing the SES index is based on categorizing the indicators into topics that are linked to principles (renew renewable resources, prevent global warming, maintain biodiversity, etc.) that originate from the four sets of environmental functions (source, sink, life support and human health and welfare) (Table 6.1).

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[26] As of March 2020, the number of SDG environmental indicators has become 92 as a result of the Comprehensive Review.

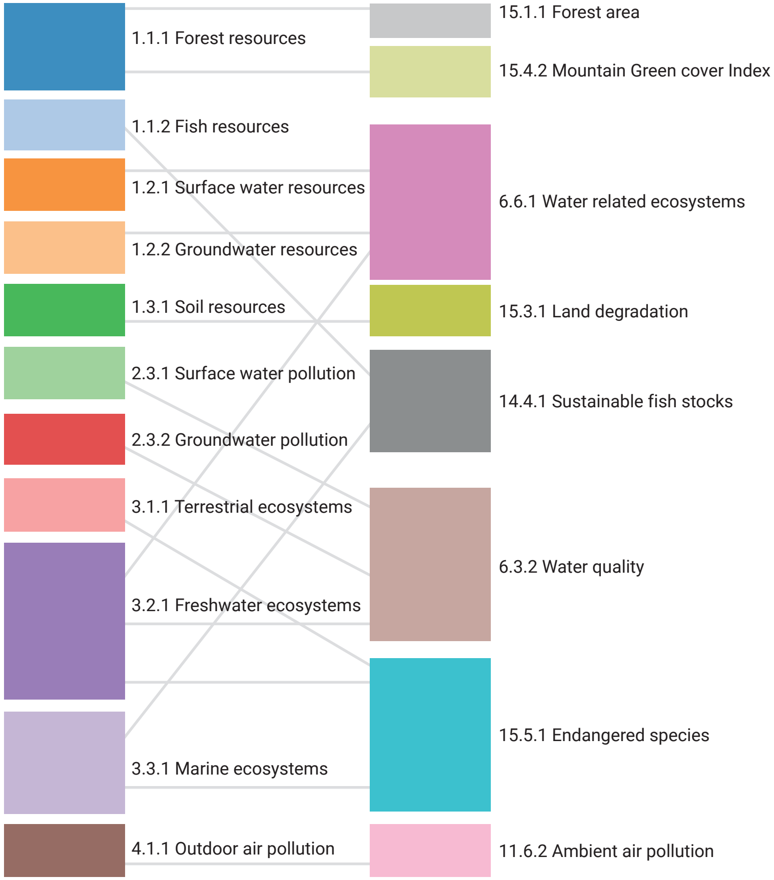
Table 6.1. The Environmental Sustainability Gap (ESGAP) approach and Strong Environmental Sustainability (SES) index

SES index	Function	Principle	Topic	Indicators
Strong Environmental Sustainability index (SES index)	Source	Renew renewable resources	Biomass	1.1.1 Forest utilization rate
				1.1.2 Fish stocks within safe biological limits
			Fresh water	1.2.1 Freshwater bodies not under water stress
				1.2.2 Groundwater bodies in good quantitative status
		Use non-renewables prudently	Soil	1.3.1 Area with tolerable soil erosion
	Sink	Prevent global warming and ozone depletion	Earth System	2.1.1 Per capita GHG/CO_2 emissions
				2.1.2 Stratospheric ozone depleting substances
		Respect critical levels and critical loads for ecosystems	Terrestrial ecosystems	2.2.1 Cropland and forest area exposed to safe ozone levels
				2.2.2 Ecosystems not exceeding the critical loads of cadmium/lead/mercury
				2.2.3 Ecosystems not exceeding the critical loads of eutrophication
				2.2.4 Ecosystems not exceeding the critical loads of acidification
			Freshwater ecosystems	2.3.1 Surface water bodies in good chemical status
				2.3.2 Groundwater bodies in good chemical status
			Marine ecosystems	2.4.1 Coastal water bodies in good chemical status
	Life support	Maintain biodiversity (especially species and ecosystems)	Terrestrial ecosystems	3.1.1 Terrestrial area with acceptable biodiversity levels
			Freshwater ecosystems	3.2.1 Surface water bodies in good ecological status
			Marine ecosystems	3.3.1 Coastal water bodies in good ecological status
	Human health and welfare	Respect standards for human health	Human health	4.1.1 Population exposed to safe levels of $PM_{2.5}$
				4.1.2 Population using clean fuels and technologies for cooking
				4.1.3 Samples that meet the drinking water criteria
		Conserve landscape and amenity	Recreation	4.2.1 Recreational water bodies in excellent status
				4.2.2 Natural and mixed world heritage sites with good conservation outlook

It is clear that Table 6.1 omits some environmental topics, such as the depletion of non-renewable resources apart from soil, or waste generation and disposal. This is because no science-based standards could be identified for these topics.

Despite the fact that the environmental SDG indicators are not currently framed in terms of science-based standards, some of them are in fact very close to the SES index indicators. Figure 6.2.1 provides a mapping between the SES index indicators in Table 6.1 and the environmental SDG indicators that are related to the state of the environment.

Figure 6.2.1. Related SES index (left) and SDG (right) indicators



With funding from AFD two countries, Viet Nam and Kenya, are extending their work on the environmental SDG indicators to explore the challenges and data availability at the country level regarding implementation of the ESGAP approach. The following two case studies describe their experience with the environmental SDG indicators and how they have sought to extend these towards calculations related to strong sustainability, as described above. This work is still in its early stages but the case studies give a flavour of the approach being taken and the progress that has been made.

6.3. Case study: Kenya

6.3.1. Activities in relation to implementing the environmental SDG indicators

Kenya has signed up to the 2030 Agenda for Sustainable Development, which provides the country with a mandate to integrate the 17 SDGs into the National Development Agenda (Republic of Kenya, Ministry of Devolution and Planning 2017), and is also Party to various conventions and protocols. The country has been involved in a couple of indicator-based processes, namely the State of the Environment report (Republic of Kenya, National Environment Management Authority [NEMA] 2018a) and the Kenyan Environmental Performance Index (KEPI) (Republic of Kenya, NEMA 2019).

Kenya has developed the Kenya Vision 2030 strategy (Republic of Kenya, National Economic and Social Council [NESC] 2010) which has introduced the SDGs into Kenya's National Development Agenda. Vision 2030 is implemented through five-year Medium Term Plans (MTPs), with a number of SDG targets implemented in the second implementation cycle (MTP II 2013–2018). At the subnational level, the SDGs are incorporated into the Country Integrated Development Plans (CIDPs). Along with mainstreaming the SDGs into Kenya's development agenda, and highlighting the importance of gender-disaggregated data, the Government is also cooperating on the implementation of the African Union's Agenda 2063 through the MTP process.

In Kenya, eight of the 12 state of the environment indicators are produced on either a one-off (SDG indicator 15.3.1 on land degradation) or multi-year basis. This includes the indicators of domestic and wild species extinction risk (SDG indicators 2.5.2 and 15.5.1), water ecosystem extent (SDG indicator 6.6.1), air pollution (SDG indicator 11.6.2), forests and vegetation cover (SDG indicators 15.1.1, 15.2.1 and 15.4.2) and land degradation (SDG indicator 15.3.1). UNEP's 2020 data drive is also supporting the production of indicators of terrestrial and marine water quality (SDG indicators 6.3.2, 6.6.1 and 14.1.1) and the second update of the indicator of land degradation (SDG indicator 15.3.1). However, indicators of marine acidification (SDG indicator 14.3.1) and fish stocks (SDG indicator 14.4.1) are not currently reported for Kenya.

6.3.2. Data gaps and challenges regarding the environmental SDG indicators

Kenya is Party to a number of environmental conventions and protocols and reports to the conventions (Republic of Kenya, NEMA 2018a). In order to fulfil these obligations, data collection at the national scale is resource intensive and some data-collection methods, such as wildlife surveys and censuses, require specialized skills, knowledge and technology. These challenges have often inhibited regular data collection in the country, leading to temporal and/or spatial inconsistency and data gaps. However, Kenya has progressed in terms of its reporting on wildlife, terrestrial areas under protection, and fisheries stock assessments. For example, the Kenya Fisheries Service undertakes regular stock assessments of fisheries, as mandated, involving data collection and generation of fishery statistics. In addition, the Kenya Marine and Fisheries Research Institute (KMFRI) conducts regular on-the-ground ocean monitoring missions (Republic of Kenya, NEMA 2010).

Kenya's NEMA has been responsible for preparing the national State of the Environment report since 2003. In its ninth edition (Republic of Kenya, NEMA 2018a), Kenya employed a system of indicator-based assessment and reporting that considers the importance of gender-disaggregated data. The National Environmental Indicators (NEIs) form the major part of the State of the Environment reporting framework (Republic of Kenya, NEMA 2018b), which has guided data collection by relevant lead agencies with key mandates on various thematic sectors. Analysis in the State of the Environment report has determined trends on the status of environment, which has enabled objectives and actions for Kenya's main environmental problems to be identified and prioritized.

6.3.3. National environmental standards and targets in relation to the SDG indicators

Kenya's own environmental standards that are stipulated in various regulations have been accepted and codified in national instruments and are used as national standards. Such legislation ranges from instruments dedicated to maintaining the integrity of the country's natural resources, to instruments defining how people and gender relate to the natural resources and the environment, some of which are supported by legislated thresholds and standards. For example, maintaining 10 per cent forest cover is a constitutional threshold (Republic of Kenya, Government of the Republic of Kenya 2010). In many cases, the country has adopted and customized internationally drawn and accepted standards for its national circumstances. In some cases, national standards provided through legislation and regulation have been used as representative of related SDG sectors. One such example is the Water Quality Regulation 2006 (Republic of Kenya, NEMA 2006), which issues water quality standards for sources of domestic water and water bodies.

6.3.4. Taking a strong sustainability approach to environmental reporting in Kenya

NEMA is leading a pilot project to implement the ESGAP framework to understand how a strong environmental sustainability approach could work in Kenya. This pilot project has produced a Kenyan ESGAP framework constructed of 12 indicators across the four functions of the framework, using a mixture of national and international data sets and standards. The ESGAP framework has highlighted issues of environmental sustainability that are not currently reported in Kenya, such as recreational water quality and ecosystem ozone exposure. The pilot project has highlighted a requirement for flexibility towards the use of indicators that are already produced in Kenya, even if such indicators are supported by policy-based (rather than science-based) environmental sustainability standards. For example, whereas the ESGAP indicator on forests is supported by a scientific standard on forest utilization rate, data are not currently collected in Kenya to produce an indicator on forest utilization rate. Alternatively, an indicator of the proportion of land area under forest cover is now entrenched in the National Constitution to maintain a threshold of 10 per cent forest cover (Republic of Kenya, Government of the Republic of Kenya 2010).

The next steps for strengthening environmental statistics is to address both temporal and spatial data gaps by strengthening the capacity of the departments or units within institutions to conduct effective and efficient data collection. The long-term aim will be to embed the ESGAP framework into the National Statistics System (NSS), which is mandated by the Kenyan National Bureau of Statistics to make resources available for data collection to support national statistics. Alternatively, the State of the Environment reporting process could be enhanced in order to strengthen the collection of environmental data that demands more scientific and technological approaches through the lead agencies responsible for such sectors.

6.4. Case study: Viet Nam

6.4.1. Activities in relation to implementing the environmental SDG indicators

Based on Viet Nam's development context and priorities, and building on the successful implementation of the Viet Nam Millennium Development Goals, a National Action Plan was issued for the implementation of 2030 Agenda for Sustainable Development (Decision 622/QĐ-TTg). This action plan internalizes 17 global SDGs into 17 Viet Nam SDGs (VSDGs) and sets 115 targets to 2030, of which 17 targets are related to natural resources and have been assigned to the Ministry of Natural Resources and Environment (MONRE). Accordingly, the Ministry of Planning and Investment (MPI) of Viet Nam has issued a set of statistical sustainable development indicators (Circular No. 03/2019/TT-BKHDT) with 158 monitoring indicators, of which 47 indicators relate to natural resources and environment.

6.4.2. Data gaps and challenges in respect of the environmental SDG indicators

Viet Nam has only a limited number of indicators for measuring the state of the environment due to the lack of nationwide environmental monitoring systems and environmental databases (Socialist Republic of Viet Nam, Ministry of Natural Resources and Environment [MONRE] 2020). To overcome this, better data and coordination between agencies and government ministries is necessary to effectively monitor performance towards achieving the VSDG targets.

A review by the Institute of Strategy and Policy on Natural Resources and Environment of Viet Nam (ISPONRE) has shown that of the 47 Vietnamese environmental SDG indicators, 16 indicators measure the state of the environment (including plant and animal genetic resources, water ecosystem extent, air quality, water quality, fish stock, greenhouse gas emissions, forests, forest cover and land degradation). Only six of these indicators have data available and can be calculated at the national level, six have scattered data or unclear calculation methods and two currently have no available data.

Additionally, of the 40 monitoring indicators on natural resources and the environment sector (Decision No. 3756/QĐ -BTNMT), only six indicators on the state of the environment (including extent of protected areas, greenhouse gas emissions reduction and marine water quality) are supported by sufficient data to be calculated.

6.4.3. National environmental standards and targets in relation to the SDG indicators

Viet Nam's policies on natural resources and the environment established specific objectives for the period 2010–2020. These are currently under review and new objectives will be set for the 2021–2030 period. The Socioeconomic Development Strategy for 2021–2030, expected to be issued by April 2021, will set the basis for sectoral environmental strategies. It will define specific goals towards 2030 such as the National Strategy for Environmental Protection Until 2030, Vision to 2050, the National Biodiversity Strategy to 2030 and the National Action Plan for Air Quality Management to 2030. Furthermore, environmental targets have been set for the period to 2030 in some existing policies such as the National Action Plan for the Implementation of the 2030 Sustainable Development Agenda (Decision 622/QĐ-TTG), the Implementation Roadmap for Vietnam's Sustainable Development Goals Until 2030 (Decision 681/QĐ-TTG), the National Programme to Ensure a Safe Water Supply for the 2016–2025 Period and the National Strategy for Integrated Solid Waste Management to 2025. At present, there are a total of 41 Vietnamese national technical regulations and standards on the environmental quality and limits of wastewater, exhaust fumes, noise pollution, solid waste and hazardous waste. Further national technical regulations on the environment continue to be finalized, especially those on air quality and emissions regulations in specific industrial fields.

6.4.4. Taking a strong sustainability approach to environmental reporting in Viet Nam

The piloting of the ESGAP framework in Viet Nam started in September 2020. As data collection and evaluation of the VSDG indicators have just begun and face a number of difficulties, there is an opportunity to adopt the ESGAP's indicators at the national level. This would enable Viet Nam to self-assess and compare with other countries on the implementation of the VSDGs based on an international methodology. This pilot project has produced a Vietnamese ESGAP framework constructed of 14 indicators across three of the four functions of the framework, excluding the life-support function for which it has proved difficult to identify appropriate indicators of biodiversity.

In terms of Viet Nam's environmental sustainability policies, most of the areas covered in the conceptual ESGAP framework are environmental policy issues of concern to the Government of Viet Nam. The ESGAP framework has also highlighted gaps in Vietnamese environmental policies such as the impacts of ozone pollution on ecosystems, regulations on the critical load of ecosystems, and standards for the ecological status of ecosystems and biodiversity.

To adopt the ESGAP framework in Viet Nam, it may be possible to use alternative indicators such as the global SDG indicators or the VSDG indicators. A challenge will be to identify existing national environmental standards related to the sustainability topics covered by the ESGAP framework or to develop new ones.

Viet Nam is in the process of assessing its national SDGs and also piloting the application of the ESGAP framework and SES index indicators for the country. The simultaneous evaluation of both the SDG and the SES index indicators will create an opportunity for Vietnamese environmental policymakers to address gaps in SDG implementation and to improve reporting on natural capital functions in Viet Nam reflected in the ESGAP framework.

6.5. Conclusion

The progress seen in Kenya and Viet Nam in terms of collecting and assessing progress related to the SDGs is highly correlated with the timely development of national policies targeting specific environmental domains. Kenya and Viet Nam are by no mean exceptional in the approach they are taking to measuring progress against the SDGs, in the data gaps and challenges they are facing in so doing, and in their interest in strong sustainability and science-based standards. Their ability to implement much of the ESGAP framework to complement their work with the environmental SDG indicators bears witness both to the increased statistical expertise in these countries and the growing political will to engage with the concept of strong sustainability and science-based standards as an important input into policymaking processes.

Although data issues remain, there is progress. The Sustainable Development Report 2020 reported increased SDG data availability across all regions in 2020, compared with 2010–2015 (Sachs *et al*. 2020). However, data for the environment-related SDG indicators continued to lag behind many of the other areas. These data issues are discussed in more detail in the next chapter.

Chapter 7: Data gaps and opportunities

7.1. The need to address data gaps

Data gaps refer to gaps in the compilation, analysis and effective use of data. The analysis in this publication highlights the underlying data sparsity for the environmental dimension of the SDGs. Gaps are found not only in the underlying data, but also in the tools and analytical methodologies for understanding the state of the environment, as well as interactions within the environmental dimension of the SDGs and interactions between the environmental dimension of the SDGs and the social and economic dimensions of sustainable development. Integrated analyses and explorations of interlinkages are vital for designing, monitoring and improving the efficacy of government interventions to achieve the SDGs.

For example, environmental conditions underpin well-being and human health. However, challenges arise when attempting to determine the associations between environmental factors and social development, human health and well-being impacts. The limited data availability complicates the understanding of health impacts caused by degraded environmental conditions. In particular, large samples with temporal and spatial data are needed to manage potential biases and confounding factors. This type of data only exists for such a small proportion of the SDGs that it is not yet possible to conduct global-level analysis of this type. Moreover, there is a lack of experience in analysing across the environment and health sectors. Closing the data gaps will enable society to approach SDG implementation holistically through economic, social and environmental considerations.

7.2. Availability of SDG data to understand environmental interactions

The SDG indicators represent a set of discrete indicators that can be used to understand individual social, economic and environmental issues. However, a methodology for integrating information across SDG indicators has not been globally agreed and a siloed approach to analysing the SDG indicators hides the fact that development is a complex system, as opposed to a series of discrete issues. For example, there is intuitively a link between the SDG indicators on protected areas and the SDG indicators on ecosystem extent or between health indicators and water and air quality or land degradation and land management indicators. Understanding these interactions requires analysis across multiple indicators and locations (using geospatial data). However, bivariate or multivariate analysis of the environmental dimension of the SDGs is only possible if there are strong underlying data systems that can be used to analyse these interactions, including having data for a sufficient number of countries for at least two time points.

Based on the analysis in this report, of the more than 2,000 environment-related potential synergies that might be useful for understanding the environmental dimension of sustainable development, there are data to analyse only 20 per cent of these interactions. In summary, a total of 2,118 potential synergies were identified between SDG indicators and their underlying sub-indicators. Seventy-five per cent of the synergies (1,581 synergies) relate to direct drivers of change and the state of the environment while 25 per cent (537 synergies) relate to the state of society and the state of the environment. However, only 429 potential synergies possessed enough underlying data to be able to be investigated (Table 7.1). Based on data availability, 20 per cent of identified potential synergies were investigated.

Table 7.1. Total number of relationships identified and investigated

	Potential synergies identified	Relationships investigated	Proportion of relationships investigated
Direct drivers of change	1,581	266	16.8%
State of society	537	163	30.4%
Total	2,118	429	20.3%

Table 7.2 represents potential synergies per SDG and the proportion of these potential synergies that were investigated (relationships) as part of this report, based on the available data. For the indicators identified as direct drivers of change, less than 50 per cent of potential synergies identified were investigated, while for some SDGs (SDG 1, SDG 11 and SDG 13), data were not available to investigate. The highest proportion of investigated relationships were in SDG 15 on land and biodiversity (31.5 per cent), SDG 9 on infrastructure support (25.8 per cent), SDGs 8 and 12 on economic growth and responsible lifestyles (21.9 per cent) and SDG 7 on energy (21.4 per cent). In SDGs 8 and 12, a closer look has been made regarding domestic material consumption (DMC, SDG indicator 8.4.2/12.2.2) due to the large number of potential synergies identified between its subproducts and the state of the environment indicators (35.1 per cent).

Data were more available to investigate the potential relationships among state of society indicators, apart from SDG 3. SDG 7 on clean fuel access had all the potential synergies investigated, SDG 2 on undernourishment and food security had 48.6 per cent investigated and SDGs 1, 11 and 13 on humans and economic

Table 7.2. Data availability per Sustainable Development Goal

	Sustainable Development Goal	Environmental issue	Total potential synergies	Proportion of relationships investigated
Direct drivers of change	Goal 1. No poverty	Disaster risk reduction	3	0.00%
	Goal 2. Zero hunger	Food security	36	5.60%
	Goal 6. Clean water and sanitation	Water	440	8.00%
	Goal 7. Affordable and clean energy	Energy	56	21.40%
	Goals 8 and 12. Decent work and economic growth; Responsible consumption and production	Economic growth and responsible consumption and production[27]	739	21.90%
	Goal 9. Industry, innovation and infrastructure	Infrastructure	31	25.80%
	Goal 11. Sustainable cities and communities	Land consumption	23	0.00%
	Goal 13. Climate action	Climate action	63	0.00%
	Goal 14. Life below water	Life below water	44	2.30%
	Goal 15. Life on land	Land and biodiversity	146	31.50%
State of society	Goals 1, 11 and 13. No poverty; Sustainable cities and communities; Climate action	Disasters: human and economic impact[28]	346	33.50%
	Goal 2. Zero hunger	Undernourishment and food security	72	48.60%
	Goal 3. Good health and well-being	Health	67	0.00%
	Goal 4. Quality education	School drinking water access	24	16.70%
	Goal 6. Clean water and sanitation	Drinking water access	24	16.70%
	Goal 7. Affordable and clean energy	Clean fuel access	4	100.00%

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[27] All duplicated indicators and their underlying sub-indicators are counted once, such as indicators 8.4.1/12.2.1 and 8.4.2/12.2.2.
[28] All duplicated indicators and their underlying sub-indicators are counted once, such as indicators 1.5.1/11.5.1/13.1.1; 1.5.3/11.b.1/13.1.3 and 1.5.4/11.b.2/13.1.3.

impact of disasters had 33.5 per cent investigated. Annex D represents the potential synergies that were identified between the pairs of SDG indicators and where data were not available to investigate them.

There is inconsistency in terms of the ability to analyse the different types of relationships, with the data gaps more pronounced in certain goals than others. In particular, the SDGs related to disaster risk reduction, climate change, cities and health do not have sufficient data for analysing a single relationship. The inability to analyse the relationships means decision makers cannot develop optimal policies that address the interlinkages between the three pillars of sustainable development. Attention to filling these data gaps related to the environmental indicators underpins the ability to achieve the 2030 Agenda for Sustainable Development.

7.3. The importance of disaggregation

Even if all data gaps related to the environmental indicators were filled, disaggregated data would still be needed to fully understand the geographic and population dynamics in order to target policy and action. Ecosystems, biodiversity, water systems and oceans encompass a variety of living beings and do not follow national boundaries. Understanding which ecosystems are at risk and which are providing the highest value of ecosystem services requires data disaggregation, which is made possible by harnessing geospatial data, ecosystem-level data and local knowledge of the interactions between ecosystems and people. Regional and local specifications limit the value of global analysis and emphasize the need for local analysis and assessment, as well as local interventions.

The way that people utilize and interact with the environment is also not consistent across population groups. Women, indigenous people and local communities, poor populations and other population groups across different countries have different ways of interacting with the environment. Understanding the human and gender dimension of the environment–social development nexus requires not only using traditional and geospatial data sources for measuring environmental states, but also coupling these data with geospatial data on populations.

To complement the understanding of ecosystems at risk and the interactions of various population groups with the environment, identifying and monitoring specific pollutants and chemicals is a necessity. The monitoring of specific pollutants and chemicals provides insight on short- and long-term effects on air, water and soil and creates opportunities to mitigate their environmental and human health impact.

7.4. Opportunities

The 2030 Agenda for Sustainable Development promotes a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development. This landmark commitment by Heads of State and Governments marks the spirit of consensus and cooperation between different nations towards a sustainable world. However, the implementation of the 2030 Agenda faces serious challenges. The main challenge in monitoring progress towards its realization relates to the lack of adequate data available to develop indicators, including the gender dimension, and to assess progress for more than half of the environment-related indicators. Another challenge to SDG realization is the lack of analytical tools robust enough to both bring together new data-science techniques such as artificial intelligence, new technologies such as cloud computing, and big data to generate knowledge.

Big Earth Data, citizen science and other new forms of data have the potential to provide important data for monitoring progress towards the 2030 Agenda and supporting various aspects of the SDGs in other ways. Technological innovations and the advent of big data have enabled the development of new tools and methodologies for data production. In addition, technological advances have made it possible to use advanced algorithms and other tools that mine new opportunities presented by artificial intelligence.

The following sections highlight a few successful examples of using new forms of data and technology. These could be embedded within a strategy to enhance governments' ability to monitor SDG progress and chart a more effective course for achievement.

7.4.1. Big Earth Data

Based on Earth science, information science and space science, Big Earth Data derives and integrates spatial data from Earth observations platforms, as well as terrestrial, oceanic, atmospheric and human activity data from other sources. The advancements of technological instruments (improved temporal resolution, coverage), large volumes of data and ease of accessibility to data have facilitated the commercial use of Earth observations (Lynnes and Huang 2018).

Through its Big Earth Data Science Engineering Program (CASEarth), the People's Republic of China is exploring ways of converting Big Earth Data into SDG information and filling data gaps by providing timely and spatially-explicit data sets on SDG indicators, constructing new indicators for improved and meaningful evaluations of SDGs, and developing case studies to monitor progress and inform policymaking (CASEarth 2019; CASEarth 2020). CASEarth has used Earth observations coupled with statistical analysis and modelling to generate data and estimates for three of the sub-indicators of 2.4.1 on sustainable agricultural practices (SDG 2 on zero hunger), SDG indicator 6.3.2 on water quality (SDG 6 on clean water and sanitation), SDG indicator 11.3.1 on land consumption rate (SDG 11 on sustainable cities and communities), SDG indicator 1.5.1/11.5.1/13.1.1 on human impact of disasters (SDG 1 on no poverty, SDGs 11 and 13 on climate action) and SDG indicator 15.3.1 on land degradation (SDG 15 on life on land).

Destination Earth (DestinE), an initiative launched by the European Commission in 2019, proposes the development of a very high-precision digital model of the Earth based on Earth observations to monitor natural and human activities (EC n.d.). This tool aims to model the physical resources of the Earth and various scenarios related to environmental phenomena, such as climate change, marine environments, biodiversity and land use, to be able to plan for major environmental degradation and disasters. The initiative feeds into the EC's Green Deal and Digital Strategy and accelerates the green transition. DestinE will feature a digital replica ('digital twin') of all living and non-living physical entities. It focuses on weather-induced and geophysical extremes and climate change adaptation tools to provide users with access to high-quality information, models, scenarios, forecasts and visualizations based on continuous observations and high-performance simulations (EC 2020). It will also allow users to integrate their own data.

KEY NOTE 6. CASEARTH'S APPLICATIONS AT SDG INDICATOR LEVEL

SDG 2 (zero hunger): CASEarth integrated remote-sensing methodologies, spatial allocation models, global crop water models, and mass balance models to estimate changes of three SDG sub-indicators of 2.4.1: land productivity, water use (represented by irrigation water consumption) and fertilizer pollution risk (represented by excess nitrogen and phosphorus). 'Environmental intensity' – a measure to quantify environmental impacts per kilocalorie produced – has been introduced to develop a matrix to determine the level of sustainability and to facilitate comparison among different agricultural zones and across indicators.

SDG 6 (clean water and sanitation): A novel remote-sensing algorithm was developed based on dual-band reflectance to retrieve the water transparency of large lakes in China (>20 km^2) during 2000–2019. This is useful for exploring the monitoring and evaluation of SDG indicator 6.3.2 (bodies of water with good ambient water quality).

SDG 11 (sustainable cities and communities): CASEarth independently created high-resolution gridded population data by gender and age, and global impervious surface products with a resolution of 10 metres for 2015 and 2018, thereby providing important data support and resolving data deficiency for the monitoring and evaluation of SDG 11. Additionally, CASEarth has proposed a new indicator – the ratio of economic growth rate to land consumption rate (EGRLCR), which expands on SDG indicator 11.3.1 (ratio of land consumption rate to population growth rate) – to monitor and evaluate tri-dimensional urban progress in the People's Republic of China in terms of land, population, and economic development.

SDG 13 (climate action): CASEarth contributed to monitoring the progress of SDG indicator 1.5.1/11.5.1/13.1.1 (number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population) with statistical and satellite images. The EM-DAT (Emergency Events Database) and population data are merged to evaluate the indicator of 1.5.1/11.5.1/13.1.1. CASEarth also produced high-resolution maps of natural disasters from 2015 to 2019, including wildfire, floods and heatwaves, using satellite images and ground weather stations. More specific information can be acquired from these maps about where the suffering is occurring by type of disaster, and what response is needed.

SDG 15 (life on land): SDG indicator 15.3.1 (proportion of land that is degraded over total land area) was scaled up to land degradation neutrality (LDN) by fusing land cover, land productivity and soil carbon changes and balancing restoration and degradation at the national scale. In addition, CASEarth optimized the Biodiversity Risk Index (BRI) based on the distribution of species and the risk categories of more than 30,000 plant species, which could better describe the risk of extinction than the Red List Index, which is based on multiple dynamic assessments. Therefore, developing conservation and restoration strategies tailored to the local realities to address conservation gaps will help improve the efficiency of conservation and halt species loss.

7.4.2 Citizen science

Citizen science (the practice of voluntary public participation in scientific research and knowledge production) offers another approach that could help address some of the data gaps for the SDG indicators. A recent study shows that citizen science data are ‘already contributing’ or ‘could contribute’ to the monitoring of one-third of the SDG indicators, and that the greatest input from citizen science data to SDG monitoring would be in environmental SDG indicators covering areas such as biodiversity, water and air quality, and forestry (Fraisl *et al.* 2020). The potential trove of SDG data is particularly important given the high proportion of environmental SDG indicators that lack data (58 per cent in July 2020).

In fact, citizen science is currently informing SDG indicators on biodiversity and protected areas (15.1.2 proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type and 15.4.1 coverage by protected areas of important sites for mountain biodiversity) through initiatives related to bird monitoring (Fritz *et al.* 2019; TReNDS n.d.). For example, eBird, one of the world’s largest biodiversity-related citizen science projects, alone collects more than 100 million bird sightings per year (The Cornell Lab of Ornithology n.d.). iRain, a smartphone app developed by UNESCO’s International Hydrological Programme (IHP), has been designed to improve near-real-time rainfall estimates and inform on floods and droughts through a citizen science approach. Citizen-reported data feeds into remote-sensing and artificial intelligence tools to improve planning and management of extreme weather events and hydrological risks (UNESCO 2016). iRain data can be used for disaster risk reduction (SDGs 1, 11, 13) and water management (SDG 6).

The Global Biodiversity Information Facility (GBIF), an international network and data infrastructure that provides open access data on biodiversity, receives substantial contributions from citizen scientists (GBIF n.d.). Almost half of the species-occurrence records in GBIF come from data collected by volunteers (Chandler *et al.* 2017). This source has tremendous potential for addressing some of the data gaps on biodiversity and ecosystem health.

In addition to global databases and data sets, citizen science tools such as Picture Pile can be leveraged to address some SDG data gaps and needs across different scales such as local, national, regional and global. Developed by the International Institute for Applied Systems Analysis (IIASA), Picture Pile is a generic and flexible tool for ingesting imagery that can be rapidly classified by volunteers. These images can be very high-resolution satellite images, orthophotos, images from unmanned aerial vehicles (UAVs) or geotagged photographs. In Picture Pile, volunteers could be provided with a pair of images from the same location but from different time periods and asked a simple question related to the theme of the images such as “Do you see any tree loss?” or “Do you see a damaged building”? If the answer is “Yes”, the volunteers swipe the image to the right, if “No”, to the left and if they are unsure, to the bottom. As a more generic tool, Picture Pile has been used to collect data on deforestation, post-disaster damage assessment, night-time lights, oil palm plantations and poverty assessment. Data from Picture Pile can also be used to calibrate and validate land cover and land-use maps, which could provide inputs to the SDGs for poverty mapping (SDGs 1 and 11), damage assessment (SDGs 1 and 11), human settlements (SDG 11), change in the water extent and ecosystem health (SDG 6), agriculture area and cropland (SDG 2), marine litter (SDG 14) and deforestation (SDG 15), among others (Fraisl *et al.* 2020; Danylo *et al.* 2018).

Although citizen science offers tremendous opportunities for SDG monitoring and implementation (including increasing the amount, accuracy, timeliness and spatial frequency of data in a cost-effective way, while mobilizing citizen action and raising awareness on global issues), its potential is far from being realized. Many initiatives exist, such as applications where users help identify wildlife in camera trap images (e.g. Instant Wild[29]) or where users are encouraged to ground-truth automated, remotely sensed deforestation/fire alerts (e.g. Forest Watcher[30]), but they rarely feed into national or global monitoring systems. Some recommendations to realize this untapped potential of citizen science data for SDG monitoring and reporting include (i) creating key partnerships and providing resources to improve the methodologies and data quality assurance processes in citizen science initiatives, (ii) promoting consistent data collection across citizen science projects to improve comparability, (iii) promoting open and interoperable citizen science data through standards and (iv) building awareness and capacities around the potential and use of citizen science data by developing use cases and best practices (Campbell *et al.* 2020; Fraisl *et al.* 2020). Initiatives such as the WeObserve SDGs and Citizen Science Community of Practice could bring key stakeholders together to address these recommendations.

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[29] https://instantwild.zsl.org/intro

[30] See forestwatcher.globalforestwatch.org

7.4.3 Other forms of big data

The use of other forms of big data for sustainable development has been recognized as an opportunity to close data gaps and achieve the 2030 Agenda. The growing volume and availability of transactional data and Internet of Things (IoT) data are used to address SDG 12 and other environmental data shortages. This type of big data is used for SDG 12 in the People's Republic of China and feeds into the Blue Map Database, a national environmental data platform for multi-stakeholder collaborations, including Pollutant Release and Transfer Registers (PRTRs) data (Institute of Public and Environmental Affairs [IPE] 2021). China is also utilizing big data for proper e-waste management, through the Baidu Recycle app, to improve the monitoring of e-waste disposal and recycling behaviour and to raise public awareness. The app invites users to identify the relevant electronic device by uploading a picture, then arranges for door-to-door pick-up (ESCAP 2016).

After the earthquake that hit Nepal in April 2015, big data from mobile phones were used for disaster risk response (SDGs 1, 11 and 13) by using anonymous SIM card locators to follow displaced people. This data allowed the Government and humanitarian organizations measuring and visualizing the displaced populations to provide more equitable relief response (ESCAP 2016).

7.5. Role of the United Nations in advancing environmental statistics

The United Nations has an important role to play in capitalizing on these and other opportunities available for closing the data gap. It has already made tremendous contributions to the advancement of environmental data, statistics, accounting and analysis, and it is poised to do much more.

Established in 1947, the United Nations Statistical Commission brings together statisticians from across the world to set statistical standards and develop concepts and methodologies to be implemented at the national and international level. The commission promoted the development of the Framework for the Development of Environment Statistics (FDES), published in 1984, and endorsed it. The framework sets out the scope of environmental statistics and indicators, recognizing the link between human activities and natural events and the environment. In 2013, the FDES was updated to factor in new techniques and methods to develop environmental statistics and it is considered as the framework for strengthening environmental statistics programmes in countries.

The United Nations was also responsible for developing the System of Integrated Environmental–Economic Accounting (SEEA) in response to the 1992 Earth Summit's call for such a system. In 2012, the United Nations Statistical Commission adopted the SEEA as a statistical standard for measuring the interactions between the environment and the economy.

These frameworks represent the basis of environmental statistics, the importance of which has been recognized and elevated by the 2030 Agenda. This increased focus has led to significant new guidelines and initiatives to close the data gap and to modernize the way data are collected, processed, integrated, disseminated and communicated within the United Nations and at the national level.

Many parts of the United Nations System – including the United Nations Statistics Division, the United Nations Regional Commissions and United Nations funds and programmes – have been called upon to strengthen national capacities to produce environmental statistics that encompass the gender dimension. For example, the United Nations Global Platform on Big Data for Official Statistics launched in 2018. This platform is a collaborative research and development forum for the global statistical community that facilitates the exchange, development and sharing of data, methods, tools and expertise, with the aim of accelerating data innovation.

The efforts made in advancing environmental statistics, both internationally and nationally, have translated into a reduction in the environmental data gap. Yet, the challenge remains. Encouraging the formation of new partnerships and creating new means to reduce the data gap is crucial if the world is to achieve sustainable development.

7.6. Where does the world want to be in 10 years (at the end of the 2030 Agenda)?

A more integrated approach to capacity-building is essential to realize the 2030 Agenda. The SDG indicator framework has a limited number of indicators related to the environmental state and trends, the relationship between the environment, people and pollution (for example, gender-environment indicators) or the relationship between consumption and production. Moving forward, there is also a need to improve data availability for reporting to other monitoring frameworks that have been developed or are being developed for disasters (the Sendai Framework), biodiversity (the post-2020 Global Biodiversity Framework), chemicals (the monitoring framework for the Strategic Approach and sound management of chemicals and waste beyond 2020), oceans (the Regional Seas Core Indicators) and climate change (the indicators in the National Determined Contribution process of the UNFCCC).

With such a proliferation of monitoring frameworks, there is a need for better integrated metrics and integrated analyses to facilitate decision-making. This report aims to explore the interdependencies between some of these issues. There is also a need to address underlying data gaps in order to be able to provide holistic analytical products.

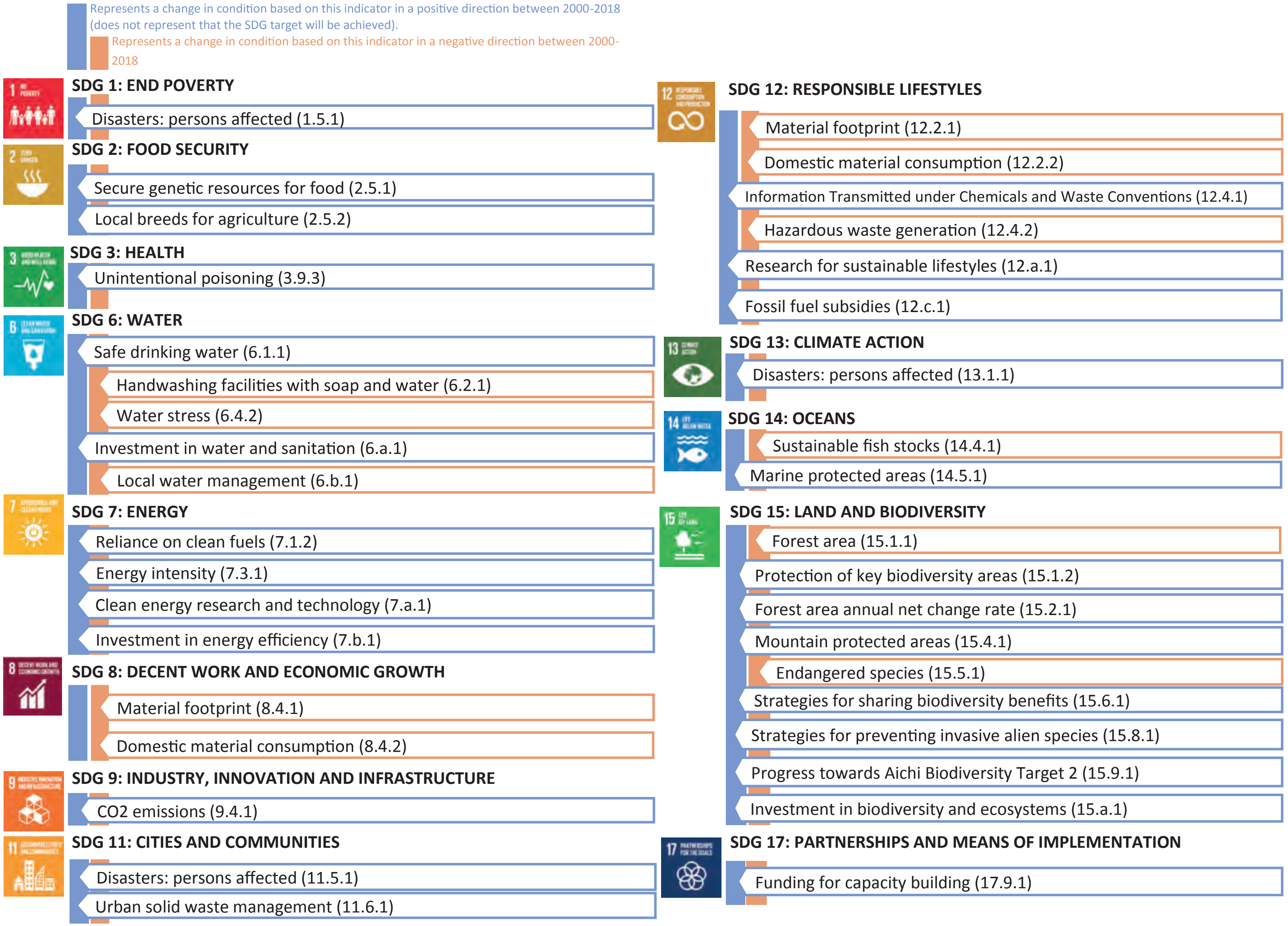
The ability to use integrated metrics and analyses requires an investment in building data systems and statistical systems that employ both traditional data and new data (such as citizen science, remote sensing, IoT devices and transactional data) and new data-science techniques. It is now possible to build environmental data products (for example on ecosystem extent, species prevalence, pollution modelling) using big data. However, ensuring that these data products are both useful and used in practice at the national level requires building national data-collection, data-management and data-analysis capacity, strengthening the role and ownership of national statistical offices (NSOs) and Ministries of Environment in terms of collecting and processing environmental data, and establishing a practice among non-environmental government agencies, and particularly the Ministries of Finance and Economic Development, of factoring environmental indicators and integrated analyses into their decision-making.

The ability to develop methodologies to help understand interactions between SDGs and other environmental issues is only possible when the underlying data are strengthened. There are positive examples where this has already been done and the lack of data is not a justification for inaction, but the need to address data gaps quickly is essential to the ability of governments, the private sector and citizens to better target their action.

Chapter 8: Conclusions and recommendations

Many countries are now expending substantial efforts to measure their progress across the environmental dimension of the Sustainable Development Goals (SDGs) and progress in some environmental areas is being made. Figure 8.1.1 summarizes the environmental indicators of the SDGs that have shown positive and negative changes at the global level between 2000 and 2018.

Figure 8.1.1. Positive and negative changes in the environmental dimension indicators of the SDGs, 2000–2018



Countries are making progress in reaching the SDG targets related to clean water and sanitation, clean energy, waste, forest-related management and persons directly affected by disasters. Environmental data published in the first Measuring Progress report (as at December 2018) showed that out of the 32 per cent of indicators with data (30 indicators), 74 per cent (22 indicators) followed a positive trend, and 26 per cent (8 indicators) indicated little change or a negative trend. In July 2020, out of the 42 per cent of indicators with data (39 indicators), 67 per cent (26 indicators) followed a positive trend and 33 per cent (13 indicators) showed little change or a negative trend.

While countries are making some progress with clean water and sanitation, there appears to be a negative change regarding the proportion of populations using safely managed sanitation services. The apparent negative change in respect of handwashing may hinder efforts related to bringing COVID-19 under control. Progress is being made on clean energy, waste and forest-related management as well as persons directly affected by disasters, although there continue to be negative trends in relation to sustainable consumption (water use, waste and material flow indicators) of natural resources and biodiversity. On a positive note, protected areas and pro-environment legislation have increased.

Some countries are making more progress than others in relation to certain SDG indicators. Considering the imbalance at the regional and national level, some outlier countries that have made more progress than other countries have been identified. For example, regarding SDG 2, the Republic of South Africa appears to be both increasing the conservation of plant genetic resources and decreasing the proportion of at-risk local breeds. For SDG 15, the Republic of Belarus is one of the few countries reporting decreasing species extinction risk measured by SDG indicator 15.5.1 and progress towards achieving Aichi Biodiversity Target 12 regarding species extinction prevention.

Overall, progress since 2000 has been insufficient to realize the 2030 Agenda and key environmental areas have continued to deteriorate. This is most obvious with regard to the two global issues of biodiversity loss and climate change, although these issues are not really holistically captured in the SDGs and thus understanding biodiversity/ ecosystem service provisioning or climate change vulnerability requires additional indicators.

With regard to biodiversity loss, the increasing extent of protected areas and other measures have not led to reductions in the number of species under threat of extinction. Without exception, the Aichi Biodiversity Targets have been missed, according to the fifth Global Biodiversity Outlook. In respect of climate change, although the CO_2 intensity of the global economy has reduced, global CO_2 emissions have not, except perhaps most recently as a result of the COVID-19 pandemic-related restrictions on travel and some industrial activities. However, there is little evidence that these emissions will not rebound once the pandemic is under control (Le Quéré *et al.* 2020). Despite the fall in emissions in 2020, it seems that atmospheric concentrations of greenhouse gases, which are what affects the climate, will continue to rise (WMO 2020). Regarding the drivers of climate change, it is clearly positive that fossil-fuel subsidies dropped between 2000 and 2018, but they remain high enough for the overall average carbon price to be negative (Watts *et al.* 2020), which is hardly consistent with stated government desires to reduce carbon emissions. Furthermore, the global forest area, which needs to increase dramatically to remove CO_2 from the atmosphere (in addition to yielding benefits in maintaining biodiversity) continues to fall. To give just one example of the negative environmental effects of fossil-fuel subsidies on areas other than just the climate, the OECD has shown how such subsidies can lead to fish stocks being overfished and encourage illegal, unreported or unregulated (IUU) fishing, while being ineffective ways of supporting fishing incomes (Martini and Innes 2018).

Furthermore, fish stocks continue to be exploited increasingly unsustainable, water stress is on the increase and seems likely to be exacerbated by climate change (Hoegh-Guldberg *et al.* 2018; IPCC 2018), and the global consumption of resources also continues to rise. Overall, it is clear from this stocktake that human society is seriously lagging behind if it is to realize the environmental dimension of the vision for 2030 of The Future We Want and the SDGs, to which the world's nations signed up in 2015.

The analysis revealed examples where correlations are significant and are consistent with intuition or published evidence. For example, water stress and water ecosystem extent are negatively correlated, domestic material consumption (DMC) related to biomass extraction is negatively correlated with the Red List Index, and the proportions of key biodiversity areas and certified forest area are correlated with both water ecosystem extent and forest area. Chapter 4 gives reasons why these correlations are consistent with published evidence and intuition.

Table 8.1. Significant indicator correlations consistent with intuition

Driver indicator	Indicator/sub-indicator description	State of the environment indicator	Indicator/sub-indicator description	Model coefficient
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	negative
8.4.2	Domestic material consumption (crops, wild catch and harvest) (tons)	15.5.1	Red List Index	negative
15.1.2	Average proportion of freshwater key biodiversity areas (KBAs) covered by protected areas (%)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	positive
15.1.2	Average proportion of terrestrial key biodiversity areas (KBAs) covered by protected areas (%)	15.1.1	Forest area (thousands of hectares)	positive
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	15.1.1	Forest area (thousands of hectares)	positive
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	positive

However, a simple correlation analysis provides only limited insight into interlinkages that ultimately need to be improved for impactful policy design. The attempt in this report to establish statistical relationships between some of the key drivers and indicators of the environmental dimension of the SDGs, reported in Chapters 4 and 5, has been largely inconclusive. As many of the authors of these chapters note, the 12 state of the environment indicators that were the dependent variables in the analysis are influenced by a multitude of factors beyond the population, gross domestic product (GDP) and regional variables that were included in the analysis, indicating the importance of national and local level analyses of systemic effects.

Data aggregated at the national level has major limitations: for example, the benefits of individual protected areas are obscured by coarse-scale variation between countries. This coarse-scale variation is driven by both underlying biogeography (many threatened species live only at low latitudes, especially in island nations) and socioeconomic capacity. In addition, some of the variable pairs do not correspond well with each other in terms of their coverage. For example, the extent of marine protected areas (SDG indicator 14.5.1) might be expected to influence the extinction risk of marine species, but not the Red List Index as a whole (SDG indicator 15.5.1). There is a scale mismatch between the global public goods that are measured by some SDG indicators (e.g. 14.4.1 on healthy fish stocks) and the national scale at which governments can apply environmental policies (Breuer, Janetschek and Malerba 2019). This emphasizes the importance of taking a coordinated approach across countries to some environmental policymaking and of recognizing that one country's actions will impact the ability of other countries to achieve their SDGs.

Ecological time lags in the policy response also exist between some variable pairs, for example, the positive effects of introducing legislation and resourcing for invasive alien species may simply need a longer time frame to manifest than that which is currently used in the analyses undertaken here. The importance of data disaggregation has been fully recognized both in geospatial and human dimensions, related to which Big Earth Data (Guo *et al.* 2020) has great potential. Investigating indicator interactions across all United Nations Member States and territories will have obscured some relationships between indicator pairs that may be very context-specific. Indeed, Pradhan *et al.* (2017) found significant heterogeneity across countries in terms of SDG indicator interactions. It has been suggested that a more context-specific approach to investigating interactions between SDG indicators should be taken in the future (Breuer, Janetschek and Malerba 2019).

However, notwithstanding these complexities, if the policy drivers of environmental change are being effective, at some point it could be expected that this would show up statistically. The fact that it does so in rather few cases, in the direction that is congruent with the policy, shows that the analyses here are insufficient to show impact through the noise of other influences. This is particularly true for those cases where the statistical analysis is clearly counter-intuitive or counter to existing published evidence.

There is a need for data and techniques that can undertake full multi-variant analyses in order to understand the implications of the full set of the SDG policies. With respect to all pairwise combinations of indicators examined, more detailed ongoing research remains a priority, for example to explore confounding factors or whether the data might warrant further disaggregation, and why some of the statistical relationships reported here run counter to what might have been expected.

Populating the SDG indicators fully will help overcome the challenge of reviewing progress at the national level. It is equally important to use disaggregated data, including the gender dimension, to fine-tune policy responses according to local contexts and the needs of specific ecosystems. The number of indicators for which even the simple statistical analysis carried out for this report, and reported in Chapters 4 and 5, was not possible tells its own story about the data challenges that still need to be addressed before progress on the environmental dimension of the SDGs can be measured with confidence. For example, Zeng *et al.* (2020) claimed that in some cases there is limited correlation between the environmental SDG indicators and other biophysical indicators. Nevertheless, some countries have made considerable advances in producing environmental statistics, with positive implications for how the environment is managed now and in the future. The case studies of the Socialist Republic of Viet Nam and the Republic of Kenya indicate substantial progress in terms of capacity built and data sets developed.

There remains a gap on the use of environmental data and statistics to inform government policy and decision-making, particularly the big environmental data produced by remote sensing, in situ sensors and artificial intelligence technologies, and the diversity of data collated through environmental–economic accounting activities. Indeed, many existing data products, statistics and indicators are under-utilized (Jensen and Campbell 2018) and there has been a lack of policy 'pull' within governments for the environmental information collated by environmental–economic accounting activities (Vardon, Burnett and Dovers 2016). Of course, the kinds of data challenges described in Chapter 7 affect these efforts as well and for the most complex issues, such as biodiversity, there are still debates about the most appropriate measure, or combination of measures, in the context of the post-2020 Global Biodiversity Framework. Numerous possible indexes are mentioned in the Convention on Biological Diversity (CBD 2020b). One of the issues that has yet to be resolved is whether biodiversity can have a single goal (for example, Rounsevell *et al.* 2020), or separate goals for ecosystems, species, genetic diversity, and ecosystem services (for example, Díaz *et al.* 2020), comparable to the goals of the Paris Agreement on climate change, that would provide similar orientation for policymakers as they grapple with this issue.

In any case, **environmental data capacities need to be strengthened if policymakers are to improve their understanding of the priority actions required to 'bend the curve' of continuing environmental deterioration**. Capacity-building is needed in three areas: i) for collection of data using international-standard methodologies to ensure data comparability, ii) for data management to ensure open access to data, and iii) for data analysis where data are used to better understand what happened, why it happened, what may happen next and how to respond.

Policymakers need science-based standards in order to guide their assessment as to what environmental improvements are necessary for their development efforts to be environmentally sustainable (Andersen *et al.* 2020). Many of these science-based standards are already available and are well understood. For example, the air and water quality standards required to support rather than damage human health are readily available from the WHO. Similarly, environmentally sustainable harvesting levels for renewable resources are readily calculated. The fact that so many of the world's fish stocks are below biologically sustainable levels is principally a matter of management policies, although scientific research will always be needed to monitor the situation and how it changes, especially in the context of climate change. Bringing together indicators around science-based standards, and environmental performance in relation to these, as in the ESGAP framework, would allow policymakers to assess on a more robust basis their progress towards environmental sustainability.

In conclusion, current data and indicators for measuring progress on the environmental dimension of the SDGs, including the minimal gender-environment targets, leave no doubt that human societies globally are still operating unsustainably. **Improved data and indicators, including gendered data, would provide more systemic insights into the risks entailed in continuing to operate outside planetary boundaries** and into the progress being made by current policy attempts to address the issues involved. However, the findings from the current report strongly suggest that a more robust policy response and redoubled implementation efforts are urgently required, and the need for improved data should not be allowed to stand in the way of such implementation.

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Annex A: Environment relevant SDG targets and indicators in the SDG Global Indicator Framework

Table A.1: List of environmental indicators in the SDG Global Indicator Framework
Note: Indicators for which UN Environment is Custodian Agency are marked in green font.

Goal	Target	Indicator
Goal 1. End poverty in all its forms everywhere	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	1.4.2 Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure
	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
		1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)
		1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030
		1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
Goal 2. End hunger achieve food security and improved nutrition and promote sustainable agriculture	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
	2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities
		2.5.2 Proportion of local breeds classified as being at risk of extinction
Goal 3. Ensure healthy lives and promote well-being for all at all ages	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.9.1 Mortality rate attributed to household and ambient air pollution
		3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
		3.9.3 Mortality rate attributed to unintentional poisoning

Goal	Target	Indicator
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
Goal 5. Achieve gender equality and empower all women and girls	5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure
Goal 6. Ensure availability and sustainable management of water and sanitation for all	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services
	6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of domestic and industrial wastewater flows safely treated
		6.3.2 Proportion of bodies of water with good ambient water quality
	6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time
		6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
	6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	**6.5.1 Degree of integrated water resources management**
		6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	**6.6.1 Change in the extent of water-related ecosystems over time**
	6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
	6.b Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Goal	Target	Indicator
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	7.1.2 Proportion of population with primary reliance on clean fuels and technology	7.1.2 Proportion of population with primary reliance on clean fuels and technology
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption
	7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP
	7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems
	7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	**8.4.1 Material footprint, material footprint per capita, and material footprint per GDP**
		8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO2 emission per unit of value added

Goal	**Target**	**Indicator**
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate
		11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)
	11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
		11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters
	11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
		11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
	11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030
		11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies

Goal	Target	Indicator
Goal 12. Ensure sustainable consumption and production patterns	12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	**12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production**
	12.2 By 2030, achieve the sustainable management and efficient use of natural resources	**12.2.1 Material footprint, material footprint per capita, and material footprint per GDP**
		12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
	12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	**12.3.1** (a) Food loss Index and **(b) Food waste Index**
	12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	**12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement**
		12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
	12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	**12.5.1 National recycling rate, tons of material recycled**
	12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	**12.6.1 Number of companies publishing sustainability reports**
	12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	**12.7.1 Degree of sustainable public procurement policies and action plan implementation**
	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
	12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
	12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability
	12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	**12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption)**

Goal	**Target**	**Indicator**
Goal 13. Take urgent action to combat climate change and its impacts	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
		13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030
		13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
	13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
		13.2.2 Total greenhouse gas emissions per year
	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
	13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025
	13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	13.b.1 Number of least developed countries and small island developing States with nationally determined contributions long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications

Goal	Target	Indicator
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	**14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density**
	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	**14.2.1 Number of countries using ecosystem-based approaches to managing marine areas**
	14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
	14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels
	14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	**14.5.1 Coverage of protected areas in relation to marine areas**
	14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
	14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries
	14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14.a.1 Proportion of total research budget allocated to research in the field of marine technology
	14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

Goal	Target	Indicator
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area **15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type**
	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area
	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	**15.4.1 Coverage by protected areas of important sites for mountain biodiversity** 15.4.2 Mountain Green Cover Index
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index
	15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
	15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked
	15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
	15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	**15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting**
	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	**15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments**
	15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	**15.b.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments**
	15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities	15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked

Goal	**Target**	**Indicator**
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	**17.7.1 Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies**
	17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation	17.9.1 Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries
	17.14 Enhance policy coherence for sustainable development	**17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development**
	17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals
	17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts	17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring
Total	**71**	**92**

Table A.2 Environmental indicators that were revised or replaced following the 2020 Comprehensive Review

Before 2020 Review	**After 2020 Review**
2.5.2 Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction	2.5.2 Proportion of local breeds classified as being at risk of extinction
4.7.1 / 12.8.1 / 13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in: (a) national education policies, (b) curricula, (c) teacher education and (d) student assessment	4.7.1 / 12.8.1 / 13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
6.3.1 Proportion of wastewater safely treated	6.3.1 Proportion of domestic and industrial wastewater flows safely treated
6.5.1 Degree of integrated water resources management implementation (0-100)	6.5.1 Degree of integrated water resources management
7.b.1 Investments in energy efficiency as a proportion of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services	7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
Deleted Indicator: 8.9.2 Proportion of jobs in sustainable tourism industries out of total tourism jobs	
11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)	11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)
Deleted Indicator: 11.c.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials	
12.1.1 Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies	12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production
12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment	12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12.7.1 Number of countries implementing sustainable public procurement policies and action plans	12.7.1 Degree of sustainable public procurement policies and action plan implementation
12.a.1 Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies	12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
12.b.1 Number of sustainable tourism strategies or policies and implemented action plans with agreed monitoring and evaluation tools	12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability
12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels	12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption)
13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications

Before 2020 Review	**After 2020 Review**
Additional Indicator: 13.2.2 Total greenhouse gas emissions per year	
Deleted Indicator: 13.3.2 Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions	
13.a.1 Mobilized amount of United States dollars per year between 2020 and 2025 accountable towards the $100 billion commitment	13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025
13.b.1 Number of least developed countries and small island developing States that are receiving specialized support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalized communities	13.b.1 Number of least developed countries and small island developing States with nationally determined contributions long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
14.1.1 Index of coastal eutrophication and floating plastic debris density	14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density
14.2.1 Proportion of national exclusive economic zones managed using ecosystem based approaches	14.2.1 Number of countries using ecosystem-based approaches to managing marine areas
15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020	15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting
15.a.1 / 15.b.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments
17.7.1 Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies	17.7.1 Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17.18.1 Proportion of sustainable development indicators produced at the national level with full disaggregation when relevant to the target, in accordance with the Fundamental Principles of Official Statistics	17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring

Table A.3 SDG Indicators reclassified to Tier II, 2019-2020

4.7.1/12.8.1/13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)
12.3.1.b Food waste index
12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12.5.1 National recycling rate, tons of material recycled
12.6.1 Number of companies publishing sustainability reports
12.7.1 Degree of sustainable public procurement policies and action plan implementation
13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025
13.b.1 Number of least developed countries and small island developing States with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density
14.2.1 Number of countries using ecosystem-based approaches to managing marine areas
14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources
15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting
17.7.1 Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development
17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring

Annex B: The SDG Regional Groupings[31]

Central & Southern Asia

Central Asia: Kazakhstan; Kyrgyzstan; Tajikistan; Turkmenistan; Uzbekistan
Southern Asia: Afghanistan; Bangladesh; Bhutan; India; Iran (Islamic Republic of); Maldives; Nepal; Pakistan; Sri Lanka

Eastern and South-eastern Asia

Eastern Asia: China; China, Hong Kong SAR; China, Macao SAR; Democratic People's Republic of Korea; Japan; Mongolia; Republic of Korea
South-eastern Asia: Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Philippines; Singapore; Thailand; Timor-Leste; Viet Nam

Europe and Northern America

Northern America: Bermuda; Canada; Greenland; United States of America
Eastern Europe: Belarus; Bulgaria; Czech Republic; Hungary; Poland; Republic of Moldova; Romania; Russian Federation; Slovakia; Ukraine
Northern Europe: Åland Islands; Channel Islands; Denmark; Estonia; Faroe Islands; Finland; Iceland; Ireland; Isle of Man; Latvia; Lithuania; Norway; Sweden; United Kingdom of Great Britain and Northern Ireland;
Southern Europe: Albania; Andorra; Bosnia and Herzegovina; Croatia; Greece; Italy; Malta; Montenegro; Portugal; San Marino; Serbia; Slovenia; Spain; The former Yugoslav Republic of Macedonia
Western Europe: Austria; Belgium; France; Germany; Liechtenstein; Luxembourg; Monaco; Netherlands; Switzerland

Latin America & the Caribbean

Caribbean: Anguilla; Antigua and Barbuda; Aruba; Bahamas; Barbados; Bonaire, Saint Eustatius and Saba; British Virgin Islands; Cayman Islands; Cuba; Curaçao; Dominica; Dominican Republic; Grenada; Guadeloupe; Haiti; Jamaica; Martinique; Montserrat; Puerto Rico; Saint Kitts and Nevis; Saint Lucia; Saint Vincent and the Grenadines; Saint Maarten (Dutch part); Suriname; Trinidad and Tobago; Turks and Caicos Islands; United States Virgin Islands
Central America: Costa Rica; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama
South America: Argentina; Belize; Bolivia (Plurinational State of); Brazil; Chile; Colombia; Ecuador; Falkland Islands (Malvinas); French Guiana; Guyana; Paraguay; Peru; South Georgia & the South Sandwich Islands; Uruguay; Venezuela (Bolivarian Republic of)

Northern Africa and Western Asia

Northern Africa: Algeria; Egypt; Libya; Morocco; Sudan; Tunisia; Western Sahara
Western Asia: Armenia; Azerbaijan; Bahrain; Cyprus; Georgia; Iraq; Israel; Jordan; Kuwait; Lebanon; Oman; Qatar; Saudi Arabia; State of Palestine; Syrian Arab Republic; Turkey; United Arab Emirates; Yemen

Oceania

Australia and New Zealand: Australia; Christmas Island; Cocos (Keeling) Islands; Heard Island & McDonald Islands; New Zealand; Norfolk Island
Oceania excluding Australia and New Zealand
Melanesia: Fiji; New Caledonia; Papua New Guinea; Solomon Islands; Vanuatu
Micronesia: Guam; Kiribati; Marshall Islands; Micronesia (Federated States of); Nauru; Northern Mariana Islands; Palau
Polynesia: American Samoa; Cook Islands; French Polynesia; Niue; Pitcairn; Samoa; Tokelau; Tonga; Tuvalu; Wallis and Futuna Island

Sub-Saharan Africa

Sub-Saharan Africa: Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo; Côte d'Ivoire; Democratic Republic of the Congo; Djibouti; Equatorial Guinea; Eritrea; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mayotte; Mozambique; Namibia; Niger; Nigeria; Réunion; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; Somalia; South Africa; South Sudan

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[31] Based on the official SDG regions: https://unstats.un.org/sdgs/indicators/regional-groups/.

Annex C: Statistical Analysis detailed results

Table C.1: Statistically significant relationships identified between direct drivers of change and environmental state indicators

The rho correlation coefficient is produced using a Pearson's correlation test applied to the indicator data only and indicates the strength of the correlation between two indicators. The model coefficient is produced by a linear regression model specified with the environmental state indicator as the dependent variable (the effect) and the direct driver of change indicator as the independent variable (the cause). This model also includes variables of population, GDP and geographic region. The r-squared value measures the amount of variance in the dependent variable explained by the statistical model. The direction of relationships between indicator pairs is derived from the model correlation coefficient. This value usually, but not always, agrees with the direction indicated by the rho correlation coefficient. When the direction of these values is in opposition, the model coefficient is given preference as it is based on the relationship between the indicators while accounting for three confounding factors: GDP, population and geographic region, whereas the rho is based on the indicator data only. As a general rule of thumb, the rho correlation coefficient can be interpreted to indicate weak (0.2-0.4), medium (0.4-0.6) and strong (>0.6) correlation between two indicators, and the model r-square value can be interpreted to indicate low (0.2-0.4), medium (0.4-0.6) and high (>0.6) exploratory power of the linear regression model. However, these results are produced from exploratory research and each relationship needs to be carefully considered on a case-by-case basis.

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
2.5.1	Plant breeds for which sufficient genetic resources are stored (number)	NA	2.5.2	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)	0.117	0.06589	0.514
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.091	-0.43681	0.568
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)	NA	6.6.1	Water body extent (permanent) (square kilometres)	-0.088	-0.43077	0.566
6.a.1	Total official development assistance (gross disbursement) for water supply and sanitation, by recipient countries (millions of constant 2017 United States dollars)	NA	15.5.1	Red List Index	0.02	-0.00459	0.208
6.a.1	Total official development assistance (gross disbursement) for water supply and sanitation, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.482	-0.06817	0.635
6.a.1	Total official development assistance (gross disbursement) for water supply and sanitation, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.471	-0.06165	0.634

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
6.b.1	Countries with users/communities participating in planning programs in water resources planning and management, by level of participation (3 = High; 2 = Moderate; 1 = Low; 0 = NA)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.225	0.39179	0.093
6.b.1	Countries with users/communities participating in planning programs in water resources planning and management, by level of participation (3 = High; 2 = Moderate; 1 = Low; 0 = NA)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.222	0.37988	0.089
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	-0.247	0.047	0.489
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.017	-0.396	0.179
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.004	-0.253	0.288
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	NA	15.5.1	Red List Index	-0.037	0.017	0.33
7.2.1	Renewable energy share in the total final energy consumption (%)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	0.212	-0.092	0.552
7.2.1	Renewable energy share in the total final energy consumption (%)	NA	15.1.1	Forest area (thousands of hectares)	-0.006	0.567	0.696
7.2.1	Renewable energy share in the total final energy consumption (%)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.12	0.319	0.22
7.2.1	Renewable energy share in the total final energy consumption (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.046	0.128	0.163
7.2.1	Renewable energy share in the total final energy consumption (%)	NA	15.5.1	Red List Index	0.045	-0.002	0.274
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	0.16	0.049	0.535
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WCH	15.1.1	Forest area (thousands of hectares)	0.351	0.107	0.582

Driver indicator	**Indicator/sub-indicator description**	**Product type**	**Environmental state indicator**	**Indicator/sub-indicator description**	**Rho correlation coefficient**	**Model coefficient**	**Model r-square value**
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	15.1.1	Forest area (thousands of hectares)	0.447	0.337	0.574
8.4.2	Domestic material consumption, by type of raw material (tonnes)	MEO	15.1.1	Forest area (thousands of hectares)	0.326	0.264	0.614
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WOD	15.1.1	Forest area (thousands of hectares)	0.558	0.75	0.638
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WCH	15.1.1	Forest area as a proportion of total land area (%)	0.046	0.122	0.17
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	15.1.1	Forest area as a proportion of total land area (%)	-0.012	0.342	0.179
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	15.1.1	Forest area as a proportion of total land area (%)	-0.008	-0.074	0.153
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WOD	15.1.1	Forest area as a proportion of total land area (%)	0.012	0.436	0.276
8.4.2	Domestic material consumption, by type of raw material (tonnes)	NMM	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.104	-0.074	0.194
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WCH	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.098	0.061	0.222
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.076	0.176	0.208
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.131	-0.076	0.178
8.4.2	Domestic material consumption, by type of raw material (tonnes)	MEO	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.06	-0.043	0.215
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WOD	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.089	0.254	0.295
8.4.2	Domestic material consumption, by type of raw material (tonnes)	NMM	15.2.1	Forest area net change rate (%)	0.077	0.142	0.108
8.4.2	Domestic material consumption, by type of raw material (tonnes)	NMM	15.5.1	Red List Index	-0.087	0.004	0.258
8.4.2	Domestic material consumption, by type of raw material (tonnes)	WCH	15.5.1	Red List Index	-0.179	-0.006	0.266
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	15.5.1	Red List Index	-0.126	-0.016	0.27

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	15.5.1	Red List Index	-0.102	0.002	0.239
8.4.2	Domestic material consumption, by type of raw material (tonnes)	MEO	15.5.1	Red List Index	-0.121	0.004	0.261
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.024	-0.058	0.058
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.214	0.15	0.579
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.271	0.071	0.471
8.4.2	Domestic material consumption, by type of raw material (tonnes)	MEO	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.218	0.251	0.619
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	6.6.1	Water body extent (permanent) (% of total land area)	-0.024	-0.058	0.057
8.4.2	Domestic material consumption, by type of raw material (tonnes)	CRO	6.6.1	Water body extent (permanent) (square kilometres)	0.215	0.19	0.59
8.4.2	Domestic material consumption, by type of raw material (tonnes)	FOF	6.6.1	Water body extent (permanent) (square kilometres)	0.272	0.072	0.472
8.4.2	Domestic material consumption, by type of raw material (tonnes)	MEO	6.6.1	Water body extent (permanent) (square kilometres)	0.219	0.258	0.625
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	15.1.1	Forest area (thousands of hectares)	-0.149	-1.034	0.668
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.224	-0.404	0.148
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	15.2.1	Forest area net change rate (%)	0.115	0.253	0.183
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	15.5.1	Red List Index	-0.005	-0.017	0.407
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.197	-0.683	0.554

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
8.9.1	Tourism direct GDP as a proportion of total GDP (%)	NA	6.6.1	Water body extent (permanent) (square kilometres)	-0.196	-0.677	0.551
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.086	0.051	0.267
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	15.2.1	Forest area net change rate (%)	0.083	0.105	0.103
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.013	0.03709	0.074
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.588	0.05805	0.637
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.02	0.03934	0.057
9.a.1	Total official flows for infrastructure, by recipient countries (millions of constant 2017 United States dollars)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.577	0.06212	0.637
12.4.2	Electronic waste generated (Tonnes)	NA	15.2.1	Forest area net change rate (%)	0.066	0.207	0.092
12.4.2	Electronic waste generated (Tonnes)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.04	-0.214	0.06
12.4.2	Electronic waste generated (Tonnes)	NA	6.6.1	Water body extent (permanent) (% of total land area)	-0.038	-0.212	0.054
12.4.2	Electronic waste generated, per capita (Kg)	NA	15.5.1	Red List Index	0.088	0.0045	0.246
12.4.2	Electronic waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.024	-0.247	0.051
12.4.2	Electronic waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.124	-0.387	0.616
12.4.2	Electronic waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (% of total land area)	-0.011	-0.223	0.045

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
12.4.2	Electronic waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.125	-0.342	0.621
12.4.2	Electronic waste recycling (Tonnes)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	0.182	0.029	0.622
12.4.2	Electronic waste recycling (Tonnes)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.057	0.088	0.116
12.4.2	Electronic waste recycling (Tonnes)	NA	6.6.1	Water body extent (permanent) (% of total land area)	-0.059	0.091	0.115
12.4.2	Electronic waste recycling, per capita (Kg)	NA	15.5.1	Red List Index	0.374	0.01225	0.423
12.4.2	Electronic waste recycling, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.419	0.534	0.222
12.4.2	Electronic waste recycling, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.152	0.538	0.628
12.4.2	Electronic waste recycling, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.412	0.536	0.221
12.4.2	Electronic waste recycling, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (square kilometres)	-0.152	0.543	0.628
12.4.2	Hazardous waste generated (Tonnes)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	-0.055	-0.041	0.618
12.4.2	Hazardous waste generated (Tonnes)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.398	0.12	0.617
12.4.2	Hazardous waste generated (Tonnes)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.396	0.119	0.619
12.4.2	Hazardous waste generated, per capita (Kg)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	-0.079	-0.062	0.628
12.4.2	Hazardous waste generated, per capita (Kg)	NA	15.1.1	Forest area (thousands of hectares)	-0.017	0.141	0.755

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
12.4.2	Hazardous waste generated, per capita (Kg)	NA	15.5.1	Red List Index	0.356	0.00341	0.454
12.4.2	Hazardous waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.008	0.049	0.147
12.4.2	Hazardous waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.196	0.311	0.647
12.4.2	Hazardous waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.008	0.048	0.147
12.4.2	Hazardous waste generated, per capita (Kg)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.194	0.31	0.648
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	-0.052	-0.433	0.621
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	15.1.1	Forest area as a proportion of total land area (%)	-0.168	-0.692	0.37
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	15.5.1	Red List Index	0.138	0.02143	0.437
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.006	0.404	0.179
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.165	3.038	0.666
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.006	0.388	0.18
12.4.2	Hazardous waste generated, per unit of GDP (kilograms per constant 2015 United States dollars)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.164	3.017	0.667
12.4.2	Hazardous waste treated or disposed (Tonnes)	NA	11.6.2	Annual mean levels of fine particulate matter in cities, urban population (micrograms per cubic meter)	0.004	-0.031	0.594

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
12.4.2	Hazardous waste treated or disposed (Tonnes)	NA	15.1.1	Forest area (thousands of hectares)	0.177	0.141	0.722
12.4.2	Hazardous waste treated or disposed (Tonnes)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.649	0.182	0.6
12.4.2	Hazardous waste treated or disposed (Tonnes)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.643	0.182	0.602
12.4.2	Hazardous waste treated or disposed, rate (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.003	0.086	0.173
12.4.2	Hazardous waste treated or disposed, rate (%)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.002	0.089	0.174
12.4.2	Hazardous waste treated, by type of treatment (Tonnes)	NA	15.5.1	Red List Index	0.318	0.00098	0.558
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.1.1	Forest area (thousands of hectares)	0.202	0.31759	0.483
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.315	0.24892	0.228
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.155	0.107	0.151
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.5.1	Red List Index	0.037	-0.00253	0.323
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.058	0.10949	0.431
15.1.2	Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.056	0.10728	0.434
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.1.1	Forest area (thousands of hectares)	0.35	0.42066	0.675

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.301	0.38815	0.242
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.11	0.248	0.192
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.2.1	Forest area net change rate (%)	-0.124	-0.093	0.091
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.5.1	Red List Index	0.066	-0.00231	0.3
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.003	0.0316	0.046
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.241	0.07636	0.609
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.022	0.04233	0.051
15.1.2	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.22	0.10188	0.613
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	15.1.1	Forest area (thousands of hectares)	0.494	0.27619	0.712
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.28	0.13061	0.192
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.071	0.053	0.161
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	15.2.1	Forest area net change rate (%)	0.012	-0.036	0.089

Driver indicator	Indicator/sub-indicator description	Product type	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	15.5.1	Red List Index	0.122	0.00174	0.296
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	0.044	0.038	0.047
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.835	0.24	0.676
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	6.6.1	Water body extent (permanent) (% of total land area)	0.051	0.036	0.045
15.2.1	Forest area certified under an independently verified certification scheme (thousands of hectares)	NA	6.6.1	Water body extent (permanent) (square kilometres)	0.842	0.239	0.682
15.2.1	Proportion of forest area with a long-term management plan (%)	NA	15.5.1	Red List Index	0.023	-0.00481	0.334
15.2.1	Proportion of forest area within legally established protected areas (%)	NA	15.1.1	Forest area as a proportion of total land area (%)	0.074	0.09874	0.101
15.2.1	Proportion of forest area within legally established protected areas (%)	NA	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.112	0.157	0.192
15.2.1	Proportion of forest area within legally established protected areas (%)	NA	15.2.1	Forest area net change rate (%)	-0.188	-0.153	0.1
15.2.1	Proportion of forest area within legally established protected areas (%)	NA	15.5.1	Red List Index	-0.16	-0.00657	0.265
15.4.1	Average proportion of Mountain Key Biodiversity Areas (KBAs) covered by protected areas (%)	NA	15.5.1	Red List Index	0.021	-0.0024	0.274
15.8.1	Legislation, Regulation, Act related to the prevention of introduction and management of Invasive Alien Species (1 = YES, 0 = NO)	NA	15.5.1	Red List Index	-0.115	-0.0265	0.29

Table C.2: Statistically significant relationships identified between state of society and environmental state indicators

The rho correlation coefficient is produced using a Pearson's correlation test applied to the indicator data only and indicates the strength of the correlation between two indicators. The model coefficient is produced by a linear regression model specified with the environmental state indicator as the independent variable (the cause) and the state of society indicator as the dependent variable (the effect). This model also includes variables of population, GDP and geographic region. The r-squared value measures the amount of variance in the dependent variable explained by the statistical model. The direction of relationships between indicator pairs is derived from the model correlation coefficient. This value usually, but not always, agrees with the direction indicated by the rho correlation coefficient. When the direction of these values is in opposition, the model coefficient is given preference as it is based on the relationship between the indicators while accounting for three confounding factors: GDP, population and geographic region, whereas the rho is based on the indicator data only. As a general rule of thumb, the rho correlation coefficient can be interpreted to indicate weak (0.2-0.4), medium (0.4-0.6) and strong (>0.6) correlation between two indicators, and the model r-square value can be interpreted to indicate low (0.2-0.4), medium (0.4-0.6) and high (>0.6) exploratory power of the linear regression model. However, these results are produced from exploratory research and each relationship needs to be carefully considered on a case-by-case basis.

State of society indicator	Indicator/sub-indicator description	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
1.5.1	Number of deaths due to disaster (number)	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.018	-0.193	0.366
1.5.1	Number of deaths due to disaster (number)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.002	-0.151	0.375
1.5.1	Number of deaths due to disaster (number)	6.6.1	Water body extent (permanent) (% of total land area)	-0.018	-0.198	0.366
1.5.1	Number of deaths due to disaster (number)	6.6.1	Water body extent (permanent) (square kilometres)	-0.002	-0.152	0.375
1.5.1	Number of missing persons due to disaster (number)	15.1.1	Forest area (thousands of hectares)	-0.012	-0.377	0.404
1.5.1	Number of people affected by disaster (number)	15.1.1	Forest area (thousands of hectares)	0.288	0.238	0.383
1.5.1	Number of people affected by disaster (number)	15.1.1	Forest area as a proportion of total land area (%)	-0.122	0.4	0.385
1.5.1	Number of people whose damaged dwellings were attributed to disasters (number)	15.1.1	Forest area as a proportion of total land area (%)	-0.081	0.715	0.382
1.5.1	Number of people whose damaged dwellings were attributed to disasters (number)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.036	1.059	0.371
1.5.1	Number of people whose destroyed dwellings were attributed to disasters (number)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.095	1.009	0.438

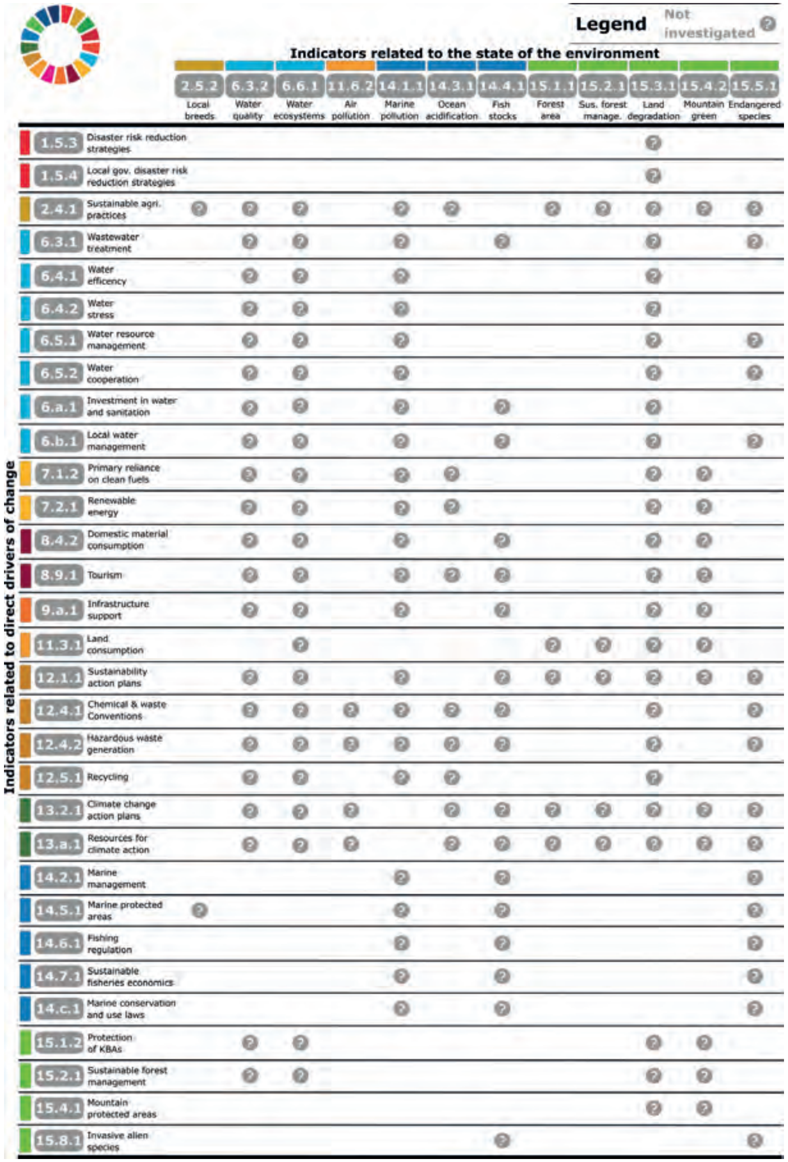
State of society indicator	Indicator/sub-indicator description	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
1.5.1	Number of people whose livelihoods were disrupted or destroyed, attributed to disasters (number)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	0.491	0.445	0.51
1.5.1	Number of people whose livelihoods were disrupted or destroyed, attributed to disasters (number)	6.6.1	Water body extent (permanent) (square kilometres)	0.495	0.443	0.51
1.5.2	Direct agriculture loss attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.026	-0.815	0.269
1.5.2	Direct agriculture loss attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent) (% of total land area)	-0.025	-0.851	0.27
1.5.2	Direct economic loss attributed to disasters (current United States dollars)	15.1.1	Forest area (thousands of hectares)	0.151	0.232	0.482
1.5.2	Direct economic loss attributed to disasters (current United States dollars)	15.1.1	Forest area as a proportion of total land area (%)	0.062	0.651	0.519
1.5.2	Direct economic loss attributed to disasters (current United States dollars)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.158	0.981	0.508
1.5.2	Direct economic loss attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.006	-0.142	0.428
1.5.2	Direct economic loss attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent) (square kilometres)	-0.006	-0.145	0.428
1.5.2	Direct economic loss attributed to disasters relative to GDP (%)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	0.235	0.051	0.072
1.5.2	Direct economic loss attributed to disasters relative to GDP (%)	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.03	-0.011	0.027
1.5.2	Direct economic loss attributed to disasters relative to GDP (%)	6.6.1	Water body extent (permanent) (% of total land area)	-0.029	-0.011	0.027
1.5.2	Direct economic loss in the housing sector attributed to disasters (current United States dollars)	15.1.1	Forest area (thousands of hectares)	0.032	0.816	0.179
1.5.2	Direct economic loss in the housing sector attributed to disasters (current United States dollars)	15.1.1	Forest area as a proportion of total land area (%)	-0.065	1.497	0.198
1.5.2	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.051	-0.72	0.113

State of society indicator	Indicator/sub-indicator description	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
1.5.2	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent and maybe permanent) (square kilometres)	-0.014	-0.536	0.119
1.5.2	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent) (% of total land area)	-0.05	-0.742	0.114
1.5.2	Direct economic loss resulting from damaged or destroyed critical infrastructure attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent) (square kilometres)	-0.014	-0.538	0.119
1.5.2	Direct economic loss to other damaged or destroyed productive assets attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent and maybe permanent) (% of total land area)	-0.014	0.335	0.267
1.5.2	Direct economic loss to other damaged or destroyed productive assets attributed to disasters (current United States dollars)	6.6.1	Water body extent (permanent) (% of total land area)	-0.013	0.347	0.267
2.1.1	Number of undernourished people (millions)	15.1.1	Forest area as a proportion of total land area (%)	-0.077	0.102	0.811
2.1.1	Number of undernourished people (millions)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.116	0.164	0.836
2.1.1	Number of undernourished people (millions)	2.5.2	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)	-0.187	0.041	0.893
2.1.1	Prevalence of undernourishment (%)	15.1.1	Forest area (thousands of hectares)	-0.071	0.042	0.713
2.1.1	Prevalence of undernourishment (%)	15.1.1	Forest area as a proportion of total land area (%)	0.011	0.05	0.71
2.1.1	Prevalence of undernourishment (%)	15.2.1	Forest area net change rate (%)	-0.284	-0.088	0.676
2.1.1	Prevalence of undernourishment (%)	2.5.2	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)	-0.506	-0.019	0.757
2.1.2	Prevalence of severe food insecurity in the adult population (%)	2.5.2	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)	-0.522	-0.128	0.773

State of society indicator	Indicator/sub-indicator description	Environmental state indicator	Indicator/sub-indicator description	Rho correlation coefficient	Model coefficient	Model r-square value
2.1.2	Total population in severe food insecurity (thousands of people)	2.5.2	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)	-0.597	-0.167	0.886
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	15.1.1	Forest area as a proportion of total land area (%)	0.017	-0.144	0.697
7.1.2	Proportion of population with primary reliance on clean fuels and technology (%)	15.2.1	Above-ground biomass in forest per hectare (tonnes per hectare)	-0.004	-0.268	0.697

Annex D: Data Unavailability

Figure D.1. Data unavailability- Direct drivers of change

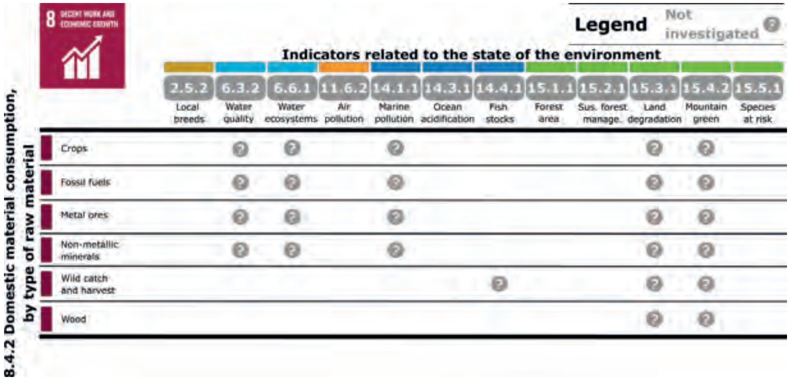


Legend: Not investigated ?

Indicators related to the state of the environment

Indicators related to direct drivers of change

	2.5.2 Local breeds	6.3.2 Water quality	6.6.1 Water ecosystems	11.6.2 Air pollution	14.1.1 Marine pollution	14.3.1 Ocean acidification	14.4.1 Fish stocks	15.1.1 Forest area	15.2.1 Sus. forest manage.	15.3.1 Land degradation	15.4.2 Mountain green	15.5.1 Endangered species
1.5.3 Disaster risk reduction strategies										?		
1.5.4 Local gov. disaster risk reduction strategies										?		
2.4.1 Sustainable agri. practices	?	?	?		?	?		?	?	?	?	?
6.3.1 Wastewater treatment		?	?		?		?			?		?
6.4.1 Water efficency		?	?		?					?		
6.4.2 Water stress		?	?		?					?		
6.5.1 Water resource management		?	?		?					?		?
6.5.2 Water cooperation		?	?		?					?		?
6.a.1 Investment in water and sanitation		?	?		?		?			?		
6.b.1 Local water management		?	?		?		?			?		?
7.1.2 Primary reliance on clean fuels		?	?		?	?				?	?	
7.2.1 Renewable energy		?	?		?	?				?	?	
8.4.2 Domestic material consumption		?	?		?		?			?	?	
8.9.1 Tourism		?	?		?	?	?			?	?	
9.a.1 Infrastructure support		?	?		?		?			?	?	
11.3.1 Land consumption			?					?	?	?	?	
12.1.1 Sustainability action plans		?	?		?		?	?	?	?	?	?
12.4.1 Chemical & waste Conventions		?	?	?	?	?	?			?		?
12.4.2 Hazardous waste generation		?	?	?	?	?	?			?		?
12.5.1 Recycling		?	?		?	?				?		
13.2.1 Climate change action plans		?	?	?		?	?	?	?	?	?	?
13.a.1 Resources for climate action		?	?	?		?	?	?	?	?	?	?
14.2.1 Marine management					?		?					?
14.5.1 Marine protected areas	?				?		?					?
14.6.1 Fishing regulation					?		?					?
14.7.1 Sustainable fisheries economics					?		?					?
14.c.1 Marine conservation and use laws					?		?					?
15.1.2 Protection of KBAs		?	?							?	?	
15.2.1 Sustainable forest management		?	?							?	?	
15.4.1 Mountain protected areas										?	?	
15.8.1 Invasive alien species							?					?



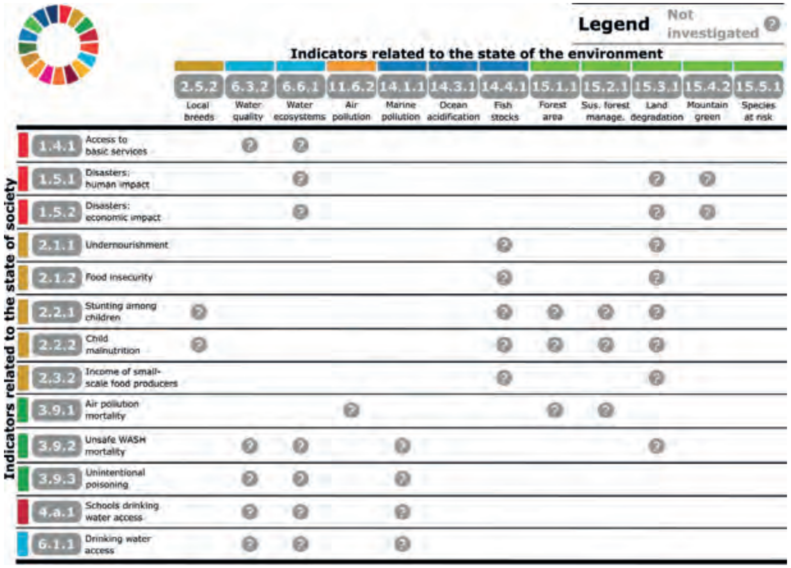
Legend: Not investigated ?

Indicators related to the state of the environment

8.4.2 Domestic material consumption, by type of raw material

	2.5.2 Local breeds	6.3.2 Water quality	6.6.1 Water ecosystems	11.6.2 Air pollution	14.1.1 Marine pollution	14.3.1 Ocean acidification	14.4.1 Fish stocks	15.1.1 Forest area	15.2.1 Sus. forest manage.	15.3.1 Land degradation	15.4.2 Mountain green	15.5.1 Species at risk
Crops		?	?		?					?	?	
Fossil fuels		?	?		?					?	?	
Metal ores		?	?		?					?	?	
Non-metallic minerals		?	?		?					?	?	
Wild catch and harvest							?			?	?	
Wood										?	?	

Figure D.2. Data unavailability – State of society



Legend: Not investigated ?

Indicators related to the state of the environment

Indicators related to the state of society

	2.5.2 Local breeds	6.3.2 Water quality	6.6.1 Water ecosystems	11.6.2 Air pollution	14.1.1 Marine pollution	14.3.1 Ocean acidification	14.4.1 Fish stocks	15.1.1 Forest area	15.2.1 Sus. forest manage.	15.3.1 Land degradation	15.4.2 Mountain green	15.5.1 Species at risk
1.4.1 Access to basic services		?	?									
1.5.1 Disasters: human impact			?							?	?	
1.5.2 Disasters: economic impact			?							?	?	
2.1.1 Undernourishment							?			?		
2.1.2 Food insecurity							?			?		
2.2.1 Stunting among children	?						?	?	?	?		
2.2.2 Child malnutrition	?						?	?	?	?		
2.3.2 Income of small-scale food producers							?			?		
3.9.1 Air pollution mortality				?				?	?			
3.9.2 Unsafe WASH mortality		?	?		?					?		
3.9.3 Unintentional poisoning		?	?		?							
4.a.1 Schools drinking water access		?	?		?							
6.1.1 Drinking water access		?	?		?							

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