UN environment programme

Measuring Progress:

Water-related ecosystems and the SDGs

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Acronyms

AfDB	African Development Bank
AIP	Africa Water Investment Programme
APWF	Asia-Pacific Water Forum
APWS	Asia-Pacific Water Summit
CBAS	International Research Center of Big Data for Sustainable Development Goals
CEOS	Committee on Earth Observation Satellites
COBSEA	Coordinating Body of the Seas of East Asia
DIMAQ	Data Integration Model for Air Quality
DPSIR	Driver-pressure-state-impact-response
EEZ	Exclusive economic zone
EO	Earth Observation
EPA	Environmental Protection Agency
ESA	European Space Agency
ESCWA	Economic and Social Commission for Western Asia
EU	European Union
FAIR	Findable, Accessible, Interoperable and Reusable
GNI	Gross National Income
HAB	Harmful algal blooms
IBA	Important Bird and Biodiversity Areas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IRENA	International Renewable Energy Agency
ISIC	International Standard Industrial Classification of All Economic Activities
KBAs	Key Biodiversity Areas
LAC	Latin America and the Caribbean
MENA	Middle East and North Africa
MPA	Marine protected areas
MRE	Marine renewable energy
NAP	National action plan
NCCA	National Coastal Condition Assessment of America
NOAA	National Oceanic and Atmospheric Administration
NSI	National source inventory
NSO	National statistical offices
OECD	Organisation for Economic Co-operation and Development
SAWI	Southern Asia Water Initiative
SDG	Sustainable Development Goal
SEI	Stockholm Environment Institute
SPA	Special Protected Areas
UAE	United Arab Emirates
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WASH	Water, Sanitation and Hygiene for All
WFD	Water Framework Directive
WHO	World Health Organization

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Foreword

The 17 Sustainable Development Goals (SDGs) and 169 targets of the universal 2030 Agenda offer a blueprint for a sustainable and resilient future, where responsible management of our planet's finite resources can create a brighter tomorrow for future generations. Global crises and conflicts, including the COVID-19 pandemic, the war in Ukraine, exacerbating food, energy, humanitarian and refugee crises, and a full-fledged climate emergency make it ever more important to redouble our efforts to implement this blueprint for building back a better world.

Today at the half-way point, the latest available data and estimates for 92 environment relevant SDG indicators tell us that the world is not on track to achieve the environmental dimension of the SDGs by 2030. However, there is some positive news. Global data availability increased to 59 per cent in 2022, from 34 per cent in 2018 and 42 per cent in 2020. And although only 38 per cent of the environment-related indicators indicate environmental improvement, this is a solid improvement compared to only 28 per cent in 2020.   Moreover, indicators of some Goals showed strong positive trends, including SDG 9 on infrastructure, SDG 7 on energy, and SDG 6 on freshwater.

The integrated and indivisible nature of the SDGs reflect the interlinked nature of land- and water-based ecosystems, and the rich biodiversity they support, which provides food, clean water and air, and raw materials that fuel economic growth, leading to prosperity and human well-being. Achieving the SDGs, therefore, requires an integrated approach that recognizes how these challenges—and their solutions—are interrelated. The third edition of the Measuring Progress report focuses on statistical methods to understand these interlinkages through the prism of water ecosystems and the SDGs. In so doing, it provides insight into how freshwater- and marine-related ecosystems are impacted by various drivers, pressures, and actions, through use of statistical analysis.

We hope that this report will encourage governments to strengthen further their statistical capacity in relation to the environment, incite further work on developing disaggregated and ecosystem-relevant data and on promoting use of non-traditional data sources like big data and citizen science. The all-sectoral approach encouraged by the SDGs, which Measuring Progress systematically explores would reinforce synergies as much as minimize trade-offs for a more holistic realization of the 2030 Agenda. With every action we take or investment we make in a sustainable future, we inch closer to the world we all want to see. With unwavering hope and determination, let us continue to strive towards realizing the 2030 Agenda.

Jian Liu

Director, Early Warning and Assessment Division

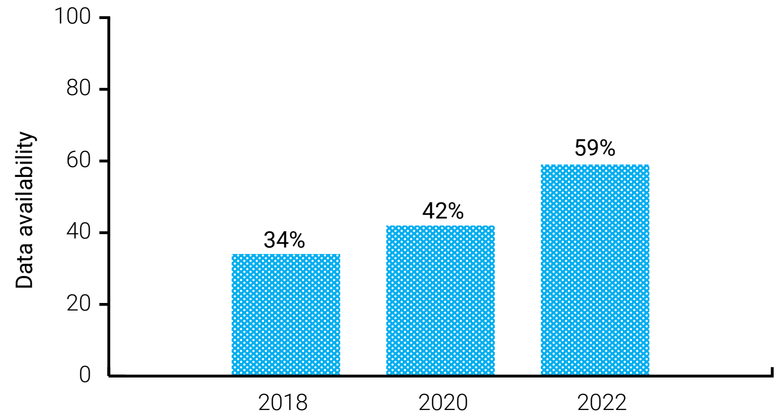
Executive Summary

The United Nations Environment Programme's (UNEP) Measuring Progress series of reports provides an overview of the progress made in data availability for the 92 environment-related Sustainable Development Goal (SDG) indicators, coupled with improvement or degradation in the trend of each indicator. It also explores the potential and limitations of using statistical analysis to demonstrate interlinkages between indicator pairs to better inform policymakers of the synergies and trade-offs between SDGs. The indicators are divided into four categories: (i) state of the environment, (ii) drivers of change, (iii) state of human well-being and (iv) socioeconomic and environmental factors. This report explores the use of multivariate statistical analysis using water-related ecosystems (freshwater and marine) as an example of the utility of this approach to explore how ecosystems are impacted by drivers, pressures and actions at multiple scales.

Substantial improvement in global data availability

Global analysis of the progress of the 92 environment-related SDG indicators demonstrates an improvement in data availability, resulting from additional data being reported by countries leading to the availability of sufficient data to aggregate at regional and global levels. In 2022, the environment-related SDG indicators with sufficient data to analyse were estimated at 59 per cent, up from 42 per cent in 2020 and 34 per cent in 2018. Indicators with more data available are mostly found in SDG 6 on freshwater, SDG 7 on energy, SDG 12 on sustainable consumption and production, SDG 13 on climate change, SDG 14 on life below water and SDG 15 on life on land, with the most improvement in data availability reported in the Latin America and Caribbean, Northern Africa, and Europe regions.

Figure ES.1 **Percentage of SDG environment-related indicators with sufficient data for analysis of progress**



This major improvement in data availability results from a sustained investment by countries in their national statistical systems to collect and report data for SDG indicators as part of their sustainable development programmes, supported by capacity development efforts by custodian agencies.

The further development of methodologies that use new data sources also contributes to improved data availability. Many national statistical offices (NSOs) are already experimenting with using big data in the production of official statistics. Currently, the dominant big data types include Earth Observation (EO) data, citizen science data and other sensor network data, combined with advanced analytical techniques (e.g. machine learning, geospatial modelling and geostatistical modelling).

Figure ES.2 Environment-related SDG indicators data trend, global level

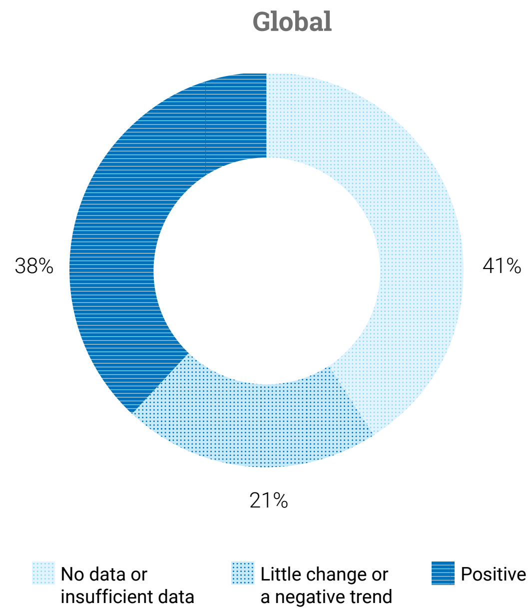
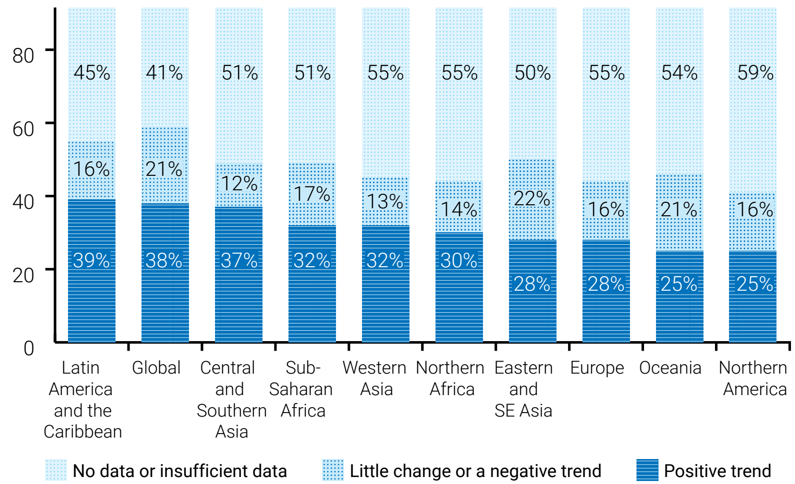


Figure ES.3 Environment-related SDG indicators data trend, global and regional levels



Status of environment-related SDG indicators

In 2022, at the global level 38 per cent of the 92 environment-related indicators showed positive change, indicating environmental improvement, and 21 per cent showed little or **negative change**. The most indicators showing positive trends were those related to SDG 9 on infrastructure, SDG 7 on energy and SDG 6 on freshwater.

The regions with the highest proportion of SDG environment-related indicators showing environmental improvement are the Latin America and the Caribbean region (39 per cent) and the Central and Southern Asia subregion (38 per cent). The regions with the lowest proportion of indicators showing environmental degradation are Central and Southern Asia (12 per cent), Western Asia (13 per cent) and Northern Africa (14 per cent).

While measuring the progress of the 92 environment-related SDG indicators focuses on evaluating trends, it does not assess the magnitude of the trends or progress towards meeting targets associated with specific indicators.

Advancing statistical methods for identifying interlinkages

This report advances the statistical methods to better assess and understand the interlinkages between pairs of indicators through the use of multivariate statistical analysis. This builds on the methods used in the previous report, Measuring Progress: Environment and the SDGs, which explored the use of correlation analysis to identify the interlinkages between pairs of indicators. Based on the driver-pressure-state-impact-response (DPSIR) framework, the analysis identifies how one state of the environment indicator is relates to indicators of a multitude of drivers of change as well as socioeconomic and environmental factors. The statistical analysis focuses on freshwater- and marine-related ecosystems and is conducted at the global, national (Colombia and Mongolia) and basin (Poyang basin, China) levels.

Global policy discussions benefit from new analytical approaches to understanding the underlying interlinkages and drivers of indicator trends. The analytical approach used has the potential to contribute to a more policy-relevant integrated analysis. The analysis confirmed many known interlinkages between freshwater- and marine-related ecosystems and variable drivers. It also identified several new interlinkages that cannot be easily explained with the existing literature, requiring further investigation to identify whether these are covariates or newly identified drivers. Consideration of these new drivers may be highly relevant to the development of new innovative policies to protect these ecosystems.

Evaluating indicators at the national level provides a more comprehensive and actionable interpretation of key interlinkages than at the global level, but global-level trends remain critical to assessing overall progress in achieving the SDGs. A unique aspect of the analysis is the inclusion of both global-level and national-level interlinkages. While some interlinkages were detected at both scales, others were only identified at the more granular national scale. The various positive and negative relationships identified between the state of the ecosystem, direct drivers of change, state of human well-being, and socioeconomic and environmental factors highlight the importance of considering the impact of indirectly related factors. While some impacting factors are common in global and national settings, identifying other national factors considered to have synergies or trade-offs with water-related ecosystems is imperative to inform the development of targeted policies and interventions to protect these ecosystems.

Findings for freshwater- and marine-related ecosystems

The analysis identified strong interlinkages related to policies that integrate land and water conservation, ensure suitable water infrastructure in urban areas, provide mitigation of pollution and address impacts from water withdrawals associated with economic activity. The analysis revealed mostly examples of relationships consistent with published evidence and intuition. For example, population living in urban areas was found to be positively interlinked to a decline in marine-related ecosystem indicators, confirming the impact of effluents from large cities on the eutrophication of coastal areas.

The inclusion of global and national levels in the statistical analysis provided an opportunity to verify global interlinkages with national case studies and highlight the impact of data disaggregation. For instance, conservation efforts were consistently positively interlinked with freshwater-related ecosystem indicators at both levels, while water-use efficiency indicators were interlinked with freshwater-related ecosystems only at the national level.

Recommendations

The analytical approach has exposed some of the critical data gaps in water-related ecosystems and has challenged the suitability of some indicators to detect meaningful change in the health of freshwater- and marine-related ecosystems. The freshwater-related ecosystem assessment was limited to interlinkages between various metrics of the area of freshwater in each country. Similarly, the lack of disaggregated catchment-level data constrained the ability to meaningfully assess coastal ecosystems. While these data sets benefit from the ability to provide consistent measurement using remote sensing across the globe, they are limited in their ability to measure the water quality, volumes or ecosystem health of waterbodies. There may be opportunities to further utilize citizen science, satellite imagery, low-cost in situ monitoring and big data to produce measures of water quality and/or volume within various waterbodies.

It is critical that the successes of the SDG indicator framework be translated into disaggregated data capable of informing subnational policies while maintaining compatibility at a global scale. Data and indicators are key for informed decision-making and policy design to know how realistic options are, what inconsistencies might result from decisions, how the cost of such inconsistencies can be mitigated and how trade-offs can be explained. Considering that most environmental policies, including water policies, are developed at the national or subnational scale, disaggregated data is needed to inform policy.

Re-evaluating the suitability of the current indicator methodologies to parse true change in the environment from data and methodological artefacts is needed to bolster data collection for other environment-related indicators. Moreover, the analysis revealed the importance of incorporating more ecologically relevant spatial groupings. Catchment-based or ecosystem-based aggregations may provide more insight into the ecological dimension of many of the interlinkages identified for freshwater- and marine-related ecosystems. However, methods and tools used are expected to be developed concomitantly to facilitate actionable use of data by policymakers working within political or geographical boundaries.

A fuller understanding of SDG interlinkages will ultimately allow for the design of more effective policy responses. For example, integrated water resources management is an optimal policy response that requires the incorporation of scientific analysis of the most relevant external drivers of ecosystem and resource issues, a comprehensive planning approach as well as a traditional approach that focuses on stakeholder input. This is critical to achieving policy coherence and recommendations that are both policy relevant and scientifically defensible.

Sustainable development and the 2030 Agenda can only be achieved through an all-sectoral approach that integrates environment-related indicator trends with robust policy analyses. Its interlinked nature calls for policy coherence for sustainable development through an integrated approach to ensure the production of complementary policies and the avoidance of trade-offs.

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Chapter 1: Background

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1.1 Introduction

1.1.1 A focus on water-related ecosystems

The 2030 Agenda for Sustainable Development and its Sustainable Development Goal (SDG) framework were constructed to interlink economic, environmental and social dimensions. The importance of achieving sustainability relies on understanding the synergies and trade-offs between implemented actions and the actions that may hinder or empower them. The Measuring Progress series explores the relationship between environmental indicators and economic or social indicators. The Measuring Progress: Environment and the SDGs report (2021) mapped those SDG indicators through the standard driver-pressure-state-impact-response (DPSIR) lens and categorized them into state of the environment indicators, state of society indicators and direct drivers indicators, enabling the identification of possible synergies between these SDG indicators by using simple correlation. The simple correlation analysis provided only limited insight into interlinkages which often prove to be complex and 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 report emphasized the need for data and techniques capable of full multivariate analyses to understand the implications of the full set of the SDG policies and better design new interventions.

In this report, data availability for one thematic area was considered to further explore possible statistical methods for analysing interlinkages. Based on data availability of the 92 environment-related SDG indicators (see Annex A, Table A.1), water indicators, including marine and freshwater, are the most populated of the 92 environment-related SDG indicators. The analysis in this report is carried out for two types of ecosystems: freshwater-related and marine-related. Considering the importance of disaggregated data and its role in identifying more focused relationships between indicators, analyses are carried out for freshwater-related ecosystems at global, national and basin levels, and for marine-related ecosystems at global and national levels. Going beyond a correlation analysis, the analysis considers additional factors beyond population, GDP and geographical region to improve the understanding of factors that influence interlinkages.

1.1.2 Water-related ecosystems and the SDGs

Water is an essential pillar of sustainable development. Water resources and ecosystems provide food (SDG 2) and energy security (SDG 7), contribute to human and environmental health (SDG 3), and are essential for manufacturing industries (SDG 9). Integrated water resources management can contribute to tackling poverty (SDG 1) and inequality (SDG 10), enhance economic development (SDG 8), develop urban settings (SDG 11) and support the protection of ecosystem services (SDGs 6 for freshwater, 14 for marine and 15 for terrestrial). Yet, the sustainability of water-related ecosystems is threatened by climate change (SDG 13), excessive pollution (SDGs 6 and 14) and overexploitation. Hence the need to reduce deteriorated water quality and water scarcity and avoid water-related conflicts (SDG 16) as well as regulate consumption and production (SDG 12) for future generations. Additionally, given the interlinkages of the water sector with all aspects of national economies, policy coherence is crucial to ensure synergy and avoid trade-offs between and among economical activities.

There is no doubt that the access to and quality of water resources impact people differently (SDG 5). As primary water collectors, women and girls spend ample time finding and collecting water instead of studying (SDG 4) or engaging in employment (SDG 8). Their role also increases their risk of exposure to contaminated water, which carries a direct impact on their health (SDG 3). Raising awareness on the importance of water access and healthy water-and marine-related ecosystems by citizens can positively impact these ecosystems and encourage partnerships to responsibly manage such resources and respond to the water crisis with improved skills and knowledge (SDG 17).

1.1.3 The importance of water-related ecosystems to the natural environment

Freshwater plays a fundamental role in support of the environment, society and the economy. Ecosystems such as wetlands, rivers, aquifers and lakes are indispensable for life on Earth. Freshwater-related ecosystems are also vital for directly ensuring a range of benefits and services such as drinking water and recreation, agriculture and energy, habitats for aquatic life forms and natural solutions for water purification and climate resilience. Freshwater-related ecosystems can be defined as "a dynamic complex of plant, animal, and microorganism communities and the non-living environment dominated by the presence of flowing or still water, interacting as a functional unit." (Dickens and McCartney 2019; MEA 2005). SDG target 6.6 aims for the protection and restoration of water-related ecosystems and includes indicator 6.6.1 which is framed around the monitoring of different types of freshwater-related ecosystems including lakes, rivers, wetlands, groundwater and artificial waterbodies such as reservoirs. In the indicator methodology, reservoirs are also included as part of freshwater-related ecosystems. Although reservoirs are not traditional ecosystems requiring protection and restoration, they contain significant freshwater in many countries and were therefore included (United Nations Statistics Division [UNSD] 2022a).

Freshwater and marine-related ecosystems are linked through the Earth's hydrologic cycle. Marine-related ecosystems are aquatic environments that contain high levels of dissolved salt and range from coastal shores to dark seabeds. Open ocean and coastal marine-related ecosystems are characterized by different physical and biological attributes (National Geographic 2022).

From the deep sea to coastal reefs, from mudflats to seagrass meadows, ocean and marine systems provide essential services to humans, including carbon capture for climate mitigation, climate regulation, oxygen provision, renewable energy, protection from storm surges and serving as a significant economic and dietary source for people worldwide. As the dedicated goal for marine-related indicators, SDG 14 includes target 14.1 on preventing and significantly reducing marine pollution, target 14.3 on minimizing and addressing the impacts of ocean acidification and target 14.4 on halting overfishing, illegal, unreported and unregulated fishing and destructive fishing practices. These three targets comprise the indicators on the state of marine-related ecosystems.

1.2 Threats to water-related ecosystems

Water sustainability reflects the need to make water available for current and future generations for consumption, agriculture and other economic activities, while preserving the health of ecosystems. Water faces major threats to its quality, availability and sustainability. Some threats may be more impactful than others, but all threats jeopardize the sustainability of water resources.

The impact of climate change and variability on water resources is becoming more visible. Changes in precipitation, ambient and water temperatures (Woolway et al. 2020), extreme weather events causing floods, droughts and storms (Crook et al. 2015) as well as changes in water quality through increased acidification of the oceans resulting from increased carbon dioxide absorption (United Nations Environment Programme [UNEP] 2017) are all exacerbated by climate change. Sea level rise is causing groundwater deterioration through saline intrusion in coastal areas (United Nations Educational, Scientific and Cultural Organization [UNESCO] 2020), which is further impacted by the change in land use causing surface run-offs to the sea and altering the natural replenishment of groundwater resources (United Nations [UN] 2022a). Additionally, the introduction of invasive species in new water environments is having devastating consequences on native biota, both in marine and riverine habitats (Crook et al. 2015).

The most significant threat originating from socioeconomic and political factors is pollution. The UNEP has designated pollution as one of the three planetary crises due to its extent and impact on the environment and human health and well-being. Its impact on aquatic ecosystems is tremendous, resulting from the disposal of untreated wastewater and industrial effluents in water streams and the masses of plastic pollution in water streams and oceans, chemicals and waste disposal. In addition to urbanization, agricultural practices and deforestation, pollution is pushing ecosystems to their thresholds, where they can no longer restore and regulate themselves, thus expediting the degradation of water quality and availability (WWAP 2015). Human overexploitation of aquatic resources is accelerating the decline in their availability and quality. This is exacerbated by the increase in worldwide water stress[1] (1.6 per cent increase between 2015 and 2019, with 72 per cent attributed to the agricultural sector (UNSD 2022b)) and overfishing in oceans, seas, lakes and rivers (decline in the proportion of fish stocks within a biologically sustainable level from 73 per cent in 2000 to 65 per cent in 2019 (Food and Agriculture Organisation [FAO] 2022a)).

Ineffective or absent water governance is one of the most significant management threats to aquatic resources. Governance arrangements sit at the heart of integrated water resources management, more specifically the effective coordination of development objectives focusing on policy and regulatory frameworks, institutional responsibilities, and financing and management (UNEP 2021a). Principle 3 of the Organisation for Economic Co-operation and Development's (OECD's) Principles on Water Governance promotes policy coherence through effective cross-sectoral coordination, focusing on policies between water and the environment, health, energy, agriculture, industry, spatial planning and land use. The overall principles intend to contribute to tangible and outcome-oriented public policies, which are based on three mutually reinforcing and complementary dimensions of water governance: effectiveness, efficiency, and trust and engagement (Organisation for Economic Co-operation and Development [OECD] 2015). Water resources are being significantly pressured by governance failures and unsustainable development pathways (WWAP 2015). The lack of a full representation of the values of water is a primary reason for limited successes in attaining integrated water resources management and failures in water governance (UN 2021a). Part of the failure of efficient water governance lies in the ageing water infrastructure as well as the inadequate funding for its operation and maintenance (UNESCO and UN-Water 2020). For instance, it was estimated that US$ 1.7 trillion is required by 2030 to achieve the Water, Sanitation and Hygiene for All (WASH) component of SDG 6, including capital investment, operating and maintenance costs (UNESCO and UN-Water 2020).

Several reasons explain why these threats – whether environmental, socioeconomic or management-related – have not been addressed yet. Although the freshwater sector is the environmental sector with the most data available to date, targeted and detailed information still lacks. For instance, the average United Nations Member State publishes data on about two thirds of the SDG 6 indicators, while 24 Member States publish less than half (UN-Water 2021). There is significant gap in disaggregated data, whether subnational, gender or basin levels, which hinders decision-making and the development of targeted policies. Although closing the data gap is essential, a persistent lack of monitoring infrastructure and data management systems

1 Water stress is the amount of water withdrawn divided by the total water resources available (UNSD 2022a).

hamper closing the data gap (UN-Water 2021). In a similar vein, there is a lack of data, information and knowledge to develop a comprehensive understanding of the oceans, their components and their interactions (United Nations Educational, Scientific and Cultural Organization - Intergovernmental Oceanographic Commission [UNESCO-IOC] 2021).

Developing targeted policies to adequately manage water resources is complex and requires cross-institutional cooperation to account for all stakeholders across all levels. For instance, the role of groundwater resources is not often fully recognized due to the complexity and diversity of hydrogeological processes, which hinders its full incorporation in policymaking (UN 2022a). In addition, another layer of complexity relates to climate change adaptation and mitigation actions, where complex interactions between energy, land, water and biodiversity need to be considered to improve the management of water resources (UNESCO and UN-Water 2020).

Poverty, social inequality and water resources are connected in a vicious cycle. Poverty and social inequality exacerbate poor water quality through the release of wastewater effluents due to unavailability of wastewater collection networks, the disposal of waste in open dumps next to water streams, which pollutes surrounding water resources, and through using basic techniques to extract groundwater, which renders it unclean and unsafe for human use. The unsafe and unclean sources of water available for use and the unaffordable prices of water from private or informal vendors also add to this cycle. This drives people to use unclean water sources or save on daily water use, which in both scenarios impacts their health, in turn causing educational or employment opportunities losses (WWAP 2015).

1.3 Presentation of report sections and what is covered under each section

The report is divided into seven chapters. The first introduces water-related ecosystems, their link to the SDG framework and the main issues threatening their sustainability. Chapter 2 provides the analysis of progress on global and regional[2] levels of the 92 environment-related indicators. The end of chapter 2 provides the link to the statistical methodology by introducing the categories of socioeconomic and environmental factors, while chapter 3 presents the methodological summary of the statistical analysis. The results of the statistical analysis are interpreted in chapter 4 with a focus on freshwater-related ecosystems, and chapter 5 concentrates on marine-related ecosystems. Despite suboptimal data availability, chapter 6 identifies data sources, current and potential usage to report on SDG indicators. Chapter 7 presents the main conclusions and recommendations, including policy, data and indicators recommendations.

2 The regional analysis is based on the SDG regional groupings, except for Northern America and Europe, which have been separated. A full description of the SDG regions, including their respective countries, is included in Annex B.

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Chapter 2: The state of the environment

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The following chapter aims to showcase the progress in data availability in relation to specified SDG indicators. The purpose is not to explain why indicators' trends are increasing or decreasing. The change in category (that is, the three distinct categories of (i) positive trend, (ii) little change or negative trend and (iii) no data or insufficient data) is based on data availability only. Data extracted from the SDG Global Indicator Database are considered to be accurate and validated before publishing.

Data for this report have been extracted from the SDG Indicators Database on 14 June 2022. Subsequent updates of the database were not considered in this report. Additionally, Annex A lists the set of the 92 environment-related SDG indicators and their selected sub-indicators, where appropriate. These sub-indicators were used to measure progress in the scorecards.

2.1 Global and regional progress on the environmental dimension of the SDGs

2.1.1 Global progress on the environmental dimension of the SDGs

Global analysis of the progress of the 92 environment-related SDG indicators indicates an improvement in data availability. Improvement in data availability is based on additional data being reported by countries, which leads to the availability of sufficient data to aggregate at regional and global levels. Compared with the Measuring Progress: Environment and the SDGs report (UNEP 2021b), the indicators with no data or insufficient data to analyse decreased from 58 to 41 per cent (Figure 2.1). Among SDG environment-related indicators, 38 per cent show positive change indicating environmental improvement, an increase from 28 per cent reported in the previous report (UNEP 2021b). In parallel, 21 per cent of SDG environment-related indicators are showing negative or little change – an increase from 14 per cent reported in 2020.

The number of SDG indicators considered environment-related vary across goals, as does the availability of data at the goal level, except for SDG 10 on reduced inequalities and SDG 16 on peace and justice, which have no environment-related indicators. SDG 4 on education and SDG 5 on gender show no improvement in data availability since 2018, although these two goals each only have one SDG indicator. For SDG 5, data are available for 36 countries and cover the 2009¬–2020 period (UN 2022b); yet the total number of countries where data are available does not allow for a global aggregate. Such data gaps mean that countries collecting data on the gender-environment nexus may not have a standardized methodology and approach, thus making it difficult to track progress. In addition, SDG 3 on health and SDG 17 on partnerships and means of implementation indicate data availability, yet no progress in data availability was made between 2018 and 2022.

Significant improvements in data availability are recorded for SDG 6 on water, SDG 12 on sustainable consumption and production, SDG 14 on oceans and SDG 15 on land and biodiversity. Each goal has many indicators considered environment-related and data availability has improved since 2018 for several indicators. In 2022, SDG 6 on water has only one indicator with no data out of 11, SDG 12 on sustainable consumption and production has four indicators with no data out of 14, SDG 14 on oceans has two indicators with no data out of nine and SDG 15 on land and biodiversity has three indicators with no data out of 14 (Figure 2.2).

Figure 2.1 Global scorecard on the environmental dimension of the SDGs

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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

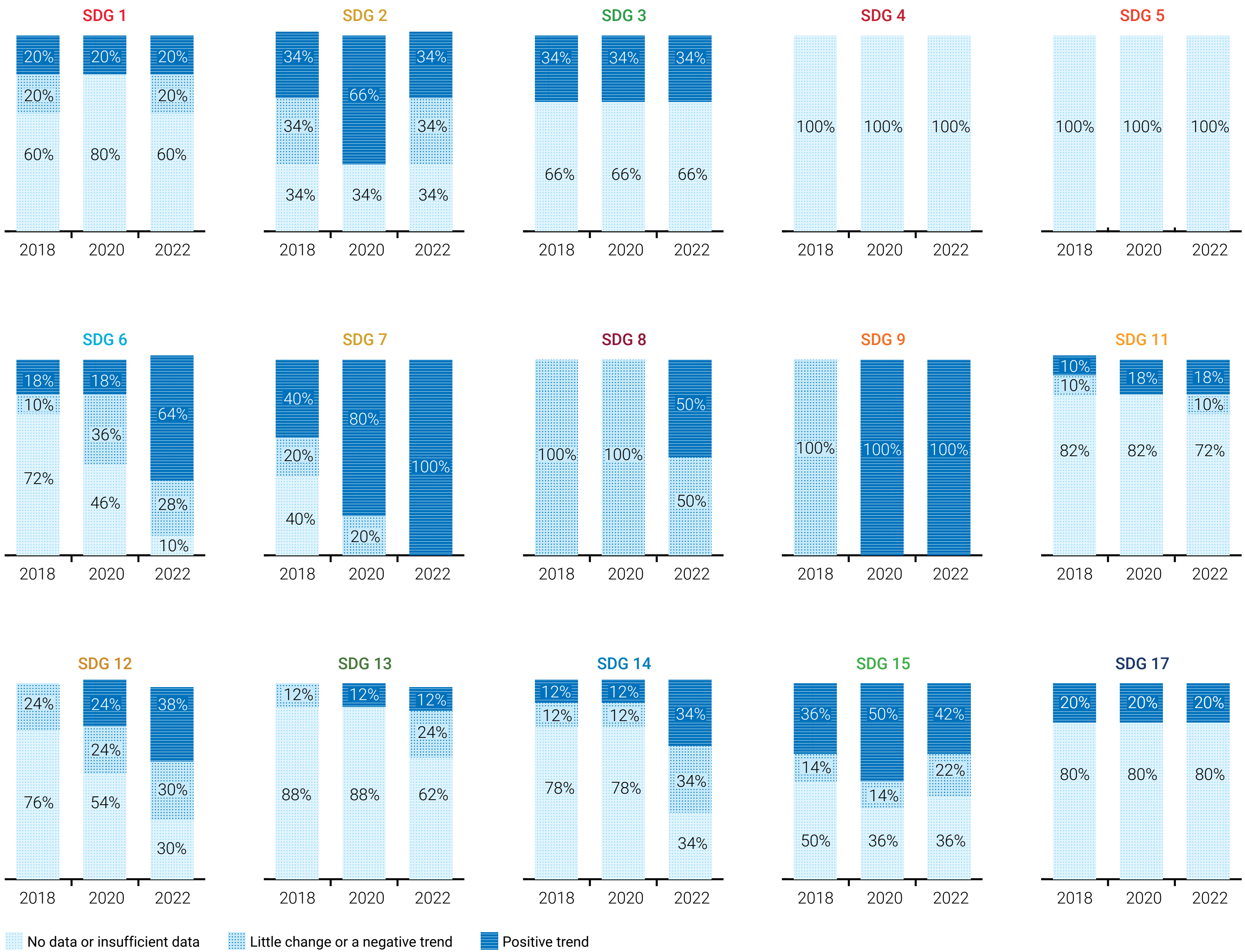
The environmental dimension is not represented in Goal 16

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 indicator for SDG monitoring (17.18.1)

Legend:
- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

Figure 2.2 Data availability for environment-related SDG indicators per goal, 2018 to 2022



2.1.1.1 Freshwater- and marine-related ecosystems

“The world’s water-related ecosystems are being degraded at an alarming rate”, is one of the main messages of the Sustainable Development Goals Report 2022 (UN 2022b). The latest data indicate a loss of 85 per cent of wetlands over the past 300 years, with rivers, lakes and reservoirs witnessing rapid change, due to many factors, of which the most profound is climate change (UN 2022b). Transboundary waters covered by operational arrangements have increased, yet “only 25 per cent of countries have more than 90 per cent of their transboundary waters covered by operational arrangements” (UN 2022b). Globally, 56 per cent of household wastewater was safely treated, leaving significant quantities of untreated wastewater discharged into water bodies causing eutrophication (UN-Habitat and WHO 2021).

Ten per cent of global population live in high or critical levels of water stress countries, while water-use efficiency improved by 12 per cent between 2015 and 2017, yet the agricultural sector, which is the largest water-use sector, indicated a modest increase (UN 2022b). Till date, at least three billion people depend on water which quality is unknown, while 1.6 billion people will lack safely managed drinking water by 2030 if the pace of progress is not quadrupled (UN 2022b).

Marine-related ecosystems are facing continuous stress, with oceans and seas being endangered by increased plastic pollution, water temperature warming, eutrophication, acidification and overfishing. In 2021, it was estimated that around 17 million metric tons of plastic entered the oceans (UNSD 2022b), while the proportion of fish stocks within biologically sustainable levels is decreasing, with a slower rate of decline over the past decade (FAO 2022a). Countries have, however, progressed with implementing international instruments to combat illegal, unreported and unregulated fishing instruments (FAO 2022a).

2.1.1.2 Data availability and indicators’ progress

There are 22 water-related SDG indicators which include 13 freshwater-related indicators and nine marine-related indicators. Out of these 22 indicators, 50 per cent are exhibiting a positive change, indicating environmental improvement. However, 27 per cent of the indicators are exhibiting little or negative change, while 23 per cent are considered to have no data or insufficient data to analyse. A deeper look into freshwater-related indicators reveals that there is no indicator without data. Of the freshwater-related indicators, 62 per cent show positive change, 23 per cent indicate little or negative change and 15 per cent have insufficient data to analyse. Marine-related indicators are spread equally between positive change, little or negative change and no data or insufficient data to analyse at 33 per cent each.

2.1.1.3 Water-related ecosystem conservation policies and accelerated action as part of the United Nations Water Action Decade and United Nations Decade of Ocean Science for Sustainable Development

Many international conventions were developed and adopted over the years to promote conservation and cooperation in relation to freshwater resources, including ecosystems. Such Conventions include the Ramsar Convention on Wetlands of International Importance (1971), Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992), and the Convention on the Law of the Non-Navigational Uses of International Watercourses (1997). In a similar vein, many conventions also targeted the regulation and conservation of marine resources and ecosystems, of which are the United Nations Conventions on the Law of the Sea (1982), the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972), Prevention of Pollution from Ships (1973), Safety of Life at Sea (1974) and Oil Pollution Preparedness, Response and Cooperation (1990). In addition, the Aarhus Convention was expanded with a binding rapid response mechanism to protect environmental defenders (UNECE 2021), including water defenders, and United Nations Member States committed to forging a legally binding international agreement by 2024 to end plastic pollution, a key threat to marine and freshwater ecosystems (UNEP 2022b).

On 21 December 2016, the General Assembly declared 2018–2018 as the International Decade for "Water for Sustainable Development" with the aim of accelerating efforts towards meeting the water-related targets of sustainable development and promoting the integrated management of water resources to attain social, economic and environmental objectives (United Nations General Assembly [UNGA] 2017a). The Decade also promotes cooperation, partnership and action by different actors at all levels and aims to stimulate the implementation of existing programmes and projects. It specifically calls for the closing of gender gaps in the water sector while stressing the importance of the full involvement of women, local communities, Indigenous peoples and other vulnerable groups in the implementation of the Decade at all levels (UNGA 2016). To guide those endeavours, UN-Water has developed an action plan for the Decade. This action plan includes four work streams: (a) facilitating access to knowledge and the exchange of good practices; (b) improving knowledge generation and dissemination, including new information relevant to water-related SDGs; (c) pursuing advocacy, networking and promoting partnerships and action; and (d) strengthening communication actions for implementation of the water-related goals. Many activities are planned to reach the objectives of the four working streams (UN-Water 2018b), and a midterm review of the Water Action Decade is planned for March 2023. Forty-three countries have pledged commitments and activities as part of the International Decade for Action (UN-Water n.d.).

On 5 December 2017, the General Assembly declared 2021–2030 as the United Nations Decade of Ocean Science for Sustainable Development and called upon the Intergovernmental Oceanographic Commission of UNESCO to develop the Ocean Decade's implementation plan (UNGA 2018). The "science we need for the ocean we want" vision is complemented by the Ocean Decade's mission to motivate transformation solutions for sustainable development by setting the target to achieve seven outcomes: clean, healthy and resilient, productive, predicted, safe, accessible, and inspiring and engaging oceans (UNESCO-IOC 2021). These outcomes can be achieved through 10 identified Ocean Decade Challenges, which promote collective action at global, regional, national and subnational levels (UNESCO-IOC 2021). Although the Ocean Decade will not focus on policy, it "will build scientific capacity to generate knowledge that will directly contribute to the goals of the 2030 Agenda" (UNESCO-IOC 2021). As at May 2022, the Ocean Decade Actions enlisted 31 global programmes, 92 projects, 15 United Nations-led actions, 42 contributions and 277 activities across more than 40 countries. In addition, resource mobilization of US$ 844 million has been secured (UNESCO-IOC 2022a).

On 1 March 2019, the General Assembly declared 2021–2030 as the Decade on Ecosystem Restoration, calling to conserve and restore all ecosystems on Earth, which include freshwater- and marine-related ecosystems (UNEP-FAO 2020).

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

Figure 2.3 Scorecard on the environmental dimension of the SDGs in sub-Saharan Africa

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

2.1.2.1 Freshwater- and marine-related ecosystems in sub-Saharan Africa

Sub-Saharan Africa consists of several terrestrial and aquatic biomes ranging from large and small freshwater rivers and lakes, including their headwaters and deltas to wetland ecosystems such as swamps, bogs and salt marshes (Wilson and Primack 2019) as well as several marine biomes. In the region, growing pressures and threats on water resources are mostly a build-up of rapidly shifting demographic trends (UNDESA 2022a), coupled with a significant number of countries having water scarcity, as well as adding the adverse impacts of climate change (Trisos et al. 2022), biodiversity loss (IPBES 2018a), pollution and land degradation (Dangui and Jia 2022). For instance, Lake Chad, shared by Cameroon, Chad, Niger and Nigeria, has a basin covering almost 8 per cent of the continent. The water once served over 30 million people but has shrunk by 90 per cent since the 1960s, having detrimental effects on other forms of economic growth, natural capital and human security in the wider Sahelian parts of the continent (Usigbe 2019). Also, as large number of rivers are transboundary in nature, countries depend on water originating from outside their boundaries (World Bank [WB] 2021a).

Water resources form the cornerstone of sustainable development, as SDGs 6 and 14 act as enablers of other goals and are simultaneously impacted by other goals. Estimates (African Development Bank [AfDB] Group 2022a) show that 75 per cent of the current and emerging jobs globally are moderately or highly dependent upon access to water and water-related services. Yet currently, water resources in sub-Saharan Africa are faced with a multitude of risks that threaten their security and the long-term water needs of the people, environment and economies. These threats have risen sharply in the last two years, owing to multiple stressors that have taken a toll on the region's economies while drawing down on national budgetary resources (AfDB Group 2022a). The Water Strategy 2021–2025: Towards a Water Secure Africa (AfDB Group 2022b) shows that the average per capita water withdrawal in Africa is less than 40 per cent of the world's average with only approximately 11 per cent of the hydropower potential utilized and around 6 per cent of cultivated land being irrigated despite the higher levels of irrigable potential[3] (AfDB Group 2022b). In addition, many countries are experiencing water stress, including Africa's five of the global eight countries expected to receive over half of the projected increase in global population by 2050 (UNDESA 2022a). Among them are countries that are experiencing constraints with either water stress and/or water supply infrastructural capacity, including the Democratic Republic of the Congo, Ethiopia, Nigeria and the United Republic of Tanzania.

Between 2000 and 2020, the sub-Saharan African population increased from 647 million to 1.1 billion people (UNDESA 2022b). Only 24 per cent of the population has access to a basic level of drinking water services, 28 per cent of the population has basic sanitation services and 18 per cent is practising open defecation (WWAP 2019). These figures are often masked by inequalities that persist in countries including between urban and rural, between subnational regions and between the richest and the poorest. The present situations are compounded by climatic variability and change mainly manifesting through droughts and floods, costing an estimated US$ 30–50 billion annually as adaptation cost to climate change in the region by 2030 (International Monetary Fund [IMF] 2020). In 2022, for example, the eastern and horn of Africa subregion experienced its worst drought in 40 years. Drier-than-average conditions have been predicted to become more frequent and severe (Office for the Coordination of Humanitarian Affairs [OCHA] 2022).

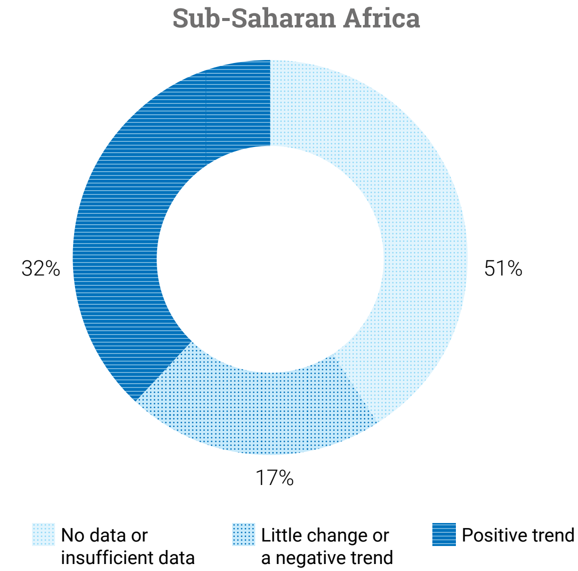
3 All values represent the entire continent of Africa as values for sub-Saharan Africa are not available.

Among sub-Saharan Africa's 50 countries, 31 are coastal and/or island States (Ngoile 1997). These countries are rich in various and diversified ecosystems, including lagoons, deltas, mountains, wetlands, mangroves, coral reefs and shelf zones. These ecosystems sustain considerable amounts of fisheries and water resources, which in turn support livelihoods and economies. In 2020, the coastal population (100 kilometres [km] of the coast) of sub-Saharan Africa was estimated at nearly 60 million people (United Nations n.d.a). Since 2000, employment in fisheries and aquaculture in Africa rose from 3.6 million people to 5.6 million people in 2020, an increase of more than 50 per cent with 10 per cent of all existing fishers located in the continent (FAO 2022b). Rapid coastal population growth and urbanization coupled with limited financial resources are continuing to exacerbate the existing constraints that include overfishing, marine pollution and loss of natural habitats. Additionally, climate change-induced sea level rise increases vulnerabilities of low-lying lagoon zones, coastal settlements and other productive areas with subsequent pressure on carrying capacity of the concomitant resources. The resultant impacts of these situations include intensified competition to access and control the shrinking resources thus increasing tension in communities, economies and natural habitats (United Nations n.d.a).

2.1.2.2 Data availability and indicator progress

Data availability concerning the 92 environment-related SDG indicators in the sub-Saharan Africa region has improved, where no data or insufficient data to analyse decreased from 65 per cent in 2020 to 51 per cent in 2022 (Figure 2.3). Environment-related indicators showing environmental improvement increased from 24 per cent in 2020 to 32 per cent in 2022, while environment-related SDG indicators showing environmental deterioration increased from 11 per cent to 17 per cent (Figure 2.4).

Figure 2.4 Environment-related SDG indicators data trend, sub-Saharan Africa



A total of 45 per cent of sub-Saharan Africa's water-related indicators show positive change, 18 per cent indicate a negative change and 36 per cent have no data or insufficient data to analyse the progress – a decrease from 64 per cent compared with the previous report (UNEP 2021b). Within the freshwater-related SDG indicators, 62 per cent indicate positive change towards environmental improvement, while 15 per cent show environmental deterioration and 23 per cent have no data or insufficient data to analyse – compared with 46 per cent in 2020 (UNEP 2021b). However, 56 per cent of marine-related SDG indicators have no data or insufficient data to analyse – compared with 89 per cent in 2020 (UNEP 2021b), while positive and negative change indicators represent 22 per cent each.

2.1.2.3 Water-related ecosystem conservation policies and accelerated action as part of the United Nations Water Action Decade and United Nations Decade of Ocean Science for Sustainable Development

Cognizant of the prevailing bottlenecks that continue to hamper progress in the water components of the 2030 Agenda in Africa, the African Union's Member States decided on collective policy response measures (GWP 2021) by adopting a continental Africa Water Investment Programme (AIP) and its SDG water investment support. The programme is led by national governments, regional economic communities and River Basin Organizations, with technical backstopping by the AIP Secretariat hosted by the Global Water Partnership Africa Coordination Unit. It seeks to transform the investment outlook for water and sanitation in Africa, by mobilizing US$ 30 billion in climate-resilient, gender-sensitive investments in water and sanitation by 2030, and creating 5 million jobs in Africa, as it recovers from the COVID-19 pandemic (UNEP 2021a). The AIP SDG water investment support programme fosters these goals by helping countries to achieve SDG 6 and water-related targets linked to health, energy, food and ecosystems. Such an integrated policy approach is timely and offers hope for progress in the region's water sector including in the interlinked food systems and value chains, which are tied to various facets of the 2030 Agenda and SDGs.

Six countries in the sub-Saharan region submitted commitments to the Water Action Decade, thereby accounting for 14 per cent of all submissions. Within their country statements, officials from Cabo Verde, Ethiopia, Ghana, Namibia, Nigeria and South Africa uniformly emphasized the central position of SDG 6 within the SDG framework and the importance of adequate funding (UN-Water n.d.).

Successfully launched at the African Conference on Priority Setting and Partnership Development for the United Nations Decade of Ocean Science, the Ocean Decade Africa Roadmap provides a framework to coordinate ocean science planning and uptake. Based on extensive stakeholder engagement, the road map further defines nine priority Decade Actions which, among others, focus on sustainable ocean management, ocean observations and forecasting and regional ocean literacy (UNESCO-IOC 2022b).

Moreover, 14 per cent of all National Decade Committees originate from sub-Saharan Africa (UNESCO-IOC 2022a). The region was successful in contributing nine Decade projects (WIOMSA/IOC-UNESCO 2022). In line with the Ocean Decade Africa Roadmap, these projects focused on establishing scientific institutions and networks related to ocean observations and monitoring as well as on educational activities to enhance ocean literacy (WIOMSA/IOC-UNESCO 2022).

2.1.2.4 Remaining gaps

The infrastructure gap constitutes one of the main constraints to progress in Africa's water resources sector. These include the infrastructure gaps in water supply as well as in the actions for curbing water pollution from land-based activities, which aggravate the impacts of climate change on water and water-related ecosystems. In addition, the hydrology of African surface water is poorly monitored (Papa et al. 2022), highlighting the need for better data availability and accessibility to reduce the data gap in the water sector in sub-Saharan Africa.

Vulnerability and slow progress in Africa's water sector and water-related ecosystems and the interlinked value chains are mainly attributed to low investments that have persisted over time (UNEP 2021a). Between 2021 and 2022, long-term investments in water have been hugely crowded out by the urgent need for African countries to address immediate health-care demands and the disrupted food supply chains as a result of the COVID-19 pandemic and ongoing conflicts. This is despite the region being off-track in many of the targets of the 2030 Agenda and Africa's Agenda 2063, in addition to the mounting triple planetary crisis of climate change, pollution and degradation of natural habitats, which continues to damage the region's freshwater, marine and coastal ecosystems. Similar to other countries around the world, gender equality in the environment context has also dramatically suffered, further slowing down ambitions to promote and monitor gender equality and youth engagement in ocean science, which was one of the enablers adopted at the Ocean Decade Africa Roadmap (UNESCO-IOC 2022c).

The African Economic Outlook 2022 (AfDB Group 2022a) shows the estimated cumulative financing needs for Africa to respond adequately to climate change, including adaptation in the water sector, ranging from about US$ 1.3 trillion to US$ 1.6 trillion in the lead -up to 2030 targets, which translates to about US$ 118.2–145.5 billion annually, with Eastern Africa requiring the highest adaptation cost due to its susceptibility to climatic stresses, lower resilience and response readiness. Green bonds and other innovative financing mechanisms that align with the Addis Ababa Action Agenda on framework for financing sustainable development (UN 2015) represent potential opportunities for reducing the financial gaps of Africa's water sector. Countries in sub-Saharan Africa have good prospects to leverage green finance due to the associated financing cost benefits that loans and equity investments do not offer (AfDB Group 2022a). This need to be complemented with a strengthened space for enabling policies including involving the private sector and other key stakeholders in water resource sustainability and access.

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

Figure 2.5 Scorecard on the environmental dimension of the SDGs in Central and Southern Asia

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)
- Renewable energy-generating capacity (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
- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Blue: Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Yellow: Represents very little negative or positive change in this indicator between 2000 and 2022.
- Orange: Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Light grey: Some data is available, but not enough to analyse changes over time.
- Dark grey: No data is available.

Figure 2.6 Scorecard on the environmental dimension of the SDGs in Eastern and South-Eastern Asia

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)
- Renewable energy-generating capacity (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
- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Blue: Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Yellow: Represents very little negative or positive change in this indicator between 2000 and 2022.
- Orange: Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Light grey: Some data is available, but not enough to analyse changes over time.
- Dark grey: No data is available.

Figure 2.7 Scorecard on the environmental dimension of the SDGs in Oceania

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

2.1.3.1 Freshwater- and marine-related ecosystems in Asia and the Pacific

The region of Asia and the Pacific encompasses the highest mountain range of the world, the deepest ocean floor, and some of the most extensive rivers and deltas in the world (IPBES 2018b). The region is home to about 55 per cent of the global population – approximately 4.4 billion people (UNDESA 2022a), with less than 30 per cent of the world's internal renewable freshwater resources, hence making water availability per capita the lowest in the world (UNEP 2019a). The region has experienced a rapid urbanization, industrialization and agriculture advancement over the past 40 years. Its economic growth and social development have lifted hundreds of millions out of poverty, and enabled many to have prosperous, productive and healthier lives. Scientific analysis, however, shows the current approach to development in the region has a significant cost on health and the environment (UNEP 2016a). Water-related ecosystems and water resource-related issues are particularly acute in the region and exacerbated by climate change (UNEP 2008a; UNEP 2008b; UNEP 2009; UNEP 2011). During the period between June and August 2022, extreme water-related weather events happened in the region. On the one hand, torrential monsoon rains caused the most devastating flooding in Pakistan's recent history, where at least one third of the country was under water and extreme flooding displaced some 33 million people and killed more than 1,200 (Mallapaty 2022). On the other hand, a record-breaking drought in China caused parts of the Yangtze River and its tributaries to dry up, an economically strategic basin serving more than 400 million people, disrupting hydropower, agriculture, shipping and factory production (Government of China 2022).

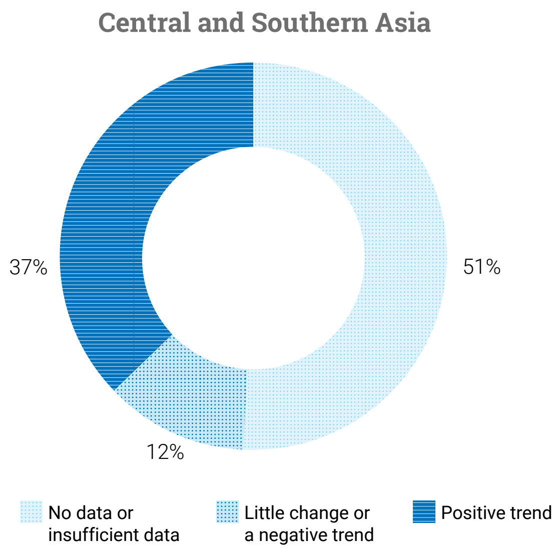
The region's seas are home to the world's largest expanse of coral reef, mangroves and seagrass, which underpin its high productivity and importance for the local communities. Many countries in the region are major seafood exporters, and hundreds of millions of people there rely on seafood (UNEP 2016a). More than 84 per cent of all fishers and fish farmers in the world were located in Asia, over 90 per cent of the global aquaculture production originates from the region, and four countries are among the top five inland water capture producers in the world (namely China, India, Bangladesh and Myanmar), accounting for over 46 per cent of the total inland water catches in 2020 (FAO 2022b). Plastic waste and pollution carry wide-ranging environmental and socioeconomic impacts in the region, damaging marine ecosystems and biodiversity and ultimately impacting human health and livelihoods (UNEP n.d.a).

2.1.3.2 Data availability and indicator progress

Asia and the Pacific is not on track to achieve any of the SDGs (UNESCAP 2022), in part because of climate change and the COVID-19 pandemic. Despite such disruptions to the efforts of countries and local communities to implement and deliver the SDGs, there has been meaningful progress in environment-related data availability. For instance, the percentage of SDG environment-related indicators with unavailable data or insufficient data to analyse has decreased from 70 per cent in 2020 to 51 per cent in 2022 in the Central and Southern Asia subregion (Figure 2.5), decreased from 65 per cent in 2020 to 50 per cent in 2022 in the Eastern and South-Eastern Asia subregion (Figure 2.6) and from 64 per cent in 2020 to 54 per cent in 2022 in Oceania (Figure 2.7). The proportion of SDG environment-related indicators showing environmental improvement increased in the three subregions to 37 per cent for Central and Southern Asia, 28 per cent for Eastern and South-Eastern Asia and 25 per cent for Oceania in 2022. The proportion of indicators showing environmental degradation also increased from 7 per cent in 2020 to 12 per cent in 2022 for Central and Southern Asia, from 12 per cent in 2020 to 22 per cent in 2022 for Eastern and South-Eastern Asia, and from 11 per cent in 2020 to 21 per cent in 2022 for Oceania (Figure 2.8).

In 2022, out of the 13 water-related SDG indicators, 46 per cent of indicators showcased an improvement in environmental

Figure 2.8 Environment-related SDG indicators data trend, Central and Southern Asia, Eastern and South-Eastern, and Oceania



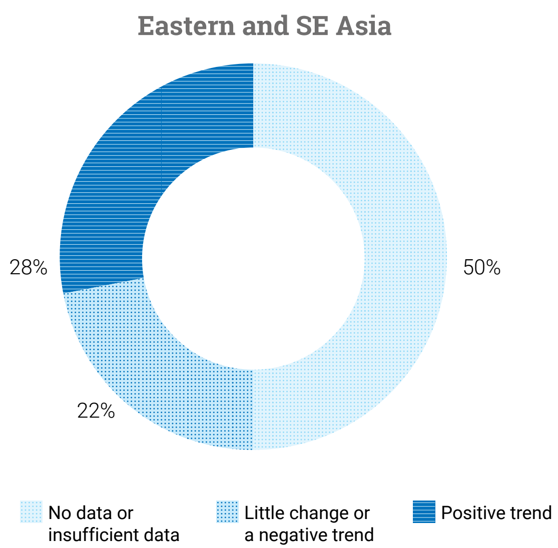
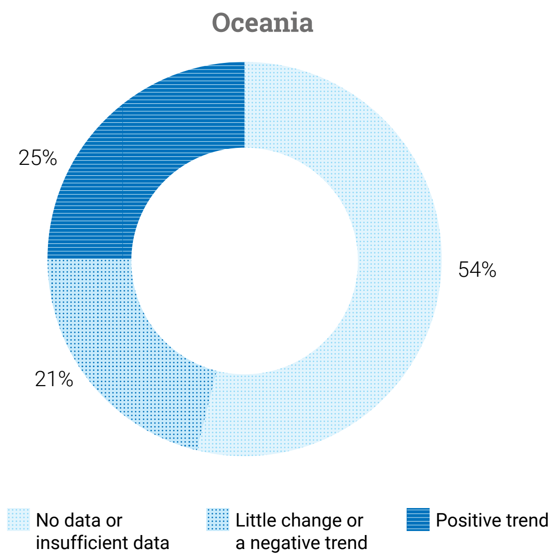


Figure 2.8 Environment-related SDG indicators data trend, Central and Southern Asia, Eastern and South-Eastern, and Oceania - continued



conditions, while 8 per cent indicated environmental degradation and 46 per cent had no data or insufficient data to analyse. On marine and coastal ecosystem protection, the Pacific small island developing States and Eastern and South-Eastern Asian countries have made progress since 2009–2010 with the establishment of marine/coastal protected areas. The average proportion of marine Key Biodiversity Areas (KBAs) covered by protected areas (SDG 14.5.1) reached 39 per cent, 34 per cent and 27 per cent in Oceania, Eastern and South-Eastern Asia, and Central and Southern Asia, respectively. Yet, 6 out of 10 marine-related SDG targets (SDG 14) lack data to analyse.

2.1.3.3 Water-related ecosystem conservation policies and accelerated action as part of the United Nations Water Action Decade and United Nations Decade of Ocean Science for Sustainable Development

Major recent regional water policies in Asia and the Pacific include the Southern Asia Water Initiative (SAWI) and two strategies released by the Coordinating Body of the Seas of East Asia (COBSEA). During its project duration from 2013 to 2021, SAWI focused on establishing a neutral platform for regional cooperation concerning major Himalayan river systems in Southern Asia, a catchment area affecting more than one billion people across Afghanistan, Bangladesh, Bhutan, China, India, Nepal and Pakistan (WB 2022a). After completion of the initiative, the Southern Asia region continues to implement cross-border water and climate activities funded by the World Bank and other trust funds.

While SAWI provides a platform for joint policymaking on freshwater in Southern Asia, COBSEA focuses on collective policies regarding marine waters and integrates the interests of nine East Asian countries in its East Asian Seas Action Plan. Within its Strategic Directions 2018–2022, COBSEA delineates activities to prevent and reduce land-based marine pollution, enhance marine and coastal planning and management and create regional policy mechanisms for coastal and marine environments (COBSEA 2018). Beyond 2022, the Strategic Directions are being prepared to cover the 2023–2027 period. The Regional Action Plan on Marine Litter 2019 was developed to curb marine pollution by preventing and reducing marine litter from land- and sea-based sources. It also includes a pledge to establish a scientific marine litter monitoring group and outlines a set of future activities undertaken by COBSEA to support the successful implementation of the regional action plan (COBSEA 2019).

As part of the Water Action Decade, at the third Asia-Pacific Water Summit (2017) held in Yangon, Myanmar, 35 state representatives and non-governmental stakeholders unanimously adopted the Yangon Declaration: The Pathway Forward (APWS 2018). Hosted by the Asia-Pacific Water Forum (APWF), signatories of the Yangon Declaration pledged to take a leading role in the Water Action Decade. A central announcement was the promise to regionally double investments in activities that address water-related disasters and water security (APWF 2017; Ishiwatari and Surjan 2019). In 2022, the participating countries to the fourth Asia-Pacific Water Summit signed the Kumamoto Declaration, pledging to enhance their water sectors by improving governance structures, mobilizing investments and stimulating science and technology communities to provide innovative solutions to water-related problems (APWF 2022).

More than one quarter of all projects related to the Decade of Ocean Science originated from the Asia-Pacific region, and six National Decade Committees were established, namely Iran, India, Indonesia, Japan, the Republic of Korea and New Zealand (UNESCO-IOC 2022a). In 2020, UNESCAP adopted resolution 76/1 (UN-ESC 2020) on "Strengthening cooperation to promote the conservation and sustainable use of the oceans, seas and marine resources for sustainable development in Asia and the Pacific" and developed a Regional Decade Programme for the region in cooperation with other United Nations agencies to support the implementation of the Decade of Ocean Science (UNESCAP 2021a).

2.1.3.4 Remaining gaps

In both quality and quantity, water in Asia and the Pacific is under threat (ADB 2020a). Acute water issues are not only attributable (to a lesser extent) to an actual low quantity in general, but more to weak water governance in the region (OECD 2021). Therefore, bridging the gaps in integrated water resources management as policy framework in Asia-Pacific through more effective, gender-responsive governance and better management practices is essential. To address acute water issues, an integrated approach that embeds gender equality and human rights with tackling the interrelated triple planetary crisis is needed.

New and innovative water financing mechanisms with participation of development partners and private sector are still lacking in the region (ADB 2020a). It was not until recently (November 2022) that the Asian Development Bank announced US$ 200 million to support programmes targeting water and sanitation resilience in the region (ADB 2022). Countries need to invest in such water financing mechanisms through policy guidelines, financial support and market incentives. Effective engagement of development partners and the private sector in both development and implementation of the new water financing mechanisms is key to the successes and sustainability of the mechanisms.

Management practices in the region require enhancement (OECD 2021). Practices of special concern include accords on transboundary water bodies, as these agreements not only effectively govern shared water resources, but also act as platforms for water diplomacy (OECD 2021). Adding to such cooperation are regional cooperation mechanisms for the conservation of marine and coastal environments, for instance the Regional Seas Programme.

In addition, the lack of timely and credible water resource data across Asia and the Pacific is a key barrier to effective policymaking (OECD 2021; UNESCAP 2020). To address this challenge, countries need to improve water data availability and quality to support evidence-based policymaking.

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

Figure 2.9 Scorecard on the environmental dimension of the SDGs in Europe

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

Figure 2.10 Scorecard on the environmental dimension of the SDGs in Northern America

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)
- Renewable energy-generating capacity (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
- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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)
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- Trade in poached or illicitly trafficked wildlife (15.7.1)
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- 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 indicator for SDG monitoring (17.18.1)

Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).

Represents very little negative or positive change in this indicator between 2000 and 2022.

Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.

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

No data is available.

2.1.4.1 Freshwater- and marine-related ecosystems in Europe

Europe hosts a diverse range of freshwater and marine biomes, including groundwater, lakes and rivers, transitional waters, coastal waters and territorial waters. In the region, around 92 per cent of countries have more than 80 per cent of their water bodies at "good ambient water quality" (UNSD 2022a; UNSD 2022b). Within the stricter definitions of the European Union (EU), the region has shown little overall improvement since measuring for the Water Framework Directive (WFD) commenced in 2009. Forty per cent of EU surface waters are ranked as "good" ecological quality according to the latest assessment report, released in 2015, well below the 2027 WFD goal of 100 per cent (European Environment Agency [EEA] 2021a). However, individual elements have improved across Europe in recent decades, such as recovery from acidification mostly due to reductions in sulfur emissions (NIVA 2020), with corresponding improvements in aquatic ecologies. Thirty-eight per cent of EU surface waters are ranked by WFD as having a "good" chemical status (EEA 2022). Overall, in the last decade, the industrial water discharged – including heavy metals, phosphorus and nitrogen – decreased as economic value increased, in accordance with EU industrial development plans. A state-level focus showcases discrepancies between countries, with some countries having increased water discharged with heavy metal contents by over 20 per cent compared with 2010 levels (EEA 2022).

Water abstraction is currently decoupled from economic growth in Europe. Between 2000 and 2017, water abstraction decreased by 17 per cent while the total gross value added from all economic sectors increased by 59 per cent, compared with a water abstraction reduction target of 20 per cent by 2020 (EEA 2019). Over half of abstracted water is used by agriculture, forestry and fishing, predominantly in southern Europe. Daily per capita water supply used has also declined by 16 per cent, largely due to improvements in conveyance systems (EEA 2018).

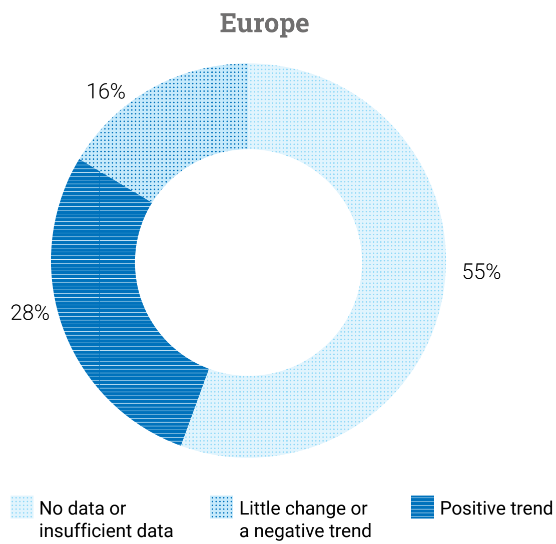
Despite reductions in water consumption, water scarcity has increased in the region, reducing available freshwater resources. This trend is particularly pronounced in southern countries, where more than half the population now lives in near permanent water scarcity. Rising climate-induced drought and flood frequencies are likely to further decrease freshwater resources in the future (EEA 2022). In response to water scarcity, efforts have focused on increasing supply and decreasing demand, typically via reservoir and dam construction, but also via saltwater desalination and the transference of water from other river basins. All these methods have ecological consequences – rerouting and damming rivers fragments their connectivity, while desalination is energy intensive and produces environmentally risky by-products (EEA 2022).

Connected to the Atlantic Ocean, Pacific Ocean, the Mediterranean Sea and the Arctic Ocean, the European region is home to a wide range of diverse marine-related ecosystems, from warm waters to polar seas. Climate change impacts marine-related ecosystems, notably coastal fringes and low-lying areas through submergence. Flooding and erosion are increasingly relevant in the region due to more frequent storms, sea level rise, ocean acidification and eutrophication (UNEP 2017a). Further, the use of Europe's seas is harming the condition of marine-related ecosystems, by changing the composition of marine species and their habitats as well as the overall physical and chemical characteristics of the sea (EEA 2021b). In the EU alone, the marine environment provides 6.1 million jobs and EUR 467 billion in gross value added (EC 2021a), despite rather low global shares of total marine catch, aquaculture production and inland catchments (FAO 2022b).

2.1.4.2 Data availability and indicator progress

Europe's data availability for the 92 environment-related SDG indicators slightly improved since 2020. Fifty-five per cent of indicators lacked data or had insufficient data to analyse in 2022 compared with 63 per cent in 2020 (Figure 2.9); 28 per cent of

Figure 2.11 Environment-related SDG indicators data trend, Europe



indicators showed environmental improvement in 2022 compared with 26 per cent in 2020; and 16 per cent indicated environmental degradation in 2022 compared with 11 per cent in 2020 (Figure 2.11).

Freshwater use has improved in efficiency (SDG indicator 6.4.1) and management implementation (SDG indicator 6.5.1) over the past five years, but water stress (SDG indicator 6.4.2) has also increased. Pre-2015 data on these indicators are limited. Freshwater quality and protection (SDG indicators 6.3.2 and 15.1.2b) has improved over the last two decades, with permanent freshwater area (SDG indicator 6.6.1) remaining stable. Marine quality and protection (SDG indicators 14.1.1a and 14.5.1) have slightly decreased and improved, respectively, over the last two decades. Fishery management (SDG indicators 14.6.1, 14.7.1 and 14.b.1) also improved in recent years, but data on these indicators remain limited. In addition, 56 per cent of marine-related SDG indicators lack data or have insufficient data to analyse.

Human water and sanitation services (SDG indicators 1.4.1, 3.9.2, 4.a.1, 6.1.1 and 6.a.1) are generally well recorded and have remained of high quality, with 60 per cent of indicators improving from 2000 to 2020. The mortality rate attributed to exposure to unsafe WASH services (SDG indicator 3.9.2) remains the lowest of the World Health Organization regions, but data limitations prevent analysis of this indicator's current trends.

2.1.4.3 Water-related ecosystem conservation policies and accelerated action as part of the United Nations Water Action Decade and United Nations Decade of Ocean Science in Europe

As in other sectors, the COVID-19 pandemic provided a bittersweet opportunity to re-evaluate existing systems (Fosse, Kosmas and Gonzalez 2021; EEA-UNEP/MAP 2020) and thus identify opportunities to accelerate aquatic ecosystem protections and restorations. While the EU Biodiversity Strategy for 2030 includes an expansion of protected EU sea regions to 30 per cent (European Commission [EC] 2021b), with the EU recovery plan allocating an additional EUR 19 billion to natural resources and the environment (EC 2020), few recovery plans were implemented so far. With recovery now under way, time will tell more fully whether this unique opportunity to rebuild in new directions was seized or not.

Transboundary management of shared rivers, lakes and aquifers remains a potential source of political tension in the pan-European region, where only 20 countries have all shared waters covered by such arrangements. With water stressors, floods and drought periods likely to increase in the future, collaboration on shared resources remains a priority to avoid deterioration of political relationships and to ensure efficient management of river basins as whole entities (Baranyai 2019).

With both the Water Action Decade (2018–2028) and the Decade of Ocean Science (2021–2030) under way, water health and biodiversity remain in the spotlight for the international community. For the Decade of Ocean Science, 115 out of 294 Decade Actions have been announced in the European region, including projects dedicated to cleaning up pollution, improving data collection and filling knowledge gaps (UNESCO-IOC 2022d). On the other hand, as a build-up to the United Nations 2023 Water Conference, which is a milestone for the Decade on Water Action, the second Dushanbe Water Action Decade Conference's final declaration proclaimed 2025 the International Year of Glaciers' Preservation and called for strengthening of transboundary cooperation, accelerated action in achieving the SDGs and the development of a Water Action Agenda mechanism to collate and accelerate all voluntary commitments at the 2023 Conference (Dushanbe Water Process 2022).

2.1.4.4 Remaining gaps

The wide range of climates, heterogeneous environments and the diverse national settings in the region consisting of 54 countries make it difficult to identify gaps that are over-grasping and relevant for all countries within the region (UNECE n.d.). Consequently, policies and procedures addressing the water realm need to be designed to deal with local conditions. While Europe is largely considered advanced in its water conservation efforts, water scarcity, drought, flooding and impacts from sea level rise are an increasingly widespread phenomenon in the region.

Several gaps related to water governance in Europe remain. While an integrative and multilevel water governance approach is in place, many countries in Europe still struggle to achieve good ecological status of their waters (Rowbottom et al. 2022). Additionally, involvement of local communities and stakeholders in water management in the region are often opaque and not transparent which results in a lack of buy-in and ownership of water management initiatives (Feldman 2022). As a result, fragmented responsibilities divided between different levels of government and various sectors lead to conflicting policies and a lack of coordination among relevant stakeholders (Wang, van Rijswick and Dai 2022d). Lastly, there is still a need for greater investment in water infrastructure, including improvements to treatment facilities and distribution networks, to ensure that clean and reliable water is available to all Europeans to reduce inequalities in access (Surówka, Popławski and Fidlerová 2021).

2.1.4.5 Freshwater and marine-related ecosystems in Northern America

The Northern America region is heterogeneous in its stress on water resources and ecosystems, as population-dense metropolitan areas are in both water-scarce and water-abundant areas. Northern America encompasses a large number of water-related ecosystems such as vegetated wetlands, rivers, lakes, reservoirs and groundwater, as well as those occurring in mountains and forests, which play a special role in storing freshwater and maintaining water quality. With large freshwater-related ecosystems such as the Great Lakes and the Mississippi River, the region is home to more lakes than any other region in the world. The six hydrological continental systems, which produce seven principal drainage basins, all face specific challenges, but climate change, nutrient pollution and invasive species remain the dominant threats to freshwater- and marine-related ecosystems.

In Canada, around 12 per cent of freshwater plants and animals are thought to be at risk and another 18 per cent are of special concern (Desforges et al. 2022). Similarly, freshwater biodiversity is imperilled in the United States of America, with 69 per cent of freshwater mussels, 51 per cent of crayfish, 43 per cent of stoneflies, 36 per cent of amphibians and 37 per cent of freshwater fish being at risk (Carpenter, Stanley and Vander Zanden 2011). The principal threats are climate change, land-use change, chemical inputs, invasive species and resource harvesting, with many rivers being influenced by all factors. Climate change is expected to alter freshwater biodiversity and resources throughout Northern America. For example, the Colorado River represents the most overallocated river in the world (Castle et al. 2014), and future climate scenarios note that the already dwindling resource used for drinking water, industry, fisheries and irrigation will further diminish (Udall and Overpeck 2017).

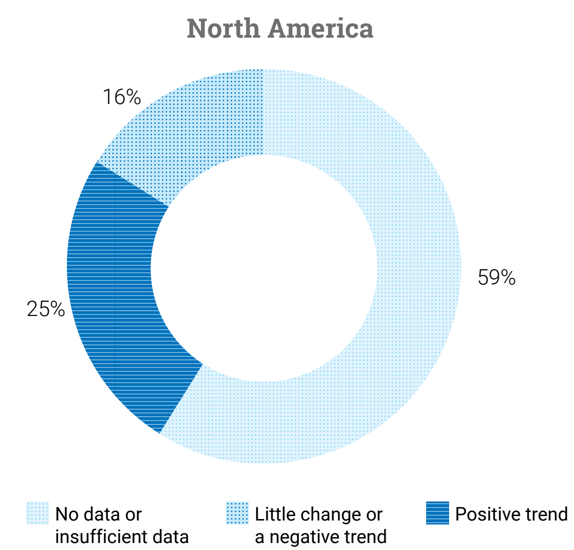
Northern America sees some of the highest per capita use of freshwater in the world (FAO n.d.), which places considerable stress on the region's freshwater-related ecosystems. For the United States of America, around 70 per cent of the freshwater used originates from surface waters, and the remaining 30 per cent from groundwater (Dieter et al. 2018). For Canada, over 95 per cent of all water used originates from surface waters, and the remaining 5 per cent from groundwater (Statistics Canada 2017a). For both countries, groundwater provides around 30 per cent of potable water for domestic use, reaching up to 80–90 per cent of potable water for some states and provinces (Dieter et al. 2018; Statistics Canada 2021; Statistics Canada 2017b). Throughout both countries, industrial uses of freshwater far outweigh domestic uses, with thermo-electric power generation, irrigation and other industrial uses accounting for around 90 per cent of total freshwater use.

Coastal ecosystems in Northern America provide fisheries production, coastal protection, carbon sequestration and water quality enhancement along with other ecosystem services that make them extremely valuable (Costanza et al. 2014). However, these ecosystems, along with the ocean surface, deep sea and sea floor habitats, are severely threatened by sea level rise, climate change, nutrient pollution, ocean acidification and habitat loss (Cooley et al. 2022). Coral reefs near the Florida Keys have been in consistent decline for 50 years, with significant reductions in total area and taxonomic richness (Gil-Agudelo et al. 2020). Coastal ecosystems that depend on vertical accretion, such as salt marshes, are expected to sharply decline due to sea level rise (Saintilan et al. 2022). Arctic ecosystems are also considerably vulnerable to ecological transformations resulting from the unprecedented warming in the region (Constable et al. 2022).

2.1.4.6 Data availability and indicator progress

Of the 92 environment-related SDG indicators, Northern America's data indicate that 25 per cent of indicators show environmental improvement in 2022 compared with 16 per cent in 2020 (Figure 2.8), and 16 per cent indicate environmental deterioration in 2022 compared with 23 per cent in 2020, while the rest of the SDG indicators lack data or have insufficient data to analyse (Figure 2.12).

Figure 2.12 Environment-related SDG indicators data trend, Northern America



Northern America's freshwater-related ecosystems have increased in size and become more protected since 2000 as shown by the indicators tracked. The proportion of total land area that comprises permanent lakes and rivers has increased by 5 per cent (SDG indicator 6.6.1) (UNSD 2022b). Only 58 per cent of Northern American water bodies currently have good ambient water quality (SDG indicator 6.3.2) (UNSD 2022b). Despite this, freshwater-related ecosystems have become better protected, with the proportion of key freshwater biodiversity areas covered by protected areas increasing from 20 per cent in 2000 to almost 26 per cent in 2021 (SDG indicator 15.1.2a) (UNSD 2022b). The use of freshwater continues to be well regulated for public health, with 100 per cent of the population having basic sanitation services (SDG indicator 1.4.1), 97 per cent using safely managed drinking water services in 2020 (up from 95 per cent in 2005) (SDG indicator 6.1.1) and few deaths attributed to unsafe water (two deaths per 100,000) (SDG indicator 3.9.2) (UNSD 2022b). Although water-use efficiency has increased – by 8 per cent from 2015 to 2019 (SDG indicator 6.4.1) – water stress, a critical indicator that highlights the demand of a region exceeding the amount of water available, has stayed stagnant since 2015 at around 20 per cent (SDG indicator 6.4.2) (UNSD 2022b).

Northern America reported data for 7 of the 10 indicators that directly concern marine-related ecosystems. The proportion of key marine biodiversity areas covered by protected areas has seen a considerable increase (SDG indicator 14.5.1) from 28 per cent in 2000 to 34 per cent in 2021 (UNSD 2022b). Although protection varies between countries, Northern America has seemingly achieved the goal of 30 per cent of marine areas becoming marine protected areas and seen an increase in funds allocated to research in the field of marine technology. With only one data point, the proportion of fish stocks within biologically sustainable levels lies at 77 per cent (SDG indicator 14.4.1), although Canada reports that 94 per cent of their fish stocks are currently at sustainable levels (UNSD 2022b). Coastal eutrophication (SDG indicator 14.1.1a) has increased from 5.25 per cent in 2005 to 6.1 per cent in 2021 (UNSD 2022b), indicating a moderate increase in nutrient pollution. Although there has been some success in reducing eutrophication in some areas (e.g., Tampa Bay, Florida), two of the largest estuaries in Northern America, the Chesapeake Bay and the St. Lawrence River Estuary, continue to experience high nutrient loads (Boesch 2019). Finally, although there is only one data point for both indicators, the degree of implementation of the instruments to combat illegal and unregulated fishing is very high (5 out of 5) (SDG indicator 14.6.1) and the degree of implementation of the institutional, policy and legislative framework that countries provide to protect local fisheries and fishermen is also high (4 out of 5) (SDG indicator 14.b.1) (UNSD 2022b).

2.1.4.7 Water-related ecosystem conservation policies and accelerated action as part of the Water Action Decade and Decade of Ocean Science in Northern America

For over 100 years, the United States of America and Canada developed environmental treaties and agreements together, as well as environmental partnerships at all levels of governments, to cover the 40 per cent of shared water border between the two countries. The first international treaty regarding the regulation of water quantity and quality was the Boundary Waters Treaty of 1909. It established the International Joint Commission, which has many advisory boards to aid in the regulation of old and new treaties in international water subtopic concerns. One such agreement is the Great Lakes Water Quality Agreement, which has led to palpable benefits in the health of the Great Lakes Ecosystem (Hartig, Krantzberg and Alsip 2020) and is signed by both countries. Its 2012 amendment focused on reducing 29 toxic pollutants alongside addressing invasive species, habitat and species loss, eutrophication and climate change impacts. In addition, all major rivers shared are regulated through large-scale acts such as the International Rivers Improvement Act which, alongside the North American Wetlands Conservation Act, regulates the construction, operation and management of river improvements and the subsequent ecosystems within them. These international environmental agreements have helped alleviate issues regarding water-related ecosystems and resources and have both prioritized water protections by internationally aiming to conserve 30 per cent of lands and waters within their countries by 2030.

At the federal level, the Canada Water Act 1970 provides the framework for cooperation between the country's provinces and territories in the conservation, development and use of its water resources. Canada has also enforced the Canadian Environmental Protection Act 1999, which addresses pollution, protection of the environment and human health to contribute to sustainable development. The Fisheries Act, one of the oldest and most important federal laws for preventing water pollution, improves the protection of fisheries and their ecosystems by prohibiting the release of harmful substances to Canadian waters unless controlled by regulation. In June 2019, changes to the Fisheries Act were made to ensure stronger protections that aid in the sustainability of Canada's fish and fish habitat. The Canadian Navigable Waters Act requires approval of any work that could intervene with any navigable Canadian waters. Canadian legislation also addresses water and ecosystem protection in territories shared with Indigenous people, through the Safe Drinking Water for First Nations Act (2013). It has since been repealed with a new piece of legislation aiming to be introduced in December 2022 through consultations with First Nations. The Arctic Water Pollution Prevention Act (1985) stipulates a "zero discharge" act and aids in marine protection and the maintenance of the traditional ways of life of the First Nations, known advocates for environmental preservation.

In the United States of America, the Clean Water Act (1972) aimed to restore and maintain the chemical, physical and biological integrity of waters and regulate the discharge of pollutants into the country's waters. The National Environmental Policy Act 1970 requires federal agencies to assess the environmental effects of proposed actions prior to making decisions, which is instrumental in ensuring cohesive and substantial water and ecosystem protection. The Endangered Species Act, another cornerstone of environmental legislation, ensures protection for fish, wildlife and plants listed as threatened or endangered. Other crucial pieces of legislation focus on specific area protection, including the Coastal Zone Management Act, the Rivers and Harbors Appropriation Act, the National Marine Sanctuaries Act and the Coastal Wetlands Planning, Protection and Restoration Act. Such water and marine-focused acts do not negate the function of broader acts targeting climate change mitigation and resilience (of which ecosystem and water conservation are likely by-products) in both countries.

Northern America has heeded the calls to action for the Water Action Decade and Decade of Ocean Science. Canada and the United States of America have committed funds and resources directly to the Decades of Action. Both countries have established National Decade Committees and have set comprehensive goals for the Ocean Decade, which include leading several worldwide initiatives. For instance, in the United States of America, the National Oceanic and Atmospheric Administration (NOAA) works on science for the sustainable use of ocean resources for a healthy blue economy, food production and societal benefits. The NOAA Ocean and Coastal Council oversees participation in the Ocean Decade and is joined by more than 20 additional federal agencies through the Interagency Working Group on the Ocean Decade. In addition, the Environmental Protection Agency (EPA) of America has submitted the Ocean Dumping Management Program, which is awaiting endorsement as a Decade of Ocean Science programme. In Canada, in November 2018, the Minister of Fisheries, Oceans and the Canadian Coast Guard offered Canada's support for the Ocean Decade, announcing an investment of up to US$ 9.5 million. Engagement in the Ocean Decade aligns with Canada's plans to advance its blue economy strategy and commitments for a sustainable ocean economy.

2.1.4.8 Remaining gaps

Northern America has made a commendable effort to update several SDG indicators since the last Measuring Progress report (2021). SDG 14, which only had one indicator reported, has now expanded to include four indicators, providing several years of data, three of which are being reported for the first time. However, the use of heterogeneous tools, methodologies and sampling sites in both countries continues to disrupt official reporting.

Using internal data, Canada and the United States of America can still fill several gaps. For example, the National Coastal Condition Assessment of America (NCCA) (Environment Protection Agency [EPA] n.d.) monitors the ecological condition of estuarine and Great Lakes near shore waters, providing a source of data that could be used to guide management actions towards improved resilience and restoration of healthy and productive oceans (SDG target 14.2). The NCCA is involved in microplastics research projects and monitors nutrients and other contaminants resulting from land-based activities (SDG target 14.1) as well as research on ocean acidification field methods and can provide information about marine acidity (SDG target 14.3). Additionally, the National Aquatic Resource Surveys, which is the umbrella programme including the NCCA, have sampled data for freshwater ecosystems (lakes, reservoirs, rivers, streams and wetlands) which could be used to report on the status of freshwater body extent. The Water Quality Portal of America (WQP n.d.), which combines data from over 400 federal, state and local organizations, may be used to inform issues such as marine acidity. Similarly, Canada's National Long-term Water Quality Monitoring Data portal measures multiple physical and chemical parameters of water quality at sampling sites throughout the nation.

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

Figure 2.13 Scorecard on the environmental dimension of the SDGs in Latin America and the Caribbean

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).

Represents very little negative or positive change in this indicator between 2000 and 2022.

Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.

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

No data is available.

2.1.5.1 Freshwater- and marine-related ecosystems in Latin America and the Caribbean

Although the freshwater reserves of Latin America and the Caribbean (LAC) are unevenly distributed across the region's 33 countries, they are the largest in the world. The ecosystems here play a key role in geochemical cycles, ecological processes and socioeconomic activities. For this reason, their rapid disappearance implies a high rate of loss in biodiversity and ecosystem services. Among the most affected natural environments are wetlands, where water quality and availability are impacted by a series of environmental stressors, including increasing urbanization, agricultural expansion and deforestation. Despite their relevance, wetlands in the region exhibit the most severe deterioration status (McInnes et al. 2020); the greatest reduction in the last 50 years has occurred in the LAC region, which has lost an estimated 59 per cent of wetland surface area (Alonso 2020).

In addition, rising temperatures directly impact the tropical glaciers of the Andes, which provide more than 80 per cent of the water for the populations and ecosystems of the semi-arid tropical regions. Their accelerated melting generates uncertainty and concern about the long-term sustainability of water use and supply for these regions so vulnerable to climate change.

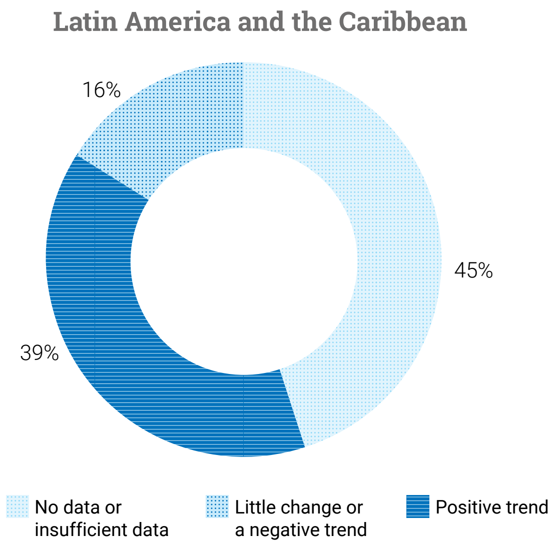
Pollution also threatens surface water habitats, which is home to 10 per cent of all known species and where 55 per cent of all fish rely on freshwater-related ecosystems for their survival. UNEP research shows that around one third of all rivers in Latin America (and Asia and Africa) suffer from severe pathogenic pollution (UNEP 2022a). Concentrations of fecal coliform bacteria, for instance, is estimated to affect around a quarter of Latin American river stretches, and there's an increasing trend of concern since bacterial levels increased to a severe level or were at a severe level in 1990 and worsened in the following decades. Water streams are facing a critical threat of heavy metal pollution, associated with mining and its intensive water use.

Twenty-seven per cent of the LAC population live in coastal areas; 23 of the region's 33 countries have more marine than terrestrial territory. For 18 of these countries, the area of its exclusive economic zone exceeds 75 per cent of their total territory (UNEP 2016b; United Nations Economic Commission for Latin America and the Caribbean [UNECLAC] 2020). For 22 countries in the region, the sea represents 60 per cent or more of their sovereign territory (UNEP 2016b; UNECLAC 2020). The LAC region treasures the second largest barrier reef in the world, 47 of the 258 global marine ecoregions (UNECLAC 2020) and has 10 of the 66 large marine ecosystems of the world (LME 2022). According to the Intergovernmental Panel on Climate Change, the ocean is projected to transition to unprecedented conditions over the twenty-first century due to several factors expected to increase the complexity of impacts and the vulnerability of the LAC's socioeconomic and ecological systems. The increasing frequency of extreme events makes these threats particularly important for the small island developing countries of the Caribbean (UNECLAC 2020). The impacts of climate change on fishing areas range from the abnormal presence of sargassum in the Caribbean and negative effects on fisheries in the south-east Atlantic, to changes in the favourable conditions for fisheries affected by the Peru (Humboldt) Current, coral bleaching, more frequent flooding events and mangrove and coastal degradation.

2.1.5.2 Data availability and indicator progress

Measuring regional progress towards environment-related targets and SDGs in general presents several obstacles, two of which prove especially challenging in LAC: the heterogeneity of definitions and insufficiency (or absence) of information or reliable data sources. According to data from the SDG Indicators Database, the LAC's region data availability has greatly improved since 2020, with a decrease in SDG indicators having no data or insufficient data from 60 per cent to 45 per cent in 2022 (Figure 2.13). The proportion of SDG indicators showing environmental improvement increased from 28 per cent in 2020 to 39 per cent in 2022, while the proportion

Figure 2.14 Environment-related SDG indicators data trend, Latin America and the Caribbean



of indicators showing environmental degradation increased from 12 per cent in 2020 to 16 per cent in 2022 (Figure 2.14).

Three categories can be identified in relation to the freshwater- and marine-related SDG indicators. The first category includes freshwater-related ecosystems (SDG indicators 6.3.2, 6.4.2, 6.5.1, 6.5.2, 6.6.1 and 15.1.2) where all indicators possess enough data to analyse, and five out of the six indicators showing environmental improvement in 2022 compared with 2020. The second category includes SDG indicators identified as human uses and activities (SDG indicators 1.4.1, 3.9.2, 4.a.1, 6.1.1, 6.2.1, 6.3.1, 6.4.1 and 6.a.1) in the LAC region. Their improvement can be evaluated for basic health and infrastructure services: the South America subregion exhibits the highest values, followed by Central America and the Caribbean. Insufficient financing seems to be the main constraint, observed especially in the slow progress of flattened curves observed for those indicators related to costly infrastructure, such as wastewater treatment or water-use efficiency.

On the other hand, the situation is different for the third category that covers marine and coastal ecosystems (SDG indicators 14.1.1a, 14.5.1, 14.6.1, 14.7.1, 14.a.1 and 14.b.1), where indicators possessing enough data to analyse increased from 11 per cent in 2020 to 44 per cent in 2022. Yet, equal proportions (22 per cent) are recorded for the remaining indicators, indicating mixed environmental situation for the region.

2.1.5.3 Water-related ecosystem conservation policies and accelerated action as part of the Water Action Decade and Decade of Ocean Science for Sustainable Development

Many conservation initiatives and policies were adopted and implemented in LAC countries. For instance, initiatives related to the development of monitoring and information systems were implemented in Antigua and Barbuda, Argentina, Brazil, Costa Rica, Mexico, Panama and Peru. National plans and strategies for the implementation of integrated water resources management and regulations on water quality standards were adopted in Antigua and Barbuda, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, El Salvador, Mexico, Paraguay and Peru.

Three LAC countries committed to actively participate in the Water Action Decade. Next to outlining national water policies, Brazil, El Salvador and Paraguay used their country statements to stress the importance of regional cooperation, their determination to improve access to sanitation and the relevance of water management for disaster risk reduction (UN-Water n.d.). In addition, UNECLAC led three region-wide initiatives to accelerate the achievement of SDG 6 on a regional level: (a) the Annual Water Dialogues 2022, used as a platform to collect inputs from UNECLAC member States for the midterm review of the Water Action Decade in 2023; (b) the consolidation of a regional water expert group including 20 institutions combining efforts to promote the achievement of SDG 6 and (c) online consultations of stakeholders from 24 LAC countries aiming to identify major regional topics for the United

Nations 2023 Water Conference. Results show that strengthening water governance, ensuring access and affordability of water and sanitation and preserving water-related ecosystems through nature-based solutions rank highest on the regional water agenda (UNECLAC 2022).

The LAC region accounts for 10 per cent of all Decade of Ocean Science projects and hosts four National Decade Committees (UNESCO-IOC 2022a). In addition, UNECLAC published a special report providing in-depth information on the progress of SDG 14 in the region and offering a range of policy recommendations to UNECLAC member States, including a call to take advantage of the Ocean Decade to create a momentum to advance marine and ocean research and establish research and monitoring networks (UNECLAC 2020). To support policy and decision makers, countries are developing national source inventories and national action plans on marine litter and plastic pollution. Examples from the LAC region are Saint Lucia and Mexico, which have developed reports on the national source inventory (NSI) and national action plan (NAP) in 2022. NSI reports provided information on sources of plastic waste and pollution and support NAPs to propose specific actions for strengthening waste management policies, clean-up campaigns and partnerships.

2.1.5.4 Remaining gaps

Freshwater-related ecosystems and the water-associated economic sectors likely show more management challenges and governance gaps than any other natural resource, as water is a key environmental component but also a human right and economic asset. Progress in implementing effective integrated water policies varies in and between LAC countries. The institutional and territorial fragmentation of stakeholders and competences, in addition to the mismatch between administrative units and hydrological basins, generates policy gaps, which are followed by accountability and funding gaps (OECD 2012).

The intrinsic multilevel, uncoordinated governance of water resources often results in silo-approaches, which in turn explain the information and capacity gaps observed in most LAC countries (OECD 2012). This cause-effect succession frequently ends up closing a circle, where the lack of information undermines communities (at all levels) in coordinating efforts to effectively manage water resources and design integrated and coherent water policies. All these factors are exacerbated by the forecasts suggesting an increase in urbanization, which is both an opportunity for sustainable development and an economic, social and environmental challenge, since its accelerated rhythm raises complex territorial effects (OECD 2022). The scenario of a rapid, unplanned urban growth, along with the context of periodic fluctuations in economy, and the contribution of water-dependent activities (e.g. agriculture and mining) in regional GDP, explains why territorial planning and budgetary weaknesses are reflected so clearly in the scarcity of information related to water- and freshwater-related ecosystems monitoring.

The large area of national marine territories and severe budgetary constraints to carry out research, monitoring and patrolling activities are a fraction of the challenges faced in the region. Increased cross-sectoral cooperation, both within and between countries, will be needed to develop robust, reliable and sustained monitoring databases for marine data and information (UNECLAC 2020). In addition, the nature of oceanic processes requires a set of systematic, comparable international indicators capable of monitoring pressures, identifying trends in the state of marine-related ecosystems and assessing the effectiveness of policies and resource-use practices.

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

Figure 2.15 Scorecard on the environmental dimension of the SDGs in Northern Africa

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

Figure 2.16 Scorecard on the environmental dimension of the SDGs in Western Asia

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)
- Renewable energy-generating capacity (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

- CO_2 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 development (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 least developed countries (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)
- Sustainable fisheries in small island developing States and least developed countries (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 indicator for SDG monitoring (17.18.1)

Legend:

- Represents a change in condition based on this indicator in a positive direction between 2000 and 2022 (does not represent that the SDG target will be achieved).
- Represents very little negative or positive change in this indicator between 2000 and 2022.
- Represents a change in condition based on this indicator in a negative direction between 2000 and 2022.
- Some data is available, but not enough to analyse changes over time.
- No data is available.

2.1.6.1 Freshwater- and marine-related ecosystems in Northern Africa and Western Asia

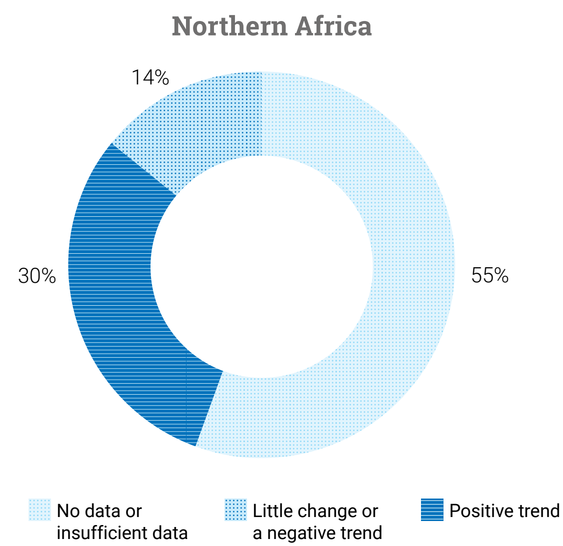
Water resources availability and type vary across the region; some countries have abundant surface water and groundwater resources and ecosystems, while others are mostly covered by deserts and depend on groundwater abstraction (UN 2022a), water desalination (Maftouh et al. 2022) and wastewater reuse for agriculture (Aydin et al. 2016) to meet the increasing water demand. In 2019, the top three countries in the world with the most severe level of water stress were located in the region: United Arab Emirates (UAE), Algeria and Bahrain (UNSD 2022b). The summer of 2022 was hotter than almost any previous summer across Western Asian countries, with temperatures rising to nearly 50° Celsius — almost 7° Celsius higher than the usual for that time of year. Even with arid and semi-arid climates in the region, many countries have witnessed flooding and droughts in recent years (Loudyi and Kantoush 2020).

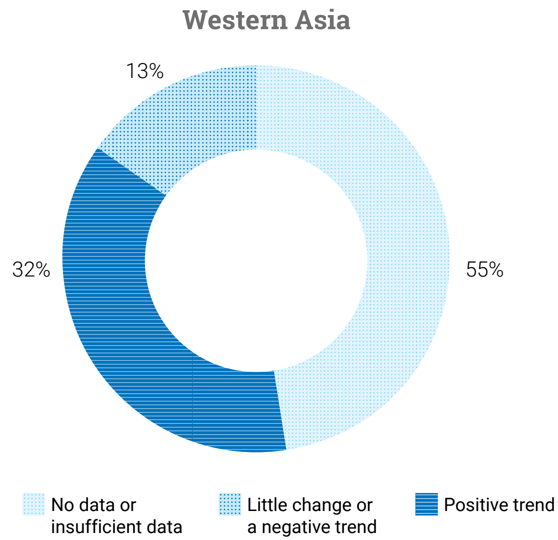
The region comprising Northern Africa and Western Asia contains a wide contrasting range of marine and costal ecosystems including springs, estuaries, mudflats, marshes, mangroves, seagrass beds and coral reefs (UNEP n.d.b). Such a diversity of ecosystems supports considerable biodiversity that is particularly vulnerable to any outside stressors such as water temperature fluctuations and changes, pollution, increased ocean acidity and changes in water flow (UNEP 2017b). Due to its unique climate conditions, the Western Asia and Northern Africa region is likely to be one of the hardest hit by climate change impacts through intensification in scope and severity of droughts and desertification (UNEP n.d.b). Some of these effects include the loss of coastal zones due to sea level rise, seawater temperature rise, increased water scarcity and increased groundwater salinity, which are the most significant for biodiversity and will have severe impacts on almost all aspects of life in the region.

2.1.6.2 Data availability and indicator progress

Out of the 92 environment-related SDG indicators, a minor change has been recorded between data availability and unavailability compared with 2020. SDG indicators that do not possess data or sufficient data to analyse decreased from 57 per cent in 2020 to 55 per cent in 2022 for Western Asia (Figure 2.16), while a decrease from 59 per cent in 2020 to 55 per cent in 2022 was recorded for Northern Africa (Figure 2.15). The proportion of SDG indicators showing environmental improvement has increased by 2 per cent to 28 per cent in 2022 for Northern Africa, while it remained constant at 32 per cent for Western Asia. A 1 per cent increase was recorded for both subregions in 2022 for SDG indicators showing environmental degradation (Figure 2.17).

Figure 2.17 Environment-related SDG indicators data trend, Northern Africa and Western Asia





Data availability of SDG indicators related to freshwater and marine ecosystems improved between 2020 and 2022. Freshwater-related SDG indicators showing environmental improvement increased from 31 per cent in 2020 to 54 per cent in 2022 in Northern Africa, while Western Asia witnessed an increase from 38 per cent in 2020 to 46 per cent in 2022. Similarly, 22 per cent of marine-related SDG indicators showed environmental improvement for Northern Africa and Western Asia in 2022, an increase from 11 per cent in 2020 for both subregions.

2.1.6.3 Water-related ecosystem conservation policies and accelerated action as part of the Water Action Decade and Decade of Ocean Science Sustainable Development

Many water conservation policies are being adopted in the region, with some countries aiming to increase their water-use efficiencies. For instance, Saudi Arabia's Ministry of Environment, Water and Agriculture launched a programme aiming to reduce daily per capita consumption from 263 litres (2019) to 150 litres by 2030. The water conservation programme will be implemented by the Government-owned National Water Company in all regions of the country. The State of Qatar, through its National Vision, aims to balance economic development with human and natural resources by rationalizing water consumption and encouraging the use of non-conventional water resources. On the other hand, preserving marine-related ecosystems is of priority as well. For instance, providing a sustainable environment and infrastructure is one of the six pillars of the UAE National Agenda, which has introduced various marine conservation programmes, including mangrove tree planting and coral restoration, and is working continuously on increasing the size of marine protected areas. By launching the Mangrove Rehabilitation Project in 2020, the UAE has been planting mangrove seed balls via specialized engineered drone rigging and then monitoring them monthly for growth over a year.

As part of the Water Action Decade, the countries of the region have pledged to prioritize water for sustainable development, demonstrated by the recommendations and positions adopted in intergovernmental and regional forums, including by the Arab Ministerial Water Council, the Economic and Social Commission for Western Asia (ESCWA) Committee on Water Resources and in regional water consultations. Also, in 2018, countries agreed to strengthen integrated water resources management, enhance cooperation on shared water resources, attend to climate change adaptation and natural disaster risk reduction and provide access to water services for all (Economic and Social Commission for Western Asia [ESCWA] 2019). Moreover, in 2019 the Arab Ministerial Water Council reviewed its adopted Arab Strategy for Water Security, which focuses on the regional priorities for improved water security (ESCWA 2019).

A couple of initiatives were planned as part of the Ocean Decade, including the West Asia Blue Waters, which attempts to link science and life to improve ocean literacy among the population in the region, as well as the initiative to improve the hydrographic and oceanographic observations to support marine research in Moroccan marine zones (UNESCO-IOC 2022a).

2.1.6.4 Remaining gaps

Nine out of the 17 most water-stressed countries in the world are in Northern Africa and Western Asia (in alphabetical order): Bahrain, Jordan, Kuwait, Lebanon, Libya, Oman, Qatar, Saudi Arabia and UAE (Hofste, Reig and Schleifer 2019).[4] Migration from rural to urban areas, a fast-growing population, poor water management, deteriorating infrastructure and water governance issues are directly affecting the water realm, and these severe impacts are disproportionately borne by the most vulnerable sectors of society (UNEP n.d.c). These factors, among others, have triggered conflicts and rivalries in the region with severe impacts on people and the environment. In this context, environmental governance, science, technology and finance for the water sector play a pivotal role in achieving prosperity and resilience by providing a platform for recovery, development and security (UNEP n.d.d). Cross-sectoral collaboration and partnership need strengthening to facilitate a more holistic decision-making approach for the conservation of water resources by the governments, private sectors and civil societies (UNEP n.d.b).

2.2 Socioeconomic and environmental factors' introduction

In the process of understanding the relationship or interlinkages between any two indicators, the need arises to identify and understand external factors that might have an impact on such complex relationship(s). In this regard, a set of external factors was selected to cover social, economic and environmental dimensions to better understand the relationship between two indicators. The socioeconomic and environmental factors were divided into five categories. Since the statistical analysis presented in the following chapters is developed around freshwater- and marine-related ecosystems, indicators selected for each type of ecosystem is different. The complete list of selected indicators is presented in Annex C. The following section introduces the perspective behind the selection of the external factors for the statistical analysis.

a. Economic and social factors

This category of indicators includes data about the economic and social circumstances that impact how communities interact with the available freshwater- and/or marine-related ecosystems. Incorporating the factors that indirectly influence water availability, usage, quality and sustainability into the statistical analysis is therefore essential to manage water resources, marine and freshwater, in a sound manner. Direct impacts of declining water-related ecosystems on economic activity and vice versa might be intuitive at first sight but can be elusive when attempting to statistically prove them on a larger, economy-wide scale (WB 2019). A total of 16 socioeconomic indicators, mainly chosen from the SDG indicators framework, are particularly important for the aquatic realm in the context of this report (seven indicators for marine-related ecosystems and nine indicators related to freshwater-related ecosystems). For the analysis, GDP per

4 Although the article mentioned more countries as part of the Middle East and Northern Africa region, only countries considered part of the Northern Africa and Western Asia region were mentioned here.

capita and the percentage of urban population among the whole population have been chosen, along with several other relevant SDG indicators. Some of these indicators measure the share of a certain industry towards the GDP (SDG indicators 2.a.1, 9.2.1 and 17.7.1), other indicators are related to employment, including gender-specific indicators (SDG indicators 5.5.1, 8.3.1 and 8.7.1) and child labour (SDG indicator 8.7.1) and finally, indicators related to nutrition (SDG indicator 2.1.1) and other relevant socioeconomic indicators such as the proportion of women and men who own a mobile phone (SDG indicator 5.5.2). Research indicates that environment-related stressors impact populations differently, making such data crucial for analysis and towards the fulfilment of the 2030 Agenda pledge to leave no one behind.

b. Physical infrastructure

The physical structures underpinning modern societies are a necessary part of development associated with growing populations but can carry devastating impacts if environmental concerns are not considered in their planning and execution (WWF 2022). Investments in drinking water and sanitation infrastructure facilities are not only essential for universal and safe access to these services, especially in developing countries, but also for limiting exposure of vulnerable aquatic ecosystems to external induced pressures (Ferreira et al. 2021). A total of 17 indicators related to water infrastructure were identified among the SDG framework to be important for their effects on water resources (11 indicators for marine-related ecosystems, six indicators for freshwater-related ecosystems). A large proportion of these indicators are directly related to WASH (SDG indicators 1.4.1, 6.1.1 and 6.2.1), as safe access and availability of services impact the quality of the water resources for the surrounding societies. Indicators also include available waste management infrastructure (SDG indicator 11.6.1), energy (SDG indicators 7.3.1 and 12.a.1) and communication infrastructure (SDG 17.8.1).

c. Human infrastructure

Human infrastructure – including the existence or absence of governance, social protection policies, institutional human capacities and water literacy and management – impacts water-related ecosystems. Water literacy refers to people having the adequate knowledge and skills at different government and civil society levels to implement improved and efficient management of the resources (Kitamura et al. 2015). This covers freshwater and marine resources. In addition, water literacy, community knowledge and knowledge management incite a more proactive role for the community in the formulation of local policies (SDG indicator 11.3.2). A total of 12 factors within the SDG framework were identified to be relevant considering the importance of human infrastructure in the realm of water-related ecosystems (six related to marine-related ecosystems and six related to freshwater-related ecosystems). These indicators relate to education (SDG indicators 4.1.2, 4.4.1 and 12.8.1), secure tenure rights to land (SDG indicator 1.4.2), civil society engagement (SDG indicator 11.3.2), private sector sustainability reporting (SDG indicator 12.6.1) and corruption (SDG indicator 16.5.2).

d. Environment

The environment is a set of complex interlinked systems with constant exchange among its different settings. As water-related ecosystems interact with and are affected by a wide variety of other ecosystems, they are also threatened by human activity, which often alters the integrity of ecosystems (Piet et al. 2019). For example, agricultural intensification and the application of nitrogen and phosphorus fertilizers can cause nutrient leaching and run-off into adherent groundwaters, lakes and rivers, and end up in marine-related ecosystems where they cause large-scale freshwater and marine eutrophication (Withers et al. 2014). Therefore, a total of nine factors within the SDG framework refer to the different aspects of the environment (four linked to marine-related ecosystems and five for freshwater-related ecosystems). These indicators relate to air emissions and pollution (SDG indicators 9.4.1, 11.6.2 and 13.2.2), terrestrial vegetation with mountain green cover and sustainable forest management (SDG indicators 15.2.1 and 15.4.2) and biodiversity (SDG indicator 15.5.1).

e. Natural resources

The transformation of raw natural resources into goods and services lead resources to be consumed at a rate that exceeds the planet's capacity for regeneration. At the same time, their absence causes detriment to water resources. For instance, deforestation leads to ecosystem degradation and the desertification of watersheds and catchment areas (WWAP 2015). Consequently, five indicators among the SDG indicator framework were identified to cover the dimension of natural resource availability and usage on the management and use of water resources (three for freshwater-related ecosystems and two for marine-related ecosystems). These factors concern terrestrial resources, such as forests (SDG indicator 15.1.1) or land degradation (SDG indicator 15.3.1).

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Chapter 3: Methodology

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3.1 Theory of change

UNEP's Measuring Progress reports aim to improve the understanding of the progress made by SDG indicators by analysing their trends, including through analysis of interlinkages between the indicators of the SDG framework using statistical methodologies. While the Measuring Progress: Environment and the SDGs (2021) report focused on understanding the interlinkages through a statistical correlation analysis, the proposed methodology herein will further develop the statistical correlation analysis of one thematic area into a multivariable analysis by including additional socioeconomic and environmental factors that might impact the relationship between the analysed indicators.

The main objective is to use the driver-pressure-state-impact-response (DPSIR) framework to investigate the relationship between actions taken by countries and their impacts on freshwater- and marine-related ecosystems as well as secondary impacts on human well being through the lens of the SDG indicators.

The methodology enables analysis of the potential impacts on freshwater- and marine-related ecosystems separately and includes different geographical levels, based on data availability. For freshwater-related ecosystems, the analysis is conducted at the global, national (Colombia and Mongolia) and basin levels (China). For marine-related ecosystems, analyses at the global and national (Sri Lanka) levels are conducted.

3.2 Analytical approach

3.2.1 Definition of components

The statistical model features four types of components. Indicators within the first three components (drivers of change, state of the ecosystem and state of human well-being) are all selected from the SDGs indicator framework.

- **Drivers of change indicators** include drivers, pressures and responses from the DPSIR model. They are indicators related to water and marine management, protection and/or restoration actions. Drivers of change are considered as an *independent*[5] variable in the analysis. The drivers are identified as direct human influences on nature and considerations used as a basis for human choices impacting nature (IPBES 2019), while pressures are factors that lead to changes in the state of the ecosystem, and responses are actions being taken to address those drivers and pressures.

- **State of the ecosystem indicators** refer to the state of freshwater- and marine-related ecosystems. They are related to the quality, abundance and habitats of freshwater- and marine-related ecosystems and are considered as *dependent*[6] variables in the analysis of the effect of drivers of change on the ecosystems.

- **State of human well-being indicators** concern the social impacts of the state of the ecosystem. They are considered as dependent variables related to the state of freshwater- and marine-related ecosystems.

5 Independent variable: "a variable whose value does not depend on another variable" (Oxford Learner's Dictionaries, n.d.) (alternative term: explanatory variable)
6 Dependent variable: "a variable whose value depends on another variable" (Oxford Learner's Dictionaries, n.d.) (alternative term: response variable)

- **Socioeconomic and environmental factors** are a group of indicators from within and outside the SDG indicator framework that might influence the relationship between the different groups of indicators (drivers of change, state of the ecosystems and state of human well-being). They are divided into five categories according to their nature: economic and social, physical infrastructure, human infrastructure, environment and natural resources. Section 2.3 provides a detailed perspective on the nature of these factors.

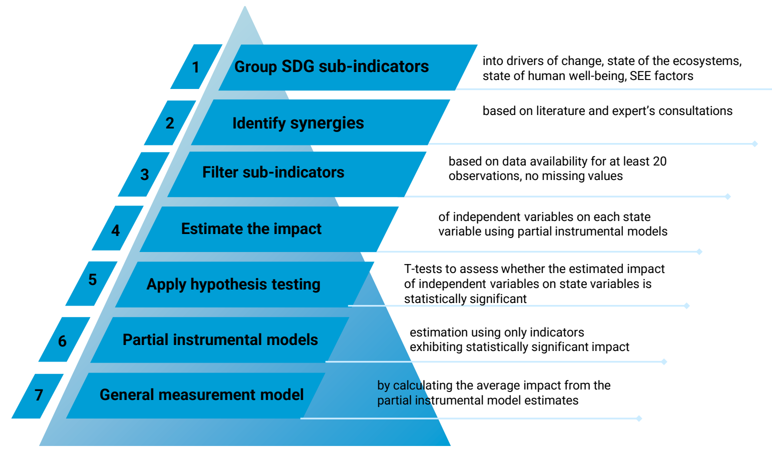
3.2.2 Theoretical models specifications

After defining the components of the statistical analysis, identifying and classifying SDG indicators into the above-identified categories was imperative (Figure 3.1). The selection of the indicators was done at the indicator level and separately for each type of ecosystem, considering the specificities of each ecosystem type according to experts' knowledge.

Potential synergies were then identified between the selected indicators for further analysis (see Annex E). Potential synergies are based on the potential impact that one indicator (independent variable) might have on another indicator (dependent variable). An initial identification of potential synergies was complemented by online experts' consultation. Theoretical models were then developed for the analysis of the state of freshwater- and marine-related ecosystems and their impact on human well-being.

The next step entailed setting the criteria for data to be used in the statistical analysis. For global and national data, the number of observations was set to a minimum of 20 observations, no gaps in the time series and using available data to date. For global-level data, the criteria were set to have data from at least 50 per cent of the countries for a global aggregate to be generated. This aligns

Figure 3.1 Statistical analysis steps



with UNEP's methodology to aggregate data to the global level. Global aggregates (i.e. one value representing global value for one year) were used in the statistical analysis, in comparison with country data. Specifically for marine-related ecosystems, the 45 landlocked countries were excluded from the analysis due to their lack of direct accessibility to and benefit from marine and coastal areas.

Multiple sources of data were used for this analysis. For SDG-related indicators, data were extracted from the SDG Indicators Database on 14 June 2022. Subsequent updates of the database were not considered in this analysis. Other sources were used, such as the Department of Economic and Social Affairs, Population Division[7] and the World Bank.[8]

7 For the "annual percentage of population at mid-year residing in urban areas" indicator, accessed 30 June 2022.
8 For Gross National Income (GNI) per capita, accessed 30 June 2022.

Table 3.1 Percentage of sub-indicators of which data are available from the proposed list in the theoretical models, freshwater and marine

	Freshwater			Marine	
	Colombia	Mongolia	Global	Sri Lanka	Global
State of the ecosystem	32%	32%	32%	10%	10%
State of human well-being	1%	1%	12%	8%	15%
Drivers of change	17%	17%	12%	20%	26%
Socioeconomic and environmental factors	18%	18%	18%	12%	21%

For basin-level analysis, the number of observations was set to 15, with the time series starting from 2004 until the most recent available data without data gaps in the time series. Basin-level data were provided by the Government of China (received on 22 June 2022).

Table 3.2 Percentage of sub-indicators of which data are available from the proposed list in the theoretical model for basin-level analysis

	Poyang Lake	Haihe River	Huaihe River	Yangtze River	Yellow River
State of the ecosystem	4%	4%	4%	4%	4%
State of human well-being	3%	0%	0%	0%	0%
Drivers of change	18%	5%	5%	5%	5%
Socioeconomic and environmental factors	20%	0%	0%	0%	0%

One of the main challenges of this analysis is related to the lack of data at the global and national levels. This point is very relevant, because only a partial study of the theoretical models has been done. Only some of the proposed sub-indicators had available data due to the numerous missing data existing in the time series. This limitation requires the design of an ad hoc measurement methodology, achieving an equilibrium between (i) the demanding requirements of the theoretical models and actual policy impact dissemination mechanisms and (ii) the data that can be used to measure such impacts. The following approaches were used to achieve this equilibrium:

- ✔ Impact is approached as a combination of **partial correlation and time arrow** to discriminate correlation (symmetric) from impact (asymmetric, pointing out future from the past). By considering partial correlation, one can discriminate the effect of the variable whose impact is being measured from the potential effects of other drivers or socioeconomic and environmental factors. Considering a time lag, one can break the symmetry of partial correlations, since past can affect the future but the future cannot change the past.
- ✔ Impact dissemination patterns are modelled as simple but **not limited to linear effects**.
- ✔ Impact intensities of different drivers and socioeconomic and environmental factors are made **comparable** through variable standardization.
- ✔ Statistical models are being used as instrumental impact measurement models and not as predictive tools.
- ✔ The information from instrumental measurement models is integrated in a **general impact measurement model** summarizing the results of the instrumental models and providing a unique comparable measurement of the intensity of each impact.

To avoid the restriction of linear impact diffusion and the comparability of the impact being measured, and to homogenize the estimated impact (indicators' units vary, that is, by per cent, age, km², US$ and so on), all indicators' data were transformed and standardized before the estimation of the instrumental models by using the logarithmic transformation.

The number of available variables in the theoretical model is larger than the number of available observations of each variable. Therefore, only partial **instrumental models** (i.e. models including a small subset of explicative variables) can be estimated.

To produce the general measurement model, all potential models including a strategy of three explanatory variables were estimated using ordinary least squares. The number of explanatory variables has been selected as the minimum number to estimate partial correlations instead of total correlations. The methodology opts for the minimum number of explanatory variables to maximize the degrees of freedom of the model and avoid model overfitting. Hence, instrumental models for which less than two coefficients are found to be statistically significant are dismissed. The regression models for each state variable are estimated independently. Formally, the instrumental regression for each ecosystem can be written as

$$\begin{pmatrix} S^1 \\ \vdots \\ S^n \end{pmatrix}_t = \begin{pmatrix} \beta_0^1 \\ \vdots \\ \beta_0^n \end{pmatrix} + \begin{pmatrix} \beta_{11}^1 & \cdots & \beta_{1m}^1 \\ \vdots & \ddots & \vdots \\ \beta_{11}^n & \cdots & \beta_{1m}^n \end{pmatrix} \begin{pmatrix} D_1 \\ \vdots \\ D_m \end{pmatrix}_{t-1} + \begin{pmatrix} \beta_{21}^1 & \cdots & \beta_{2k}^1 \\ \vdots & \ddots & \vdots \\ \beta_{21}^n & \cdots & \beta_{2k}^n \end{pmatrix} \begin{pmatrix} C_1 \\ \vdots \\ C_k \end{pmatrix}_{t-1} + \begin{pmatrix} \varepsilon^1 \\ \vdots \\ \varepsilon^n \end{pmatrix}$$

$$\begin{pmatrix} W^1 \\ \vdots \\ W^l \end{pmatrix}_t = \begin{pmatrix} \gamma_0^1 \\ \vdots \\ \gamma_0^l \end{pmatrix} + \begin{pmatrix} \gamma_{11}^1 & \cdots & \gamma_{1n}^1 \\ \vdots & \ddots & \vdots \\ \gamma_{11}^l & \cdots & \gamma_{1n}^l \end{pmatrix} \begin{pmatrix} S^1 \\ \vdots \\ S^n \end{pmatrix}_{t-1} + \begin{pmatrix} \gamma_{21}^1 & \cdots & \gamma_{2k}^1 \\ \vdots & \ddots & \vdots \\ \gamma_{21}^l & \cdots & \gamma_{2k}^l \end{pmatrix} \begin{pmatrix} C_1 \\ \vdots \\ C_k \end{pmatrix}_{t-1} + \begin{pmatrix} \delta^1 \\ \vdots \\ \delta^l \end{pmatrix}$$

Where:

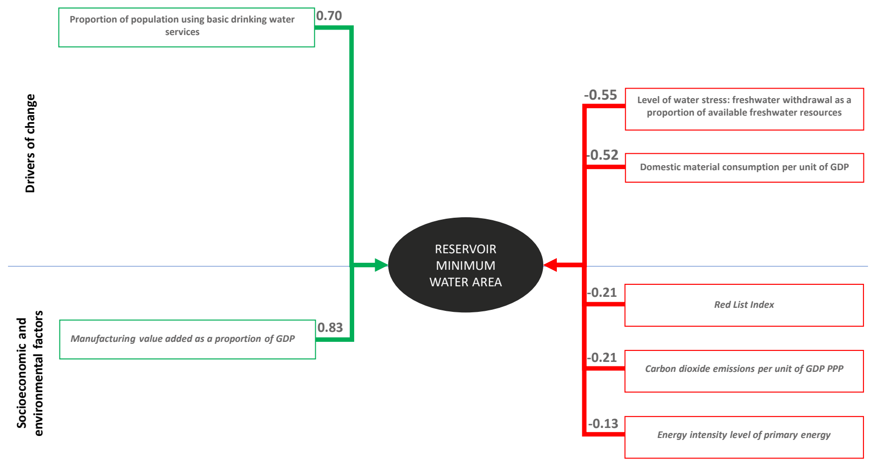
- *m+k = 3*
- *n+k=3*
- S_n: State of the ecosystem
- W_n: State of human well-being
- D_n: Drivers of change
- C_n: Socioeconomic and environmental factors
- β, γ: Model coefficients
- ε_i, δ_i: Error of the model

After the estimation, the t-test is applied to test the null hypothesis for each individual impact coefficient being null at a significance level of 0.05. Models are re-estimated after the elimination of one non-significant coefficient, providing a measure of the intensity of impacts that can be considered as non-null. This impact measure is given by the corresponding estimated coefficient ($\hat{\beta}$ for impact in the state of the ecosystem and $\hat{\Upsilon}$ for impact in the state of human well-being). The value of the estimated coefficients that are significantly non-null for all the instrumental models for each response variable is presented below and used to conduct the following analysis of the results.

3.3 Presentation of results

		RESERVOIR MINIMUM WATER AREA				
Type	Description	M01	M02	M03	M04	M05
Divers of change	Proportion of population using basic drinking water services	0.7	0.81	0.6		
	Electronic waste generated, per capita					
	Average proportion of freshwater Key Biodiversity Areas (KBAs) covered					
	Average proportion of terrestrial KBAs covered					
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.47		-0.34	-0.85	
	Material footprint per unit of GDP		-0.34		-0.83	-0.39
	Domestic material consumption per unit of GDP					
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP				0.83	
	Red List Index					-0.21
	Carbon dioxide emissions per unit of GDP PPP			-0.83		
	GNI per capita, Atlas method					
	Completion rate					
	Installed renewable electricity-generating capacity					
	Proportion of population with access to electricity					
	Energy intensity level of primary energy		-0.13			
	Urban population as percentage of total population					

Notes:
- There are five instrumental models (denoted as M1 through to M5) for which at least two coefficients are significantly non-null.
- All indicators presented above were tested.
- Indicators showing no coefficients were found to be statistically insignificant.
- Green cells indicate positive coefficients; red cells indicate negative coefficients.



Notes:
- Indicators located above the blue line are considered as direct drivers indicators.
- Indicators located below the blue line are considered as socioeconomic and environmental factors.
- The indicator located in the centre is the dependent variable, while all other indicators are considered independent.
- Green indicates a positive relationship (an increase of the explanatory variable (driver or socioeconomic and environmental factor) and translates into an increase in the level of the response state variable).
- Red indicates a negative relationship (an increase of the explanatory variable (driver or socioeconomic and environmental factor) translates into a decrease in the level of the response state variable).

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Chapter 4: Freshwater-related ecosystems

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Many relationships were identified as significant for freshwater-related ecosystems. The following chapter explores the significance of such relationships and whether such relationships are confirmed by scientific evidence.

4.1 Interlinkages analysis of freshwater-related indicators at the global level

4.1.1 The impact of drivers of change on the state of freshwater-related ecosystems

A set of SDG indicators were identified as drivers of change to have potential impact on freshwater-related indicators. Two indicators from the SDG framework (SDG 6.3.2 and SDG 6.6.1) were identified as state of freshwater-related ecosystems indicators. SDG 6.3.2, on the proportion of bodies of water with good ambient water quality, refers to "natural, untreated water in rivers, lakes and groundwaters and represents a combination of natural influences together with the impacts of all anthropogenic activities" (UNSD 2022a). The calculations for this indicator are based on in situ measurements from surface-water and groundwater samples. However, at the time of extracting the data to conduct the statistical analysis, only two data points were available (years 2017 and 2020), which hindered the analysis of the interactions of the drivers of change with this indicator. SDG 6.6.1, on the change in the extent of water-related ecosystems over time, is an indicator that monitors the expansion or shrinkage of lakes and rivers (permanent and seasonal water area), reservoirs, mangroves and wetlands. It is derived from satellite-based Earth observations (UNSD 2022a).

In addition to the drivers of change, a set of socioeconomic and environmental indicators were considered as part of the statistical analysis. The list of these indicators is presented in Annex D. The following section analyses the results obtained from the statistical analysis for freshwater-related indicators.

6 CLEAN WATER AND SANITATION

a. SDG 6.6.1 sub-indicators on lakes and rivers water area (permanent and seasonal)

SDG 6.6.1 aims to monitor the changes in size, water quality and quantity of water-related ecosystems, divided by type of ecosystem and by using satellite-based Earth observations. Two sub-indicators of SDG 6.6.1 are the water area of lakes and rivers, which are (a) permanent and (b) seasonal. These two sub-indicators are categorized as state of the ecosystems as they represent the expansion or reduction of water-related ecosystems. Between 2000 and 2019, these two indicators show an improvement in the water area of lakes and rivers, whether seasonal or permanent (SDG 6.6.1).

Three indicators (SDG 15.1.2 sub-indicators include the average proportion of freshwater KBAs covered and the average proportion of terrestrial KBAs covered; SDG 15.4.1 includes the average proportion of mountain KBAs covered) show positive impact on lakes and rivers permanent seasonal water area (SDG 6.6.1). Freshwater, terrestrial and mountain KBAs are "sites contributing significantly to the global persistence of biodiversity", and the freshwater-related ecosystems represent one of the most threatened broad habitat types globally (Holland, Darwall and Smith 2012; Máiz-Tomé et al. 2017). In recent years, the global coverage of protected areas and core protected areas has shown a steady growth trend (Maxwell et al. 2020). At the same time, the global area of permanent water bodies is also in an increasing trend (Borja, Kalantari and Destouni 2020). On the other hand, freshwater-related ecosystems are highly dependent on the surrounding terrestrial areas, which include terrestrial and mountain KBAs as well as freshwater protected areas. For freshwater KBAs, terrestrial KBAs and mountain KBAs, the larger the area is, the larger the protected river and lake area is (Holland, Darwall and Smith 2012). Additionally, the more protected areas around freshwater-related ecosystems, such as lakes and rivers, the easier it is for water networks to propagate (Linke and

Hermoso 2022). Therefore, freshwater, land and mountain KBAs show a strong positive relationship with the area of permanent and seasonal water bodies around the world.

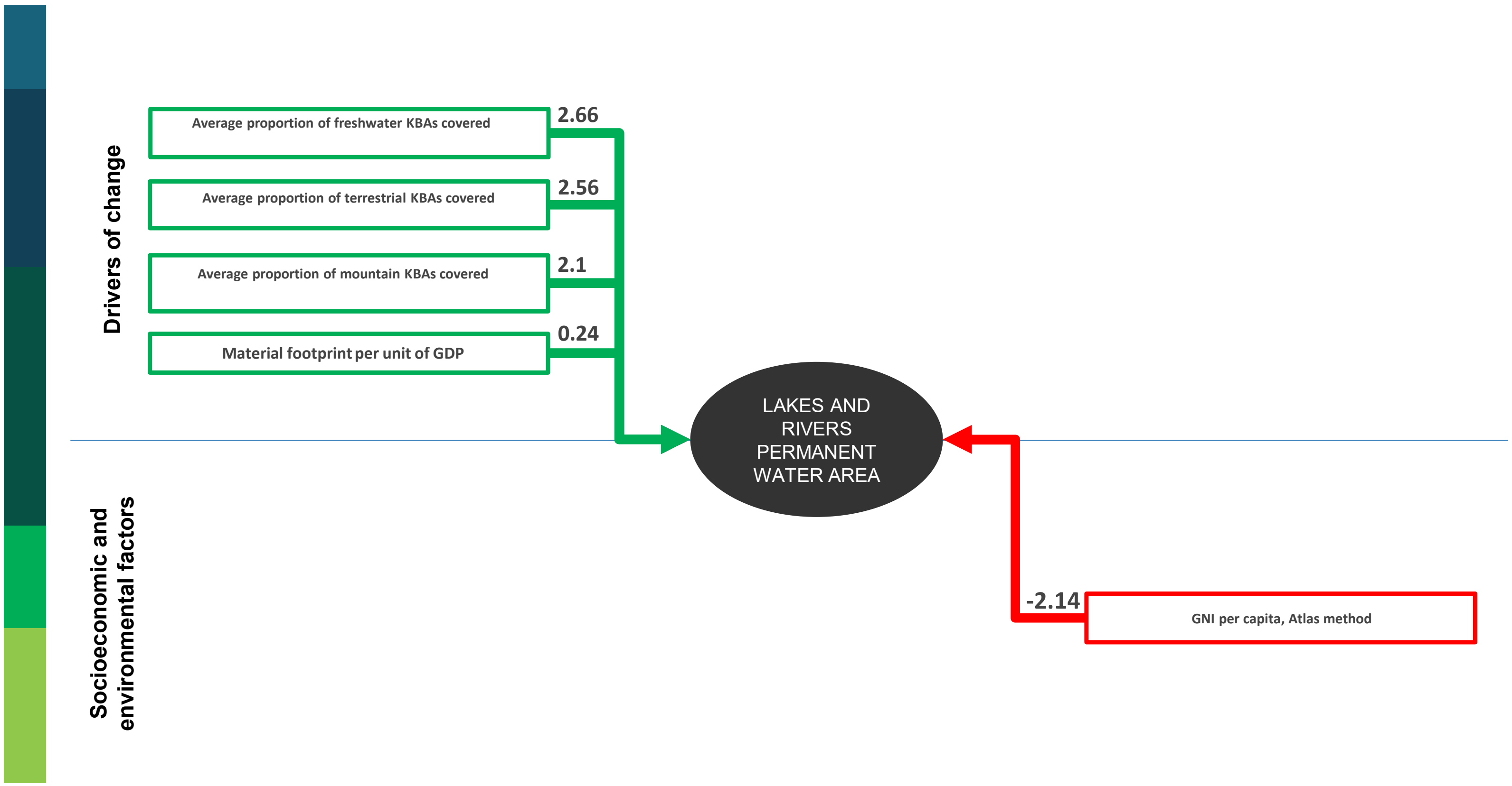
The statistical analysis indicates a weak positive relationship between material footprint per unit of GDP (SDG 8.4.1/12.2.1) – which is a natural resources consumption-based indicator – and the lakes and rivers permanent and seasonal water area (SDG 6.6.1). As a resource, water is known to be used in the production of biofuels. These require significant volumes of water for the irrigation of crops (Convention on Biological Diversity [CBD] n.d.), which involves adding the volumes of water used during the actual process of extracting resources from the environment, leading to resource depletion and water pollution (Wiedmann et al. 2013). Given the quantities of water required in the mining sector, for instance, water-saving strategies and techniques are being developed in mineral processing plants to reduce and/or recycle the quantities of water required for extraction (Michaux et al. 2019), hence exerting less pressure on water streams such as lakes and rivers. The shift towards decoupling material extraction from water resources might be the reason for the positive relationship. However, in practice, the relationship is expected to be negative.

The statistical analysis resulted in a strong negative relationship between GNI per capita, Atlas method[9] and lakes and rivers permanent and seasonal water area. Strong income growth leads to rising living standards and more demands for commodities (WWAP 2015). This all leads to increased water use, which exerts greater pressure on the available water resources (lakes and rivers) and reduces the water available to meet the increasing demand from economic activities and households alike. This can be interpreted by the negative relationship where an increase of GNI per capita might decrease the lakes and rivers permanent and seasonal water area (SDG 6.6.1). At the global level, this indicates that decoupling economic growth from water resource use has not yet been accomplished. However, since data used is aggregated to the global level, one cannot assume that decoupling has not been achieved in any country.

Renewable energy sources include hydropower, solar, wind, geothermal, bioenergy, wave and tidal. Globally, hydropower is by far the largest modern renewable energy source, but with solar and wind power rapidly growing, hydropower development is reduced, bearing a positive impact on the maintenance of seasonal water bodies (He et al. 2019). According to International Renewable Energy Agency [IRENA] statistics (IRENA 2022a), the world annual growth in electricity-generating capacity from hydropower sources since 2000 has been much slower (ranging between 1 and 4 per cent per year) compared with wind and solar generating capacities. Solar and wind generating capacities combined accounted for more than the hydropower capacities worldwide in 2020 (IRENA 2022a). On the other hand, expanding the renewable energy capacities, more specifically solar and wind as these sources are not water intensive, coupled with reduced extraction and processing of fossil fuel, leads to improvement in lakes and rivers water area (SDG 6.6.1). This can be related to the weak positive relationship between (a) renewable electricity-generating capacity (SDG 7.b.1), (b) renewable energy share in the total final energy consumption (SDG 7.2.1) and (c) the proportion of population with access to electricity (SDG 7.1.1) as well as lakes and rivers seasonal water area. Similarly, SDG 7.3.1 on the energy intensity level of primary energy consumption (representing the total energy supplied to the economy per unit value of economic output) is expected to have a negative relationship with lakes and rivers seasonal water area (SDG 6.6.1), as the decrease in energy intensity is considered beneficial to the environment, which is the case in the obtained results.

9 The World Bank’s Atlas method of conversion is used to smooth fluctuations in prices and exchange rates in the cross-country comparison of national incomes (WB 2022b).

Figure 4.1 General model for lakes and rivers permanent water area, global level

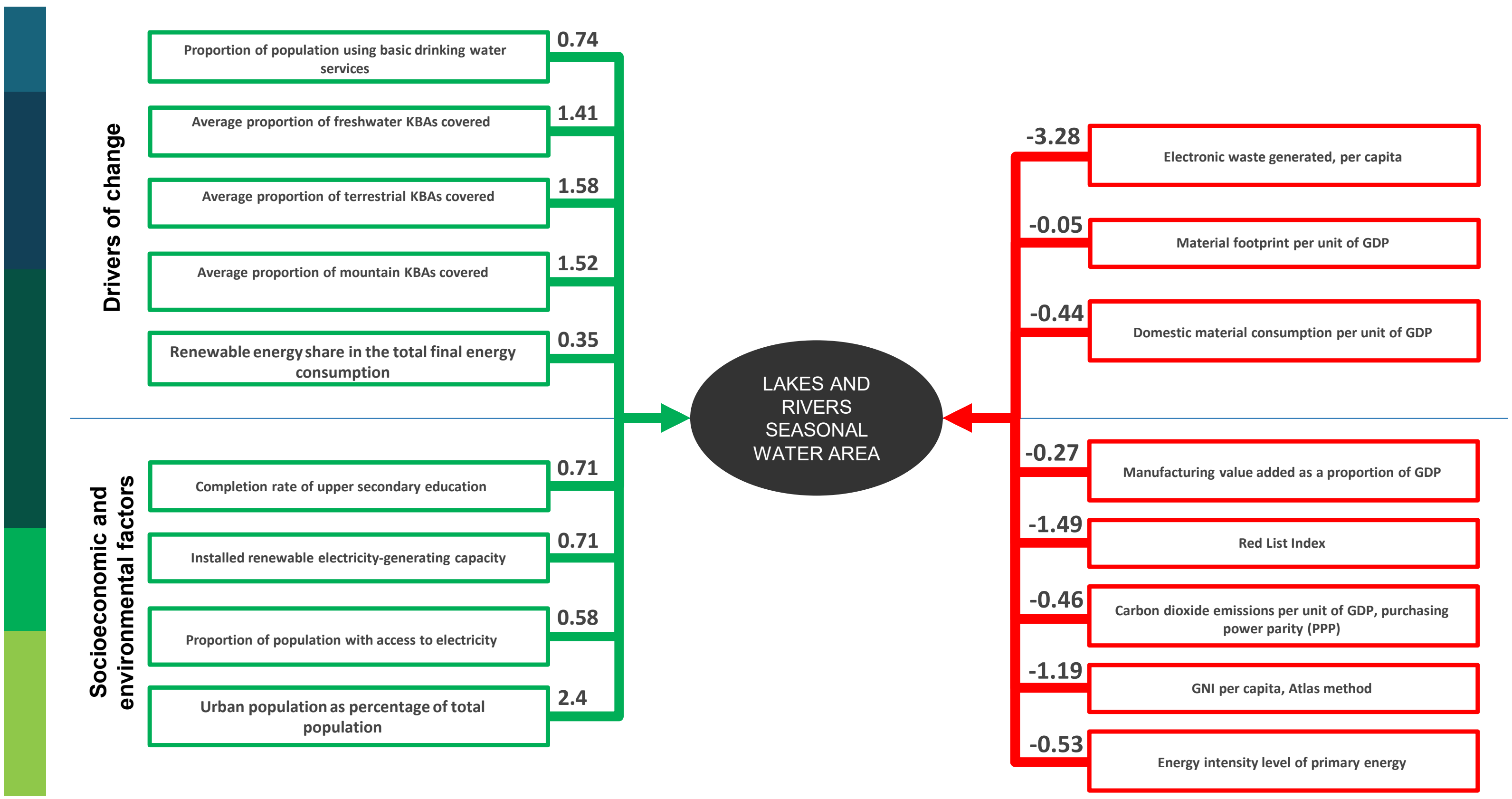


On the other hand, (a) domestic material consumption per unit of GDP (SDG 8.4.2/12.2.2) and (b) manufacturing value added as a proportion of GDP (SDG 9.2.1) were identified as having a negative relationship with lakes and rivers seasonal water area (SDG 6.6.1). The expansion of the manufacturing sector requires more natural resources (that is, more water) unless environmentally sound techniques are used. Additionally, the less domestic material consumption to produce one economic output, the better it is for natural resources, as processes are becoming more efficient, requiring fewer natural resources to be allocated and a lower energy requirement to produce the same quantities of products. This explains the negative relationship between SDG 8.4.2/12.2.2 and SDG 9.2.1 obtained from the statistical analysis.

The statistical analysis has shown that increased electronic waste generated per capita (SDG 12.4.2) has a negative relationship with lakes and rivers seasonal water area (SDG 6.6.1). In fact, global e-waste generated per capita has been increasing to reach 7.3 kilograms (kg) in 2019 and is expected to reach 9 kg per capita in 2030 (Forti et al. 2020). The rapid innovation in new technologies requires a fast-paced electronics production. The production of electronic products depends on the mining and extraction of a different variety of metals. The extraction and transformation of these metals to be used in products (via mining, grinding, flotation, gravity concentration, medium separation and hydrometallurgical processes) and auxiliary activities (e.g. dust suppression, cooling and washing equipment) are water-intensive processes, not forgetting the water used for energy (drilling, cooling and emission control systems at thermoelectric power plants) (Madaka, Babbitt and Ryen 2022). This has led to water depletion in surrounding water bodies and degradation of water downstream of mining sites (Madaka, Babbitt and Ryen 2022), which reflects the results of the statistical analysis. However, it is uncertain why such a strong negative relationship was not found to be statistically significant in lakes and rivers permanent water area (SDG 6.6.1).

The statistical analysis has shown a positive relationship between the proportion of population using basic drinking services and lakes and rivers seasonal water area. Basic drinking water services is defined as drinking water from an improved source, provided

Figure 4.2 General model for lakes and rivers seasonal water area, global level



collection time is not more than 30 minutes for a round trip, from piped water, boreholes or tube wells, protected dug wells and springs, and packaged or delivered water (UNSD 2022a). The higher the population with access to water resources, the higher the pressure exerted on natural resources to allocate more quantities of water. However, the increase in the proportion of population using basic drinking water services might imply fewer people using water by other inefficient means, such as household leaks (EPA 2022), or by wasteful means, such as running the tap while brushing their teeth or washing their hands or the dishes (EPA 2022).

Urbanization, specifically rapid urbanization, will lead to the reduction of surface water (Palazzoli, Montanari and Ceola 2022). In many urbanized areas, surface and ground waters are already depleted (WWAP 2015). This is due to an increased demand for manufacturing, thermal electricity generation and domestic use resulting from growing urban populations in developing countries (WWAP 2015). Yet, the move to urban areas leads farmers to leave their agricultural activities which in turn leads to decreased water needs for the agriculture sector, which could be the reason for the positive relationship.

A negative relationship between CO_2 emissions per unit of GDP (SDG 9.4.1) and lakes and rivers seasonal water area (SDG 6.6.1) was identified. As the efficiency in economic processes improves, meaning less CO_2 emissions to produce one unit of economic output, fewer quantities of water are required, and less pressure is exerted on water-related ecosystems. This reflects the results of the statistical analysis for lakes and rivers seasonal water area. What remains obscure is that this relationship was not identified as statistically significant with rivers and lakes permanent water area.

6 CLEAN WATER AND SANITATION

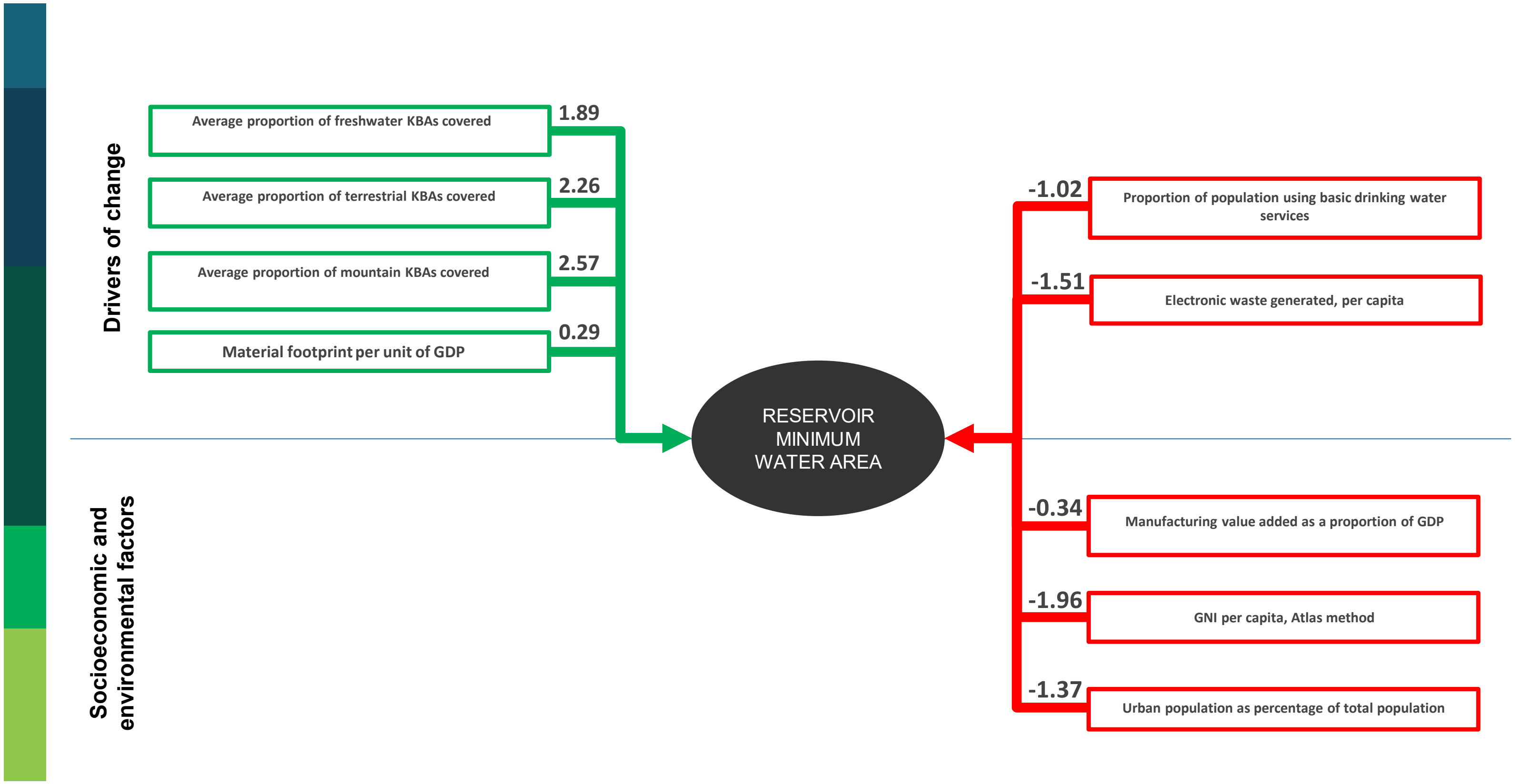
b. SDG 6.6.1 sub-indicators on reservoirs water area (minimum and maximum)

Reservoirs are artificial waterbodies built by humans for purposes such as water supply, hydropower generation, flood control and irrigation. In both SDG 6.6.1 sub-indicators on reservoirs water area (a) minimum and (b) maximum, the statistical analysis showed the same type of relationships with independent indicators. For instance, there was a positive relationship between (a) the average proportion of mountain KBAs covered (SDG 15.4.1), (b) the average proportion of terrestrial KBAs covered (SDG 15.1.2) and (c) the average proportion of freshwater KBAs covered (SDG 15.1.2) with both reservoirs minimum and maximum water area (SDG 6.6.1). These three indicators show the strongest impact on reservoirs water area. As presented in the section on lakes and rivers, conservation efforts carry a positive impact on freshwater resources, which include reservoirs water area.

Regarding SDG 8.4.1/12.2.1 on material footprint per unit of GDP, the statistical analysis shows a weak positive relationship with reservoirs minimum and maximum water area (SDG 6.6.1). As presented in the lakes and rivers section, this relationship is expected to be negative.

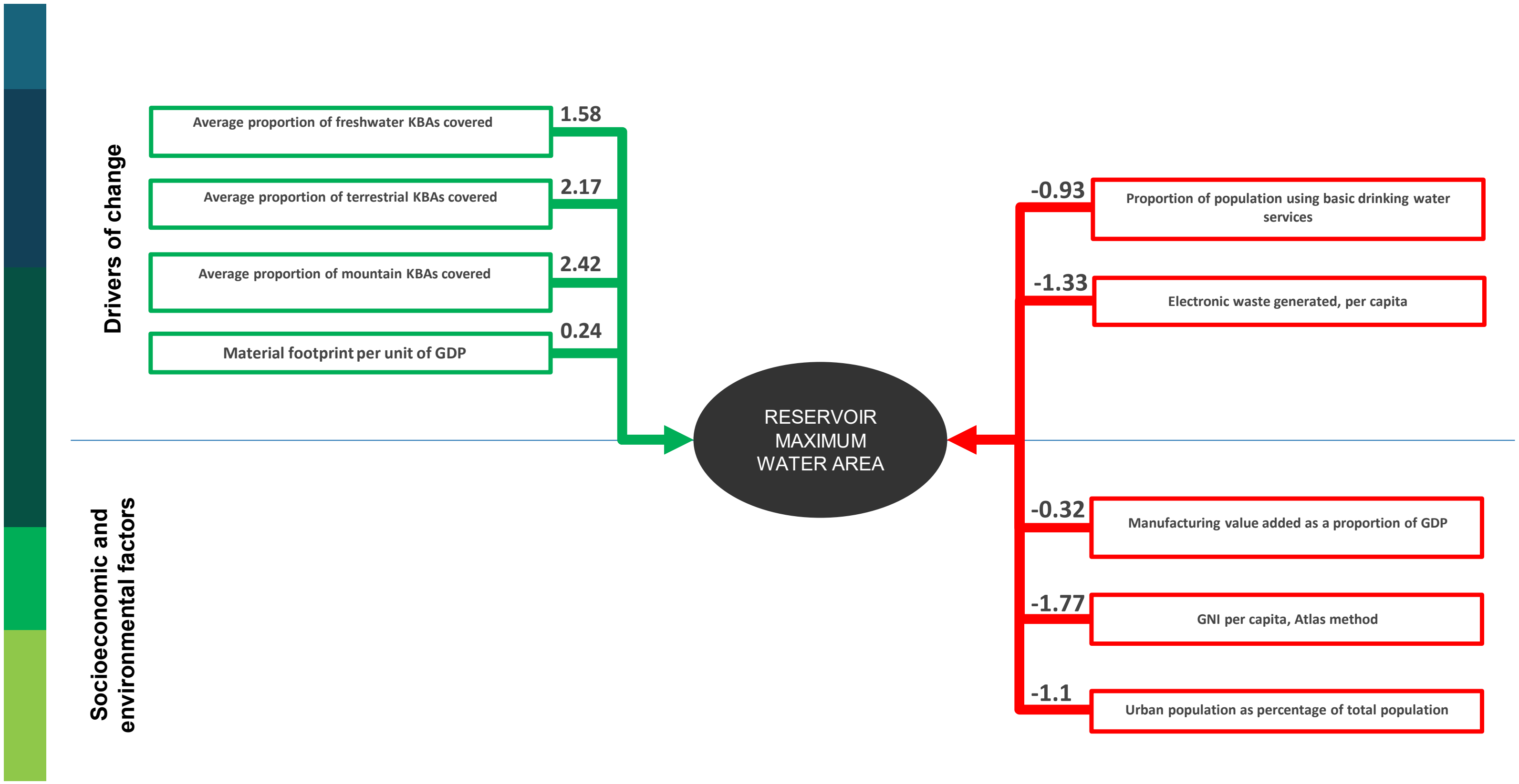
A strong negative relationship was also identified between electronic waste generated per capita (SDG 12.4.2) and reservoir minimum and maximum water area (SDG 6.6.1). As provided in lakes and reservoirs section, the production of electronic equipment is water intensive, which means that the more electronic equipment is generated, the more water is required to produce them. In addition, the innovations in that sector coupled with a consumer behaviour has led to the generation of more electronic waste – a significant source of water pollution (Akram et al. 2019).

Figure 4.3 General model for reservoirs minimum water area, global level



The statistical analysis has indicated a negative relationship between (a) GNI per capita, Atlas method, (b) SDG 1.4.1 on the proportion of population using basic drinking water services and (c) urban population as a percentage of total population and reservoir maximum and minimum areas (SDG 6.6.1). The increase in the GNI per capita leads to improved lifestyles with increased water consumption. As one main aspect of a reservoir is to supply water for households, industries and agriculture, this also means that increased per capita income, increased urban population as a percentage of total population and an increased proportion of population using basic drinking water services would negatively impact the water area of reservoirs used to supply such communities, which is presented by the negative relationship.

Figure 4.4 General model for reservoirs maximum water area, global level



c. Conclusion

At the global level, many indicators showed positive or negative relationships with SDG 6.6.1 sub-indicators on lakes and rivers permanent and seasonal water area and on reservoirs minimum and maximum water area. Among the positive relationships, land conservation indicators were strongest, consistent with the expectation that land conservation is also a water protection effort. A weak positive relationship with material footprint per unit of GDP (SDG 8.4.1/12.2.1) was identified, which may indicate that the world is moving closer towards a decoupling of economic activities from resources use, though it is expected to be negative.

The strongest negative relationship was identified between GNI per capita and lakes, rivers and reservoirs water area (SDG 6.6.1). As global GNI per capita grows, leading to more water use, decoupling water resources from economic growth has become essential to preserve surface-water and groundwater resources. One cost-effective way to achieve this decoupling is for governments to develop and implement integrated water resources management strategies at national, subnational and basin levels (UNEP 2016c). Electronic waste generated per capita (SDG 12.4.2) was also found to have significant strong negative relationship with water resources. This implies the need for stronger policies targeting the production and management of electronic wastes, both within national borders and transboundary, more specifically focusing on the potential of recycling or reusing materials in the context of shifting from a linear to a circular economy.

Reservoirs water area (SDG 6.6.1) were negatively impacted by the proportion of population using basic drinking water services (SDG 1.4.1) and the percentage of urban population. Although accessing clean drinking water is a basic human right, the focus of better access lies in increasing the efficiency of water use or water infrastructure including water supply networks. Such actions require national water policies that target water infrastructure, regulatory systems and water use.

4.1.2 State of freshwater-related ecosystems' impact on state of human well-being

a. SDG 1.1.1 sub-indicator on the proportion of population below international poverty line

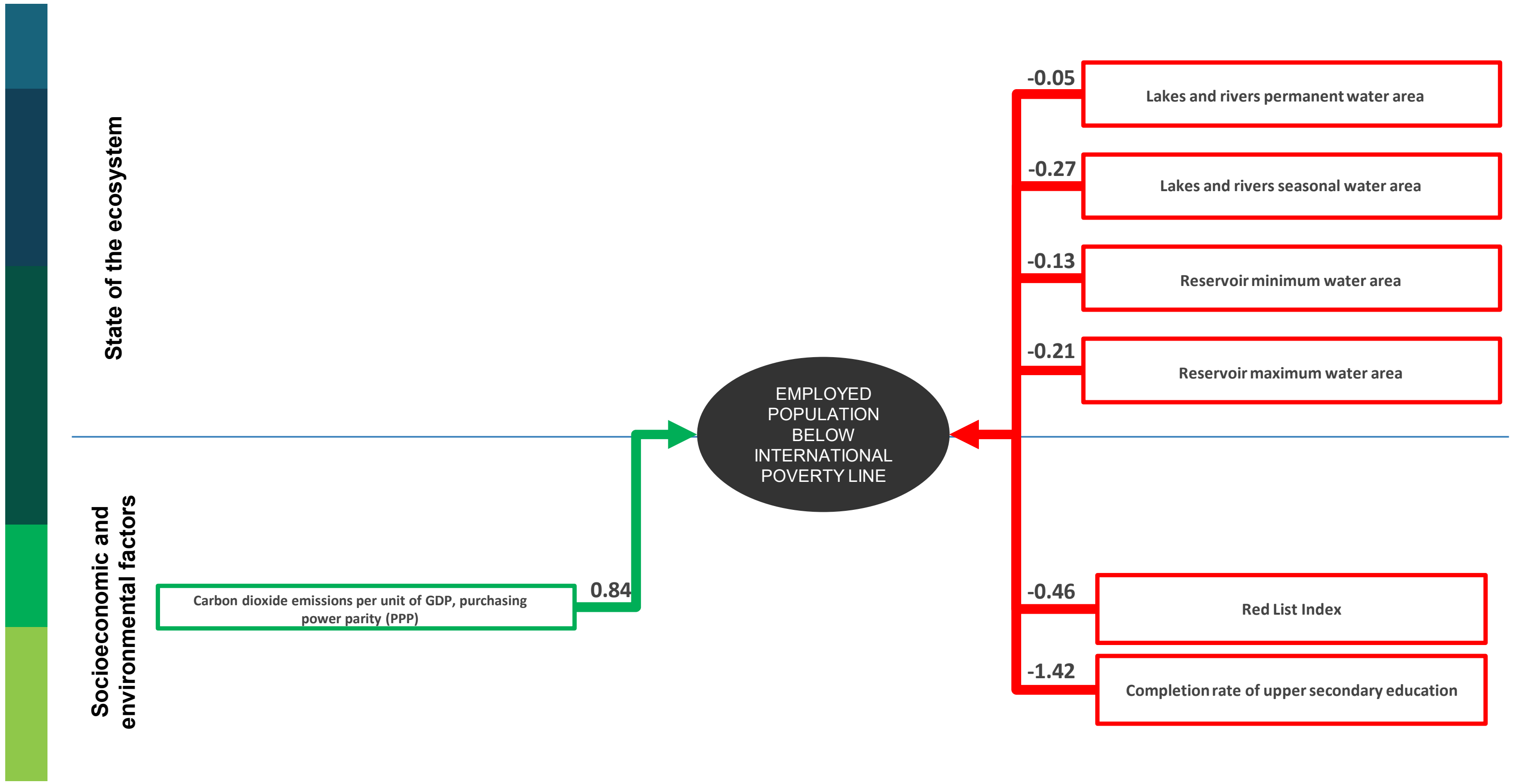
SDG indicator 1.1.1 on employed population below the international poverty line monitors the share of employed persons living in households with per capita consumption or income that falls below the international extreme poverty line of US$ 1.90 per day (UNSD 2022a).[10] This indicator's main target is to reduce the proportion to zero, thereby eradicating extreme poverty. The adequacy of earnings and income is a fundamental aspect of human rights and essential in alleviating poverty across the world (Sullivan and Hickel 2023). Gender analyses of poverty-related data indicate that women constitute the majority of the world's poor. Such information is crucial to ensuring that poverty eradication efforts focus on the inclusion of women as key stakeholders as well as in economic empowerment activities such as environmental management and governance.

A total of four state of the ecosystem indicators were identified to have negative relationships with SDG 1.1.1. The negative relationships between water quantity and poverty are well recorded in the literature. Reduced water availability or water scarcity exacerbates the consequences of poverty (Gleick and Cooley 2021). The 2016 edition of UNESCO's World Water Development Report (WWAP 2016) states that unsustainable water management, in addition to other natural resources, causes significant harm to economies and society by reversing poverty reduction gains. Additionally, women and girls tasked with water collection spend more of their time collecting water for domestic consumption rather than in pursuit of education or economic empowerment, further pushing them into poverty and sometimes putting them in danger when the water source may be in a secluded or conflict-torn area.

Water, as well as being a basic necessity, benefits society and communities in the form of ecosystem services that help create jobs related to water, including agriculture or aquaculture in freshwater streams, which alleviate poverty. Studies have noted that aquaculture has the potential to help alleviate poverty, especially in areas where there is sufficient freshwater or even marine water available for aquaculture. In the Philippines, poverty among farmers unengaged in aquaculture was found to be around 71 per cent while poverty among farmers engaged in aquaculture of small-scale tilapia was around 43 per cent (Palanca-Tan 2018-2019). Such proclamations and impacts of water availability on the

10 Please note that in September 2022, the World Bank updated the extreme poverty line to $2.15 per person per day based on 2017 PPPs (WB 2022b).

Figure 4.5 General model for employed population below international poverty line, global level



proportion of employed population below the international poverty line (SDG 1.1.1) confirm the results of the statistical analysis about the negative relationship.

The statistical analysis identified one positive relationship between SDG 9.4.1 on CO_2 emissions per unit of GDP and SDG 1.1.1 on employed population below the international poverty line. Much research across the literature discusses the impact of CO_2 emissions and its role in alleviating poverty (Hubacek et al. 2017; Bruckner et al. 2022). Both studies found that lifting people out of extreme poverty (US$ 1.90 per day) would not jeopardize the climate target, as it would only result in an increase of 1.6 to 2.1 per cent or less of carbon emissions. However, no literature studies could be found on CO_2 intensity and its impact on proportion of population below the international poverty line, making it a challenge to interpret the results.

The statistical analysis has identified a strong negative relationship between the completion rate of upper secondary education (SDG 4.1.2) and the proportion of employed population below the international poverty line (SDG 1.1.1). "Water education is often linked with poverty eradication..." (UNESCO 2009). Skills development, through school learning reduces poverty and unemployment. UNESCO states that "for every one US dollar spent on education, as much as US$ 10 to US$ 15 can be generated in economic growth" (UNESCO 2012). This indicates that an improvement in the completion rate of upper secondary education would mean a decrease in the percentage of employed population below the international poverty line (SDG 1.1.1), reflecting the results of the analysis.

The Red List Index measures the conservation status of all species. Using this index, the statistical analysis identified a negative relationship between SDG 15.5.1 and SDG 1.1.1 on employed population below the international poverty line. In fact, a study looking at research linking biodiversity conservation to poverty alleviations found that the most important attribute of poverty alleviation was the abundance or extent of biodiversity (Roe and Geneletti 2016). This is because biodiversity loss is connected to the loss of ecosystem service provisioning. Whether people are employed or not, biodiversity conservation from the species status perspective impacts poor communities by limiting their access to available food, thus deepening their poverty. Many poor and malnourished communities depend on inland fisheries, that is, freshwater fisheries (McIntyre, Reidy Liermann and Revenga 2016), which is also explained by the negative relationship that suggests an increase in the Red List Index (which translates to a decrease in a species' risk of extinction) might decrease employed population below the international poverty line (SDG 1.1.1).

8 DECENT WORK AND ECONOMIC GROWTH

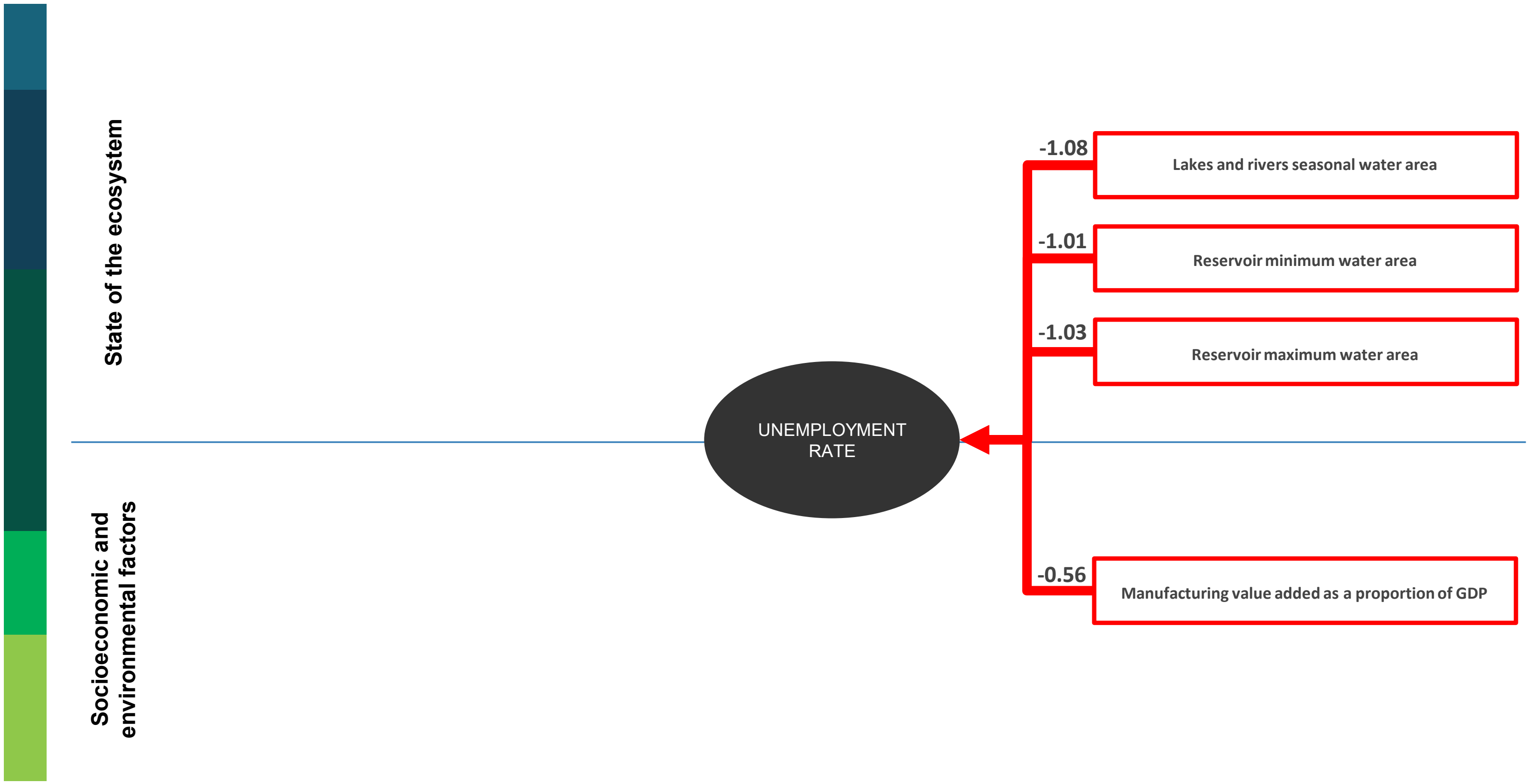
b. SDG 8.5.2 sub-indicator on unemployment rate

SDG 8.5.2 conveys the percentage of unemployed persons in the labour force (all those of working age, usually aged 15 and above). Unemployment reflects the underutilization of a country's labour supply as well as the inability of an economy to generate employment for those persons who want to work but do not or cannot, even though they are available for employment and actively seeking work (UNSD 2022a). Unemployment does not present equally across age and gender. Youth and women, among other groups, are more likely to be unemployed (ILO 2021).

The statistical analysis identified only negative relationships with state of the ecosystem indicators and socioeconomic and environmental factors. For the state of the ecosystem indicators, SDG 6.6.1 sub-indicators on lakes and rivers seasonal water area and reservoirs minimum and maximum water area showed a negative relationship with unemployment rate (SDG 8.5.2). There are two aspects of how water resources are linked to employment. The first aspect is the role of water resource availability in reducing unemployment while the second aspect is about the role of water resources as a sector in providing jobs. For instance, the World Water Development Report 2016 stated that people who have the least access to water and sanitation are usually the most likely to have poor access to health care and stable jobs, thus continuing the cycle of poverty (WWAP 2016). As presented in other sections in this chapter, water resources are necessary to all sectors of the economy, in particular to agriculture, industry and energy. More specifically, water is an essential resource in many industries, and its availability, along with the efficiency of its use, impacts the growth of sectors. This is directly linked to job creation in the economy. It is estimated that three out of four jobs globally depend on water (WWAP 2016). The second aspect of the role of water resources as a sector in providing jobs is presented in the section on employed population below the international poverty line (SDG 1.1.1).

The statistical analysis has also identified a negative relationship between manufacturing value added as a proportion of GDP (SDG 9.2.1) and unemployment rate (SDG 8.5.2). A study in the West Kalimantan Province of Indonesia has identified a positive relationship between manufacturing value added and employment.

Figure 4.6 General model for unemployment rate, global level



The study shows that the higher the value added, the more the manufacturing industries will absorb a proportion of the workforce (Jamaliah 2016). In addition, improvement in manufacturing value added will interest investment, increasing the demand for the goods and services industry. The more the role of manufacturing value added per GDP is reduced, the more significant the role of manufacturing in countries' national economic development becomes (UNSD 2022a). An increase in manufacturing value added as a proportion of GDP (SDG 9.2.1) would lead to a decrease in unemployment rate (SDG 8.5.2), as presented in the results of the statistical analysis.

c. SDGs on malnutrition and undernourishment

An essential macronutrient, water plays a fundamental part in many physiological and metabolic processes. In children, these processes are particularly complex as thirst and thermoregulation develop. For children, the percentage of body water content decreases significantly in the first 2 years of life, from approximately 75 per cent at birth to 55 per cent around puberty.

Not only do the quantity and quality of what is drunk affect health in later life, but also the accessibility of the water itself, as regular hydration alongside nutrition undergirds a healthy and balanced diet. It has recently been shown for the first time that by increasing water intake over a four-day period to 2.5 litres a day significantly improves cognitive flexibility compared with low water intake (0.5 litres a day) in children (Khan et al. 2019). Safe accessible water can also support the growth and development of nutritious foods which in turn can optimize the health of a population.

The health of ecosystems, their quality and integrated management of water resources are closely intertwined with nutritional changes in the population. Access to adequate water sanitation in low- and middle-income countries has been pivotal in reducing infectious diseases among children and in improving food choices. These actions have led to a reduction in the prevalence of diarrhoeal diseases and have helped reduce the prevalence of undernutrition in children. Despite this progress, malnutrition remains a public health challenge across low- and middle-income countries, where overweight and obesity continue to grow, and the reduction of stunting and wasting is slow.

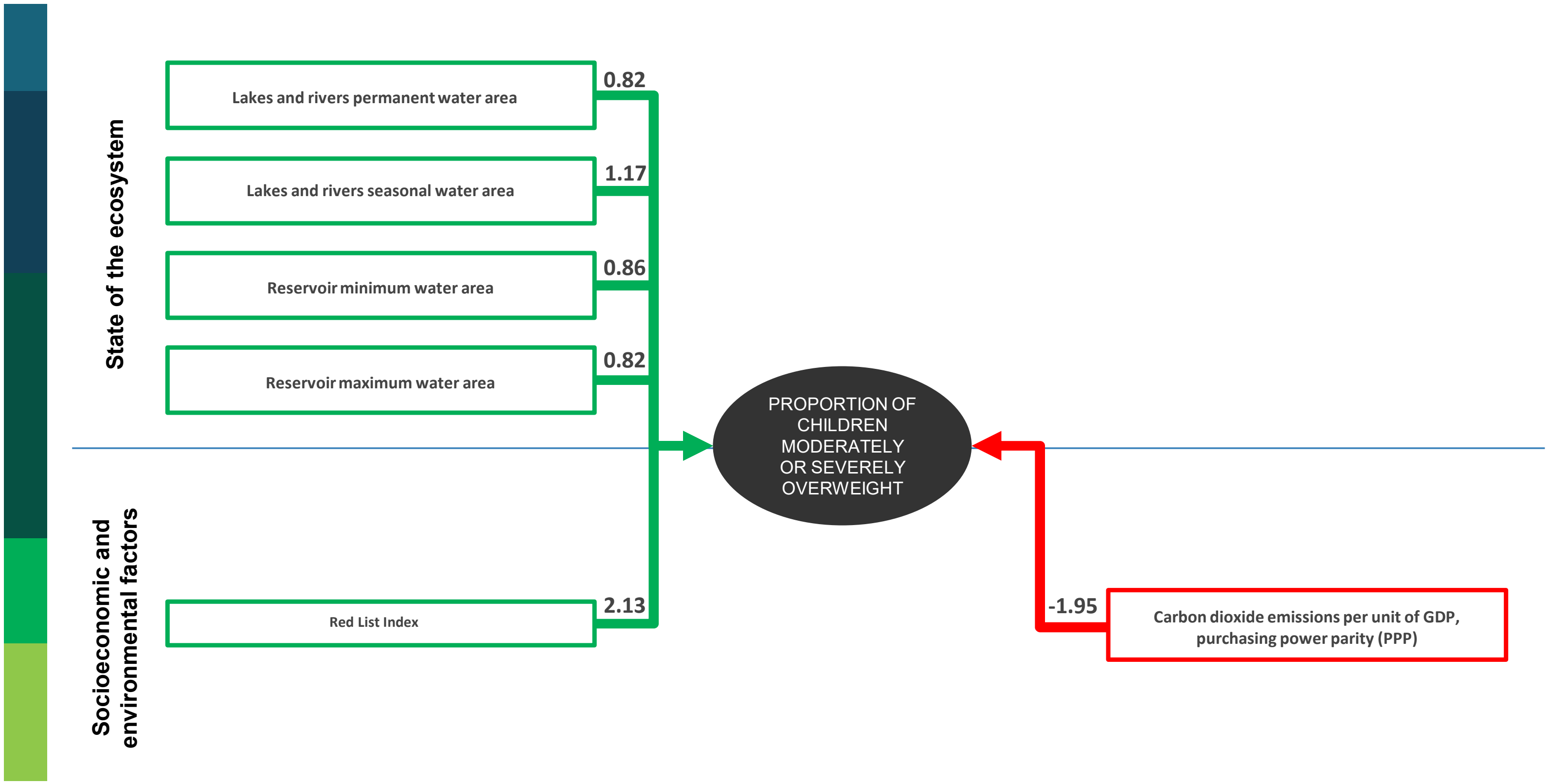
In this context, three indicators are used in the following section to better understand the impact of water resources availability (SDG 6.6.1) and undernourishment and malnutrition. SDG 2.1.1 defines undernourishment as “the condition by which a person has access, on a regular basis, to the amount of food that are insufficient to provide the energy required for conducting a normal, healthy and active life, given his or her own dietary energy requirements” (UNSD 2022b). The SDG 2.2.1 and 2.2.2 malnutrition indicators on children stunting (child is too short for their age) and on the prevalence of overweight (the child is too heavy for their height) are both pertinent, respectively, to undernutrition (WHO 2021) and children’s having too few calories for the amount of consumed food (UNSD 2022b).

As stunted and overweight are different forms of malnutrition (together known as the double burden of malnutrition), the interpretation of the statistical analysis results will be combined. The statistical analysis has identified negative relationships between SDG 6.6.1 on lakes, rivers and reservoirs water area and SDG 2.2.1 on the proportion of children moderately or severely stunted. Water resources, such as lakes, rivers and reservoirs play an essential role in agriculture and food production. The lack of water for crop irrigation or livestock feeding impacts the income of households and reduces their ability to purchase nutrient-dense food (Chase et al. 2019), leading to undernourishment. Freshwater-related ecosystems have a particular impact on undernutrition and significant stunting, possibly due to mediation through protein-energy malnutrition and micronutrient deficiencies arising from food production and nutrient quality in the food supply chain. On the other hand, freshwater resources house varieties of protein-dense fish that can alleviate malnutrition problems (Phosa 2016). Therefore, increased lakes, rivers and reservoirs water area (SDG 6.6.1) could lead to a decrease in the proportion of children moderately or severely stunted (SDG 2.2.1).

In parallel, many low-income and middle-income countries’ dietary habits have changed where nutrient-deficient food has been replacing healthy food – specifically the cheap ultraprocessed food and beverages (Popkin, Corvalan and Grummer-Strwan 2020), which require a significant amount of water to be produced (Garzillo et al. 2022). Though this explains how overweight impacts water resources, it remains challenging to interpret how the increase in water resource availability may lead to an increase in the proportion of children moderately or severely overweight (SDG 2.2.2).

The direct exploitation of organisms has been categorized as the second main direct driver of species extinction (IPBES 2019). The human impact on species’ extinction threat level is accelerating. According to UNEP, “the loss of diverse diets is directly linked

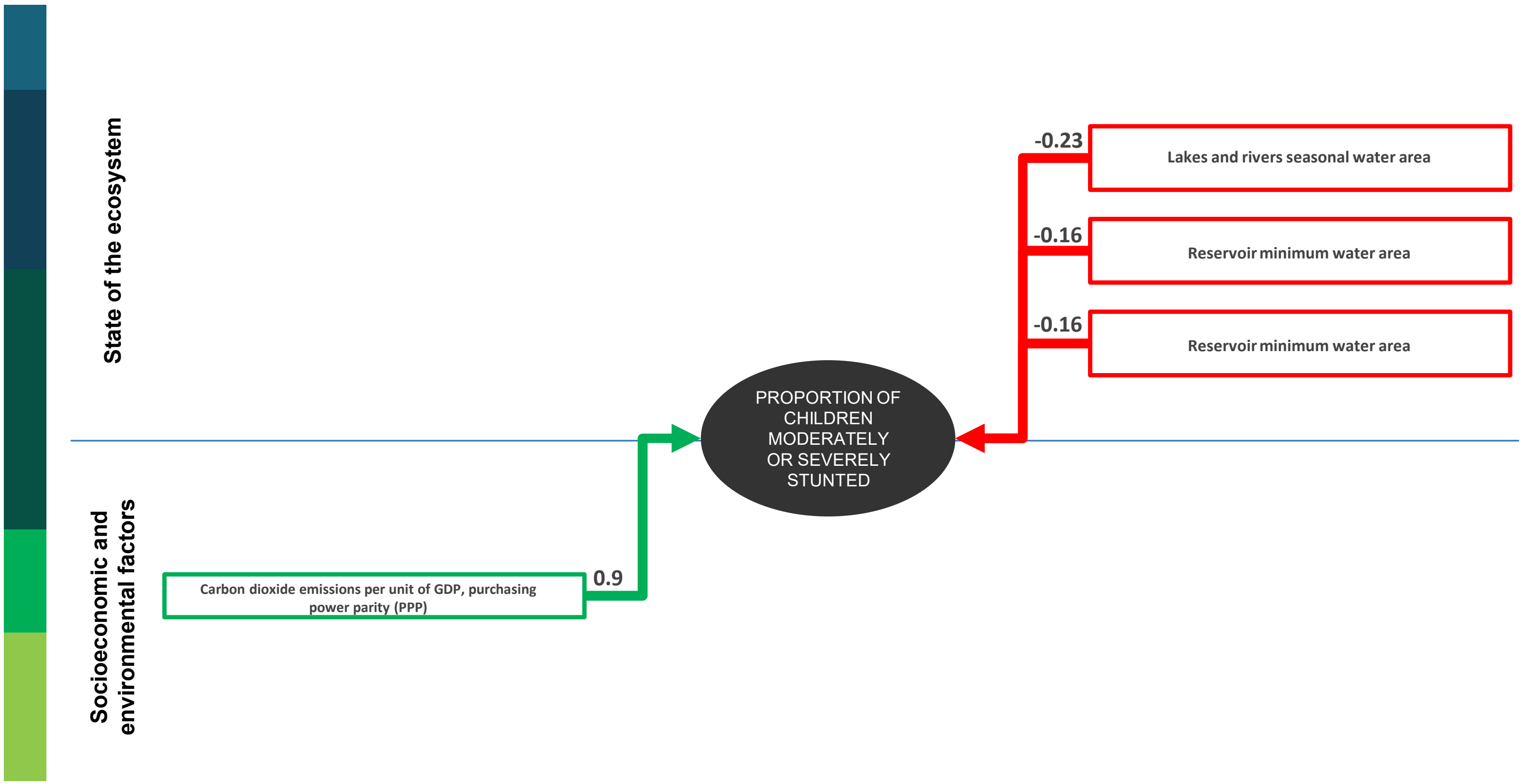
Figure 4.7 General model for the proportion of children moderately or severely overweight, global level



to diseased or health risk factors, such as diabetes, obesity and malnutrition" (UNEP 2019b). Hence, the more species that are at risk for extinction (SDG 15.5.1 on the Red List Index is increasing), the higher the proportion of children moderately or severely overweight (SDG 2.2.2), which reflects the strong positive relationship identified by the statistical analysis.

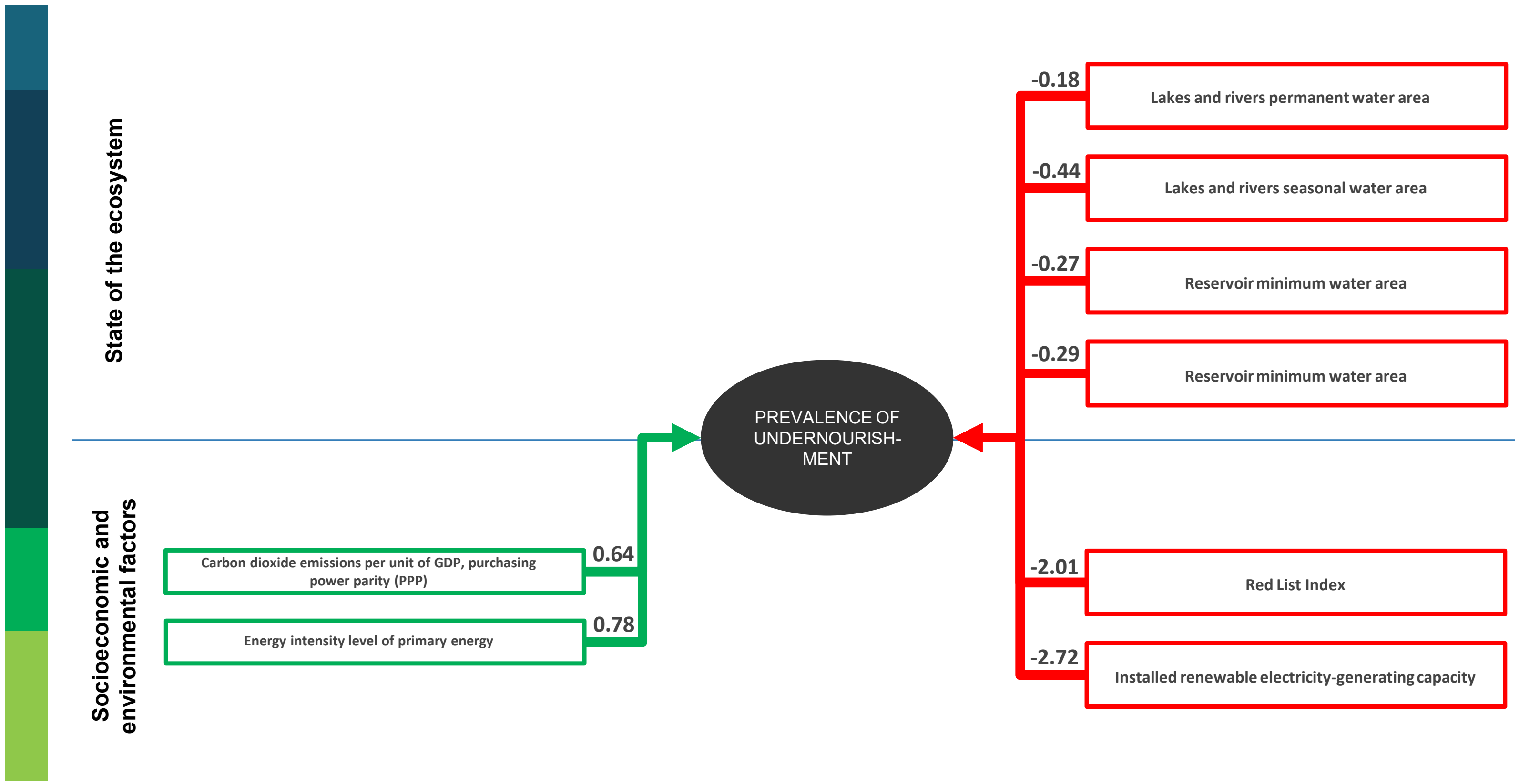
CO_2 emissions per unit of GDP (SDG 9.4.1) is a factor that affects both stunting and wasting on one hand and overweight and obesity on the other. Much research has been done on the impact of increased CO_2 emissions on agricultural production (Springmann et al. 2016), which reduces nutrients in agricultural products (Myers et al. 2014; Ebi and Ziska 2018) and leads to malnutrition. Although research is not extensive on the impact of CO_2 intensity on malnutrition, it may be deduced that, with decreased CO_2 emissions per unit of GDP (i.e. less CO_2 required to produce one economic output), less pressure would be exerted on agricultural production. This is expected to be reflected in a decrease in the proportion of children moderately or severely stunted (SDG 2.2.1) and a decrease in the proportion of children moderately or severely overweight (SDG 2.2.2).

Figure 4.8 General model for the proportion of children moderately or severely stunted, global level



Undernourishment, as previously defined, focuses on the insufficient intake of food for maintaining a healthy and active life. The statistical analysis identified a negative relationship between the SDG 6.6.1 sub-indicators on lakes, rivers and reservoirs water area and on the prevalence of undernourishment (SDG 2.1.1). A study in India in 2019 revealed that maintaining or reducing water use while maintaining cereal production was possible, as the same water quantities were used between 2005 and 2014 and achieved an increase of 26 per cent in cereal production. By shifting cereal production to the dry season and enhancing maize, millet and sorghum production, India was able to maintain or reduce water use (Kayatz et al. 2019). Reducing water use in the agriculture sector helps increase water availability, in turn expanding lakes, rivers and reservoirs water area, while at the same time being able to produce more crops to feed populations and procure sufficient food intake to reduce undernourishment (Mughal and Sers 2020).

Figure 4.9 General model for prevalence of undernourishment, global level



The statistical analysis identified a positive relationship between CO_2 emissions per unit of GDP and the prevalence of undernourishment (SDG 2.1.1). Increased CO_2 emissions were found to negatively impact livestock production systems through their impact on pasture and rangeland quality (biomass and nutritional quality) and quantity (Mbow et al. 2019). Therefore, an increase in CO_2 emissions per unit of GDP (SDG 9.4.1) may imply an increase in the prevalence of undernourishment (SDG 2.1.1) (Mbow et al. 2019).

The statistical analysis identified a positive relationship between the energy intensity level of primary energy (SDG 7.3.1) and prevalence of undernourishment (SDG 2.1.1) as well as a negative relationship between installed renewable electricity-generating capacity (SDG 7.b.1) and prevalence of undernourishment (SDG 2.1.1). Electricity and energy are essential factors in the value chain of food production and utilization, which comprises production domains of different types of food, post-harvest processing, food storage and transformation, transport, distribution and preparation, among other processes (Candelise, Saccone and Vallino 2021).

More specifically, rural areas' access to off-grid renewable energy technologies can lead to agricultural development through increasing productivity, efficiency and food products storage. The increased access to electricity (increasing the installed renewable electricity-generating capacity) leads to improved levels of food security and a decrease in prevalence of undernourishment (Candelise, Saccone and Vallino 2021). Moreover, carbon-intensive electricity production carries a negative impact on the prevalence of undernourishment (Raiten and Combs 2019; Shah, Dulal and Awojobi 2019). This can be interpreted as: the higher the energy intensity level of primary energy (SDG 7.3.1), the higher the prevalence of undernourishment (SDG 2.1.1).

As previously presented, the more species that are at risk of extinction, the more negative the impact on children's nutrition and health becomes. The results of the statistical analysis reinforce this argument, as a decrease in the risk of species going extinct may cause a decrease in the prevalence of undernourishment (SDG 2.1.1).

d. Conclusion

Malnutrition and undernourishment were shown to be strongly impacted by SDG 7.b.1 on installed renewable electricity-generating capacity and by SDG 9.4.1 on CO_2 emissions per unit of GDP, and less strongly by water resources. As these indicators impact the provision, quality, access, storage and utilization of food products, they exert significant impact on malnutrition and undernourishment. Therefore, targeted policies that consider these indicators could play an essential role in reducing malnutrition and undernourishment.

Employed population below the international poverty line (SDG 1.1.1) was strongly impacted by completion rate of upper secondary education (SDG 4.1.2) and CO_2 emissions per unit of GDP (SDG 9.4.1). The first indicator focuses on improved education, showing no uncertainty about the impact that improved education has on financial status and livelihood. With mounting evidence of the impact of CO_2 emissions on people's health, limiting or reducing CO_2 emissions requires financial and emissions policies to call for more efficient and stricter regulation in countries' economic sectors.

Unemployment rate (SDG 8.5.2) was found to be negatively impacted by lakes, rivers and reservoirs water area (SDG 6.6.1). As most jobs are found in water-intensive sectors, be they energy production, manufacturing or agriculture, and due to the limited water resources that are available on the planet, these sectors are focusing on exploring new technologies that are less water intensive. Hence, appropriate policies that encourage sectors to be less water dependent (financial incentives or taxation), yet simultaneously have in place regulatory systems to limit the use of water in these sectors, could be impacting jobs and water resources positively.

4.2 Interlinkages analysis of freshwater-related indicators at national level

4.2.1 Colombia

Colombia, a country in north-west South America, encompasses 1,600 km of northern coastline that borders the Caribbean Sea, and 1,300 km of western coastline that borders the Pacific Ocean. The population is largely concentrated in the mountainous interior, where Bogotá, the national capital, sits a high plateau in the northern Andes Mountains (Anselm, Brokamp and Schutt 2018). Colombia is considered one of the most water-rich countries in the world, whose water resources include mountain lakes, deep-lying aquifers, streams, rivers and the water emanating from the Páramos wetlands (WB 2020a). However, there is a misconception between freshwater availability and water demand mainly because of the lopsided geographical distribution of Colombia's water, with most freshwater aquifers being located in the Amazon Basin where

Map 4.1 Official map of Colombia (United Nations, 2022)

the population is sparse (OECD/ECLAC 2014). Colombia has the most diverse bird species in the world, with over 1,900 species (Renjifo, Amaya-Villarreal and Butchart 2020).

Access to safely managed drinking water (i.e. water from improved sources that are accessible on premises, available when needed and free from faecal and chemical contamination) has slowly been increasing in Colombia. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater and packaged or delivered water. As of 2020, approximately 73 per cent of Colombia's population have access to such water. Urban water supply coverage is still far more extensive (80 per cent of urban population) than rural water supply coverage (40 per cent of rural population), and even for many of those in rural areas with access to water supply, water quality is so low that the supply is not potable (WB 2020a). Women are often disproportionately impacted by environmental issues due to their social and economic vulnerabilities and having less access to economic resources, education and legal rights (UNEP 2020).

For example, women in Colombia often rely on agriculture and fishing as sources of income, and environmental degradation can significantly impact these sectors.

4.2.1.1 Impact of drivers of change on the state of freshwater-related ecosystems

a. SDG 6.6.1 sub-indicators on lakes and rivers water area (permanent and seasonal)

The SDG 6.6.1 sub-indicators covering lakes and rivers water area, whether permanent or seasonal, are tested in this section to provide better insight from a national perspective on the relationship between drivers of change and socioeconomic and environmental factors. Based on Colombia's data, lakes and rivers permanent water area increased from 2000 to 2013 and then decreased until 2019 to lower values than 2001 data. The lakes and rivers seasonal water area, however, show an increasing trend since 2000.

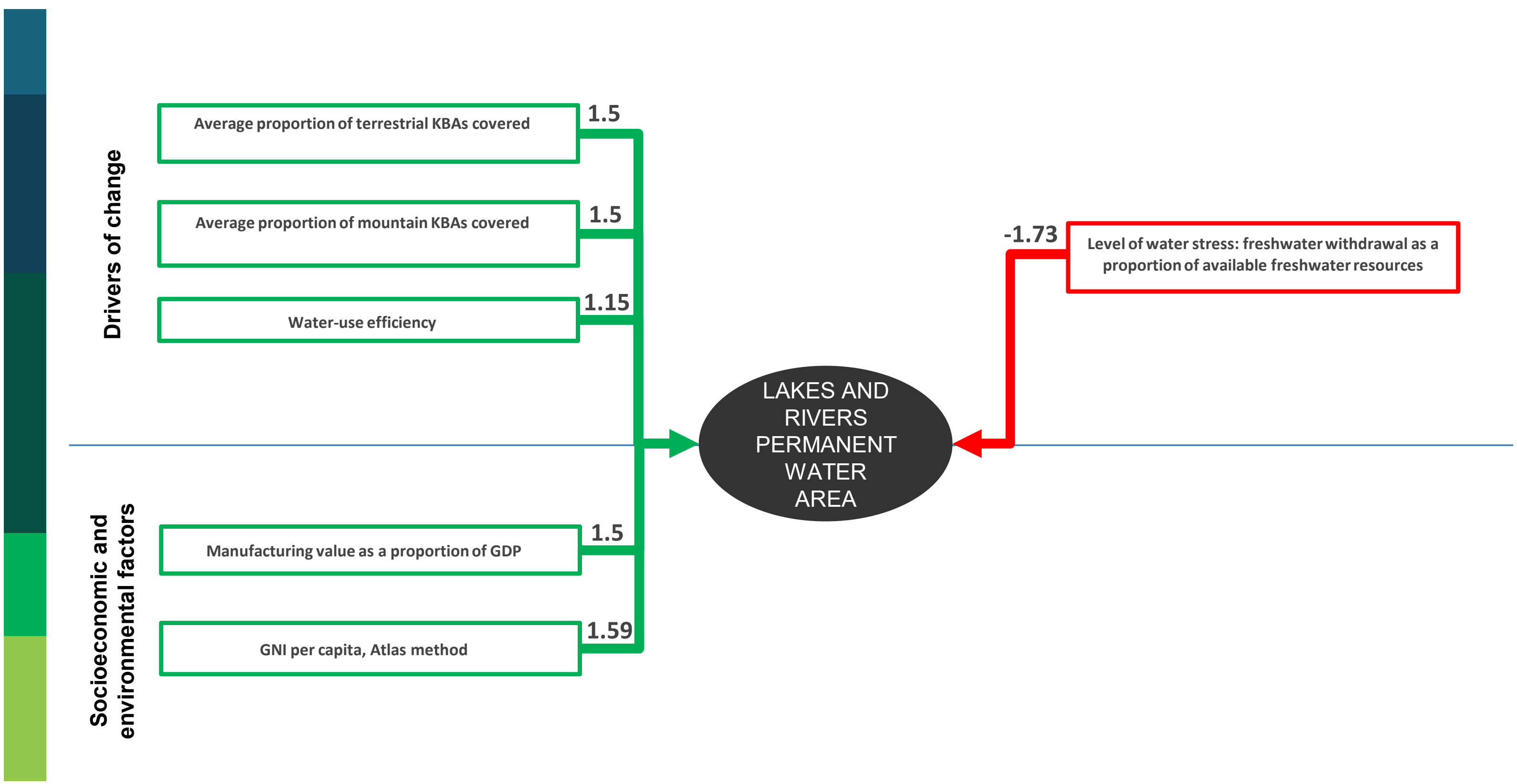
The following show a similarly increasing trend since 2000:

- SDG 1.4.1 on proportion of population using basic drinking water services
- SDG 6.1.1 on proportion of population using safely managed drinking water services
- SDG 15.1.2 on average proportion of freshwater KBAs covered by protected areas
- SDG 15.1.2 on average proportion of terrestrial KBAs covered by protected areas
- SDG 15.4.1 on average proportion of mountain KBAs covered by protected areas
- SDG 6.4.2 on level of water stress (freshwater withdrawal as a proportion of available freshwater resources) and GNI per capita

In comparison with the statistical analysis results obtained in the global section, SDG indicators 15.1.2 and 15.4.1 on the average proportion of terrestrial KBAs and mountain KBAs, respectively, show a strong positive relationship with lakes and rivers permanent and seasonal water area (SDG 6.6.1). Terrestrial KBAs and mountain KBAs play an important role in the conservation and maintenance of their respective ecosystems, which promotes the function of water conservation in the headwaters of rivers and lakes as well as the stability and continuous expansion of the permanent water area of rivers and lakes (Anselm, Brokamp and Schutt 2018; Rodriguez, Armenteras and Retana 2015; Ruiz Toro et al. 2020). On the other hand, the SDG 15.2.1 sub-indicator on average proportion of freshwater KBAs covered by protected areas only shows a strong positive relationship with lakes and rivers seasonal water area (SDG 6.6.1), and a non-statistically significant relationship with lakes and rivers permanent water area (SDG 6.6.1).

The statistical analysis has shown a strong negative relationship between SDG 6.4.2 on water stress and lakes and rivers permanent water area (SDG 6.6.1). It is certain that an increase in water

Figure 4.10 General model for lakes and rivers permanent water area, Colombia



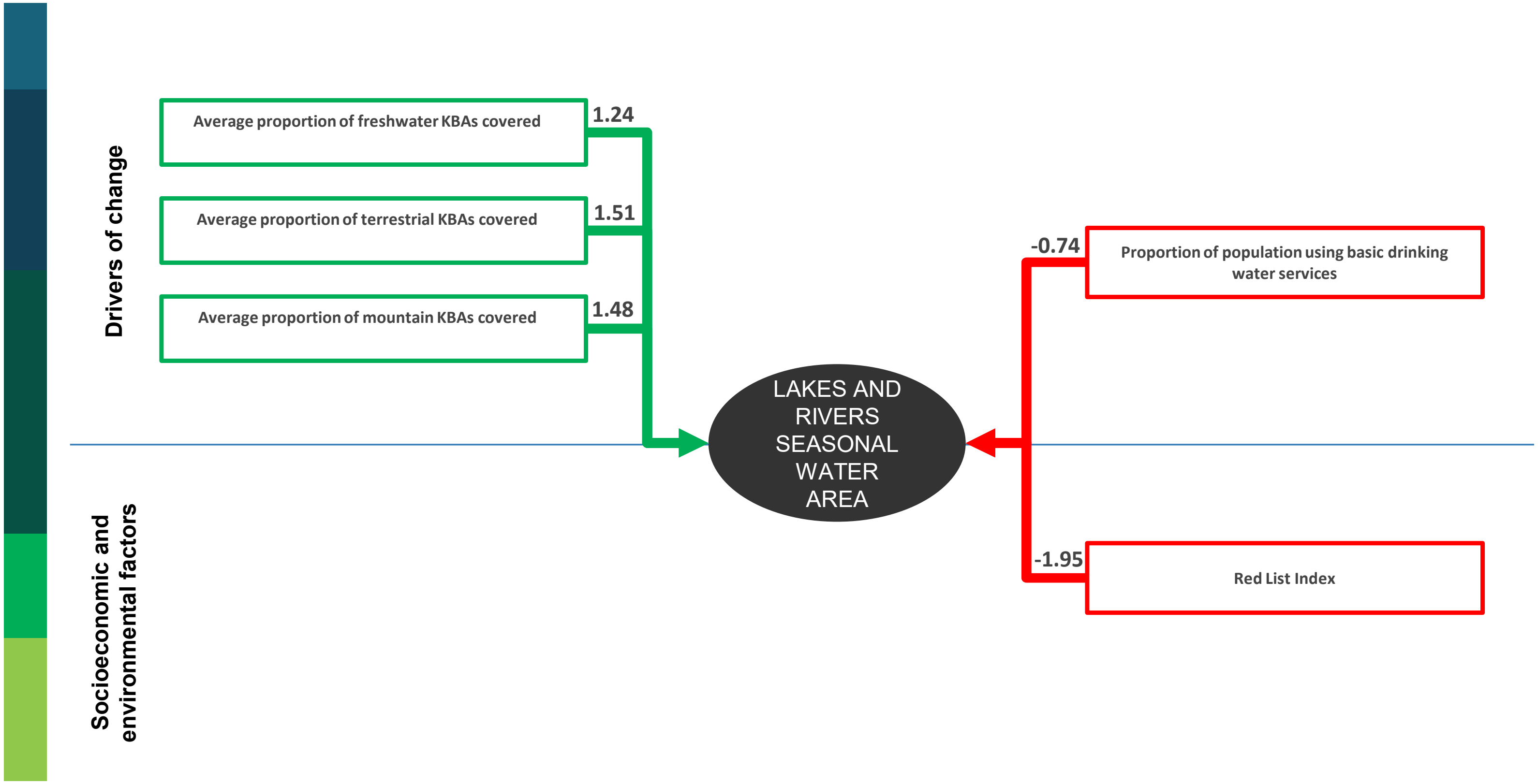
stress, which represents the proportion of withdrawal of available freshwater resources, will lead to a decrease in lakes and rivers water area, as the extracted water comes from these resources, which can be seen in the decreased water area. Because of Colombia's fast economic growth, there are significant plans for agro-industrial expansion, which may seriously affect water availability (Pimentel, Prada and Walschburger 2021). In contrast to water stress, SDG 6.4.1 on water-use efficiency has shown to have a strong positive relationship with lakes and rivers permanent water area (SDG 6.6.1). Using the International Standard Industrial Classification (ISIC) of All Economic Activities, the indicator measures the unit of economic output for each cubic metre of water at three sectoral levels: (a) agriculture (ISIC A), (b) industry including power production (ISIC B, C, D and F) and (c) services (ISIC E and ISIC G–T), meaning that the higher the water-use efficiency of any sector, the less water is required to generate the same economic output. This decreases the need to withdraw water from permanent lakes and rivers to supply the sectors, which leads to an increase in lakes and rivers permanent water area (SDG 6.6.1), and vice versa.

While the evidence in the global section shows a negative relationship between GNI per capita and lakes and rivers permanent water area (SDG 6.6.1), Colombia sees a positive relationship. Although an increase in GNI per capita would generally lead to an increase in water consumption and extraction, this can differ in a territory where vast water resources are available and population is sparse, as with Colombia.

The increase in manufacturing value added as a percentage of GDP (SDG 9.2.1) refers to the expansion of the manufacturing sector as part of the economy. The more this sector expands, the more natural and other resources are needed. Unless an increase in manufacturing value added as a proportion of GDP (SDG 9.2.1) is based on environmentally sound practices (that lead to the expansion of the manufacturing sector), its relationship with lakes and reservoirs permanent water area (SDG 6.6.1) is expected to be negative.

As discussed in the global section, the relationship between proportion of population using basic drinking water services (SDG 1.4.1) and lakes and rivers seasonal water area (SDG 6.6.1) is expected to be negative, as the allocation of more water to the population will lead to a decrease in water area. This is the case in Colombia, where its data inform that the proportion of population using basic drinking water services has been constantly increasing since 2000.

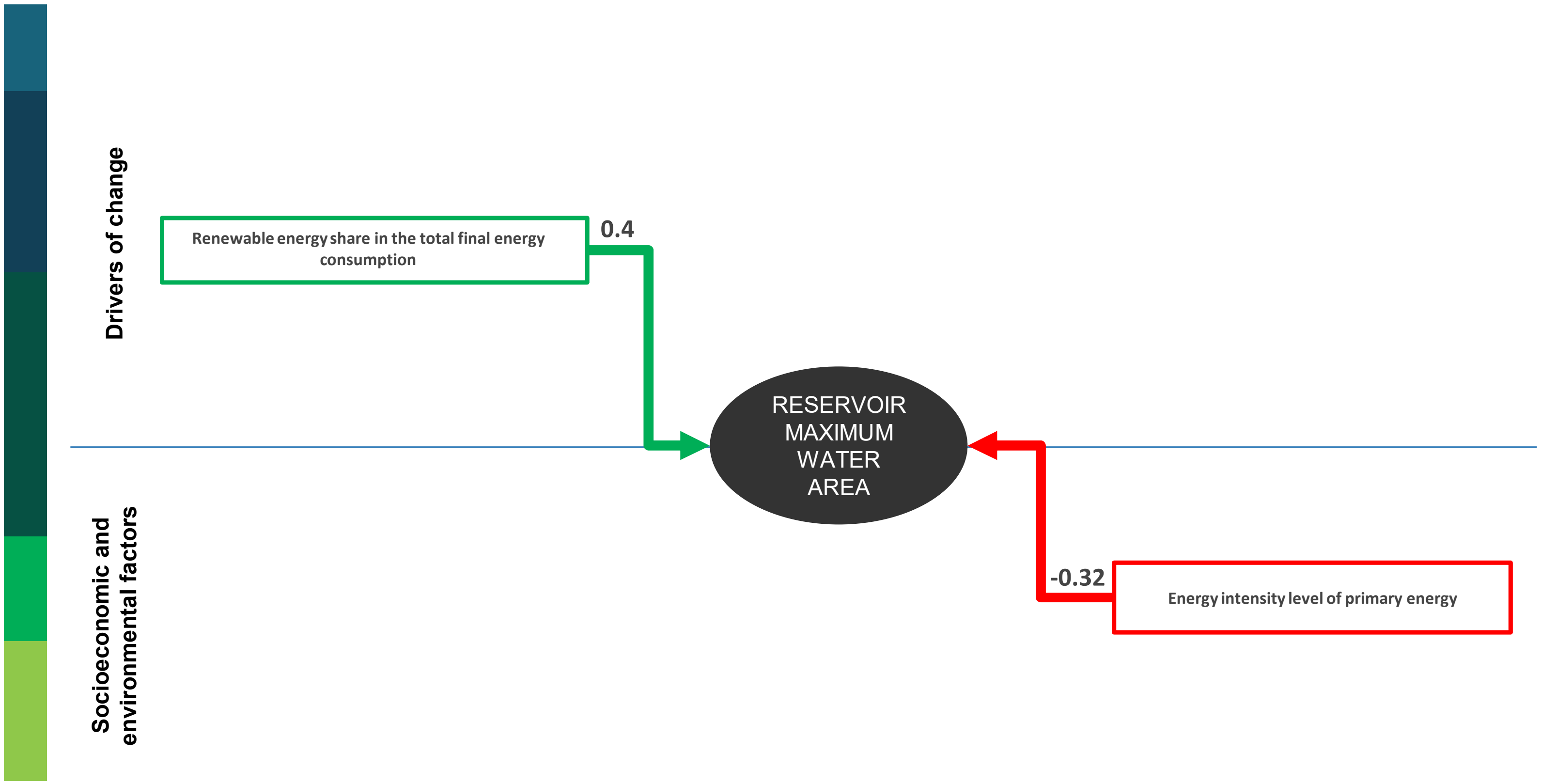
Figure 4.11 General model for lakes and rivers seasonal water area, Colombia



b. SDG 6.6.1 sub-indicators on reservoirs water area (minimum and maximum)

The statistical analysis has identified a positive relationship between the renewable energy share in the total final energy consumption (SDG 7.2.1) and reservoir minimum and maximum water area (SDG 6.6.1). Colombia's energy mix had renewables at almost 23 per cent in 2019. Of that 23 per cent, around 11 per cent originated from hydropower electricity. More water storage is needed to operate upstream hydroelectric power plants, which increases the reservoirs water area (He et al. 2019). As presented in the lakes and rivers section, the increase in renewable energy capacities and generation is beneficial for water resources, which explains the positive relationship with reservoirs minimum and maximum water area. In addition, the negative relationship between SDG 7.3.1 on energy intensity level of primary energy and SDG 6.6.1 on reservoirs minimum and maximum water area results from the less water required when energy intensity is improved (lower energy requirement to produce one unit of output), especially for energy sources such as fossil fuels and nuclear energy (Sarkodie and Owusu 2020; D'Odorico et al. 2018; Scanlon et al. 2017).

Figure 4.12 General model for reservoirs maximum water area, Colombia



As presented in the section on lakes and rivers, indicators related to preservation of the surrounding environment of water resources play an important role in water conservation. This is also confirmed by the positive relationship between the average proportion of freshwater KBAs covered (SDG 15.1.2) and average proportion of mountain KBAs covered (SDG 15.4.1) with reservoir minimum water area (SDG 6.6.1).

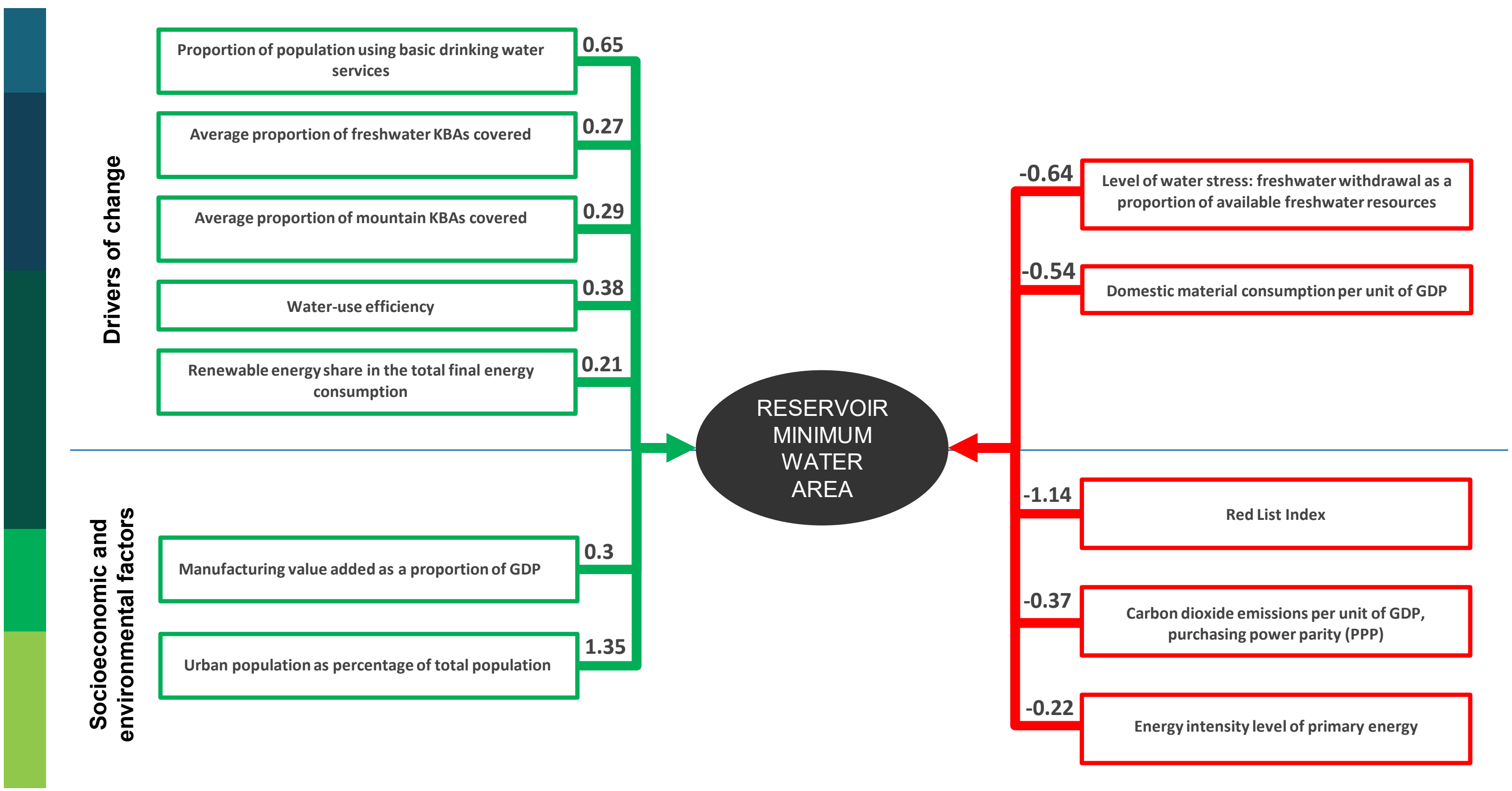
The statistical analysis identified strong positive relationships between (a) urban population as percentage of total population, (b) proportion of population using basic drinking water services (SDG 1.4.1) and (c) water-use efficiency (SDG 6.4.1) and reservoir minimum water area (SDG 6.6.1). As more people move to cities (increase of urban population as percentage of total population), the water service providers of those cities will become more efficient in water delivery, for example by reducing water loss in networks (Campuzano Ochoa et al. 2015; Mahjabin et al. 2018). This would lead to a higher proportion of population using basic drinking water services and increased water-use efficiency in the residential sector as well as contribute to the consumption of fewer water resources, including reservoirs water area (SDG 6.6.1).

As presented in Colombia's lakes and rivers water area section, its level of water stress carries a negative impact on water resources. From this it can be concluded that a higher level of water stress coincides with fewer water resources available and quantities that can be stored (e.g. reservoirs) and vice versa (Weber et al. 2017).

The statistical analysis has identified a negative relationship between domestic material consumption per unit of GDP (SDG 8.4.2/12.2.2) and reservoir minimum water area (SDG 6.6.1). The higher the domestic material consumption per unit of GDP is, the less efficient processes become, requiring more water.

The statistical analysis shows a positive relationship between manufacturing value added as a proportion of GDP (SDG 9.2.1) and reservoir minimum water area (SDG 6.6.1). As presented in the global section, the increase of manufacturing value added as a proportion of GDP, coupled with environmentally sound practices to support the expansion of the sector might require

Figure 4.13 General model for reservoir minimum water area, Colombia



fewer natural resources. In Colombia in 2021, the agribusiness sector represented 7.4 per cent of the value added as proportion of GDP (UNSD 2022c). In response to climate change in the country, ecosystem-based adaptation methods in the agriculture sector – coupled with political will and policy coherence – are improving the resilience to vulnerable farmer communities (WRI 2022). On the other hand, the negative relationship between CO_2 emissions per unit of GDP (SDG 9.4.1) and reservoirs water area (SDG 6.6.1) is driven by improved efficiencies, as presented in the global section.

c. Conclusion

Colombia's analysis has shown a strong positive relationship between biodiversity conservation and water resources. Being the second-most biodiverse country on Earth, the Colombian Government developed the Biodiversity Action Plan (2016–2030) to implement the National Policy for the Integral Management of Biodiversity and its Ecosystem Services. This action plan to conserve biodiversity is aligned with the national policy for the integrated management of water resources, among other national policies that centre the conservation of biodiversity and threatened species and ecosystem restoration, among others (MESD 2017). These conservation efforts combined show the significance of such identified relationship to the national context.

In addition, water-use efficiency indicators show a strong positive relationship with water resources. In 2010, Colombia adopted its policy on integrated water resources management, which, in addition to water resource management, focuses on the efficiency of use and evidence-based decision-making, among other targets (OECD 2020). Water resource management in Colombia is community-based; water is a fundamental human right there, and legal instruments are in place to ensure community participation in management and decision-making (Fromherz and Lyman 2021). The strongest negative relationship was identified between the level of water stress and water resources, which is expected to be monitored closely due to the country's agro-industrial expansion.

4.2.1.2 State of the freshwater-related ecosystems' impact on the state of human well-being

In this section, SDG 6.1.1 on proportion of population using safely managed drinking water services is considered as the dependent variable, hence the section will present the impact of the state of the ecosystem and socioeconomic and environmental factors on the proportion of population using safely managed drinking water services.

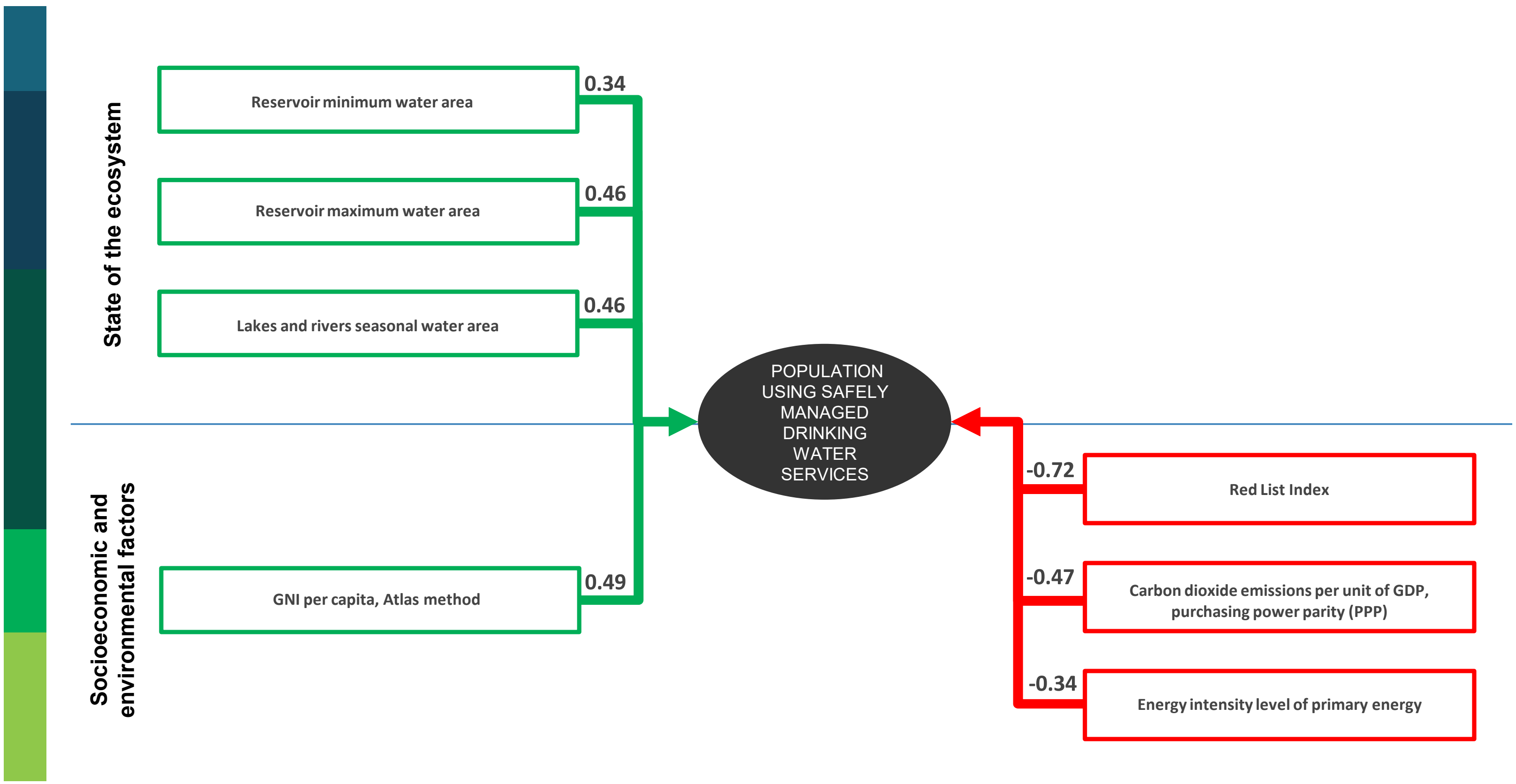
a. SDG 6.1.1 sub-indicator on proportion of population using safely managed drinking water services

The seasonal water area of freshwater lakes and rivers as well as that of reservoirs (SDG 6.6.1) has a positive relationship with the proportion of population using safely managed drinking water services (SDG 6.1.1). A 0.46 per cent increase in the proportion of population in Colombia using safely managed drinking water services is directly related to an increase of 1 per cent in the seasonal water area of lakes and rivers (SDG 6.6.1). Similarly, when reservoirs minimum and maximum water area (SDG 6.6.1) increase, so too does the proportion of population using safely managed drinking water services (SDG 6.1.1).

Colombia's alpine wetlands, or páramos, provide essential ecosystem services in the regulation of the country's hydrological cycle (OECD/ECLAC 2014; WB 2020a). They are also the source of major rivers in the country including the Cauca, the Magdalena and the Meta. Around 70 per cent of the Colombian population's water supply originates from the páramos. For example, the páramos in the Chingaza National Park, Sumapaz Páramos and Cruz Verde supply water to Bogotá (OECD/ECLAC 2014). Payment by the Bogotá water utility to the Chingaza National Park helps to protect this habitat and secure most of the supply of good-quality drinking water to Bogotá, as well as some of the water supply for the country's hydropower generation (OECD/ECLAC 2014). The Belmira páramo supplies water to Medellín, and the Santurbán páramo supplies water to Bucaramanga (OECD/ECLAC 2014). Mining operations and growing agricultural activities threaten much of the páramos, which Colombia's population depends on for freshwater. A decrease in the area of these sensitive and unique freshwater ecosystems will carry significant implications for the future of drinking water services in Colombia (WB 2020a).

Around 24 per cent of Colombia's freshwater-related ecosystems show transformations caused by urbanization, agriculture expansion, cattle ranching and infrastructure development (WWF-Colombia 2017). Future water yield will largely be determined by land usage and the impact of climate change. Data indicate that Colombia will be unable to sustain the hydrological functionality of watersheds without safeguarding forest, water and coastal ecosystems via the designation and effective management of key protected areas (Valenzuela 2022). This would not only protect biodiversity, but also support ecosystem services such as water provision and climate regulation, enhancing community well-being.

Figure 4.14 General model for population using safely managed drinking water services, Colombia



There is a positive relationship between GNI per capita and proportion of population using safely managed drinking water (SDG 6.1.1). As presented in the global section, an increase in national income per capita leads to improvements in people's lifestyles and their abilities to afford and access improved water sources and services. Access to clean drinking water and sanitation reduces health risks and frees up time for education and other productive activities.

The statistical analysis implies a negative relationship between SDG 15.5.1 on the Red List Index and SDG 6.1.1 on the proportion of population using safely managed drinking water services. Such a relationship is challenging to interpret, because the proportion of population using safely managed drinking water services typically affects the extinction level of various species. The building of infrastructure and the withdrawal or diversion of water to attend to population needs for drinking water causes species to decrease. In addition, due to the expansion of illicit crops and mining activities, freshwater-related ecosystems have deteriorated, and species including game birds, predatory birds, parrots and large frugivores have become the most threatened in the high Andean Forest páramo (Renjifo, Amaya-Villarreal and Butchart 2020).

There is a significant negative relationship between CO_2 emissions per unit of GDP (SDG 9.4.1) PPP and proportion of population using safely managed drinking water services (SDG 6.1.1). Lower CO_2 emissions per unit of GDP PPP implies less CO_2 emitted per unit of GDP. This relationship could result from Colombia's heavy reliance on hydropower, which causes CO_2 emissions from fuel combustion to be lower per unit of GDP (OECD/ECLAC 2014). Since drinking water supply requires energy, greater use of hydropower would ensure a lower level of CO_2 emitted.

The share of the energy intensity from fossil fuels in Colombia is slowly decreasing. While this indicates improvement in energy efficiency, especially for the production of energy from fossil fuels, the water requirement to produce one unit of output is reduced, that is, less quantity of water used from lakes and rivers. This negative relationship is visible in Colombia.

b. Conclusion

With the páramos providing over 70 per cent of the drinking water in Colombia, their protection is essential. Land-use changes, specifically those caused by mining and illicit agriculture, are upsetting the delicate ecosystem services that the páramos provide. As water supply is intricately linked with the health of water-related ecosystems, it is essential that Colombia maintain a sustainable balance between the protection of ecologically importance water sheds and socioeconomic growth opportunities.

4.2.2 Mongolia

Located in Eastern Asia, Mongolia is one of the largest landlocked countries in the world, with a land area of around 1.56 million km^2 (Government of Mongolia 1997). Its remarkable variety of terrains consists of upland steppes, semi-deserts and deserts, while in the west and north of the country, forested high-mountain ranges alternate with lake-dotted basins. Most of Mongolia is a plateau, with an average elevation of about 1,580 metres above sea level. The highest peaks feature in the Mongolian Altai Mountains (Mongol Altain Nuruu) in the south-west, a branch of the Altai Mountains system. Some three quarters of Mongolia's land area comprise pasturelands, which support the immense herds of grazing livestock. Freshwater-related ecosystems belong to the three major drainage systems of Central Asia: the Arctic Drainage Basin, Amur River's drainage basin and the Central Asian Internal Drainage Basin (Lebedeva et al. 2020). The country's population is unevenly distributed, with most living in the central and northern regions where socioeconomic activities are concentrated. The southern region, where large mining activities are carried out, is the least populated. The capital city Ulaanbaatar is home to almost

Map 4.2 Official map of Mongolia (United Nations, 2022)

half the country's population. The rapidly intensifying effects of climate change are having a profound impact on the lives of people in Mongolia, especially girls and women, as they often rely on pastoralism and agriculture as sources of income (UN WOMEN 2022b).

Although Mongolia contains plentiful water resources, they are unevenly distributed across the land and seasons. Large freshwater lakes and major rivers are found in the northern and western regions of the country. The southern region, where arid and desert ecosystems dominate with little rainfall, relies mainly on groundwater resources for drinking water supplies, livestock and mining. In recent decades, freshwater-related ecosystems in Mongolia have experienced remarkable lake shrinkage due to intensifying human activity and climate change (Hasumi, Hongorzul and Terbish 2011; Liu et al. 2022; Shinneman et al. 2010; Yadamsuren et al. 2020). The endorheic lakes have also been threatened by both salinization and eutrophication (Tang et al. 2021), namely the Great Lakes region of western Mongolia. Encompassing a diversity of lake ecosystems, from alpine freshwater to lowland salt lakes, this region increasingly faces environmental threats from excessive grazing and climate change (Bouchard, Hayford and Ferrington 2022).

Mongolia has made progress in water and sanitation. Nonetheless, providing access to safe drinking water for the entire population remains a challenge. At the national level, 88 per cent of the total population in 2020 had access to improved drinking water sources, but only 30 per cent had access to safely managed drinking water (UN n.d.b). Access to water and sanitation varies geographically and socially. Several programmes on adequate housing, implemented by the government since 2006 (SHC of Mongolia 2022), have resulted in the provision of access to safe drinking water for thousands of additional households in Ulaanbaatar and in provinces.

4.2.2.1 Impact of drivers of change on the state of freshwater-related ecosystems

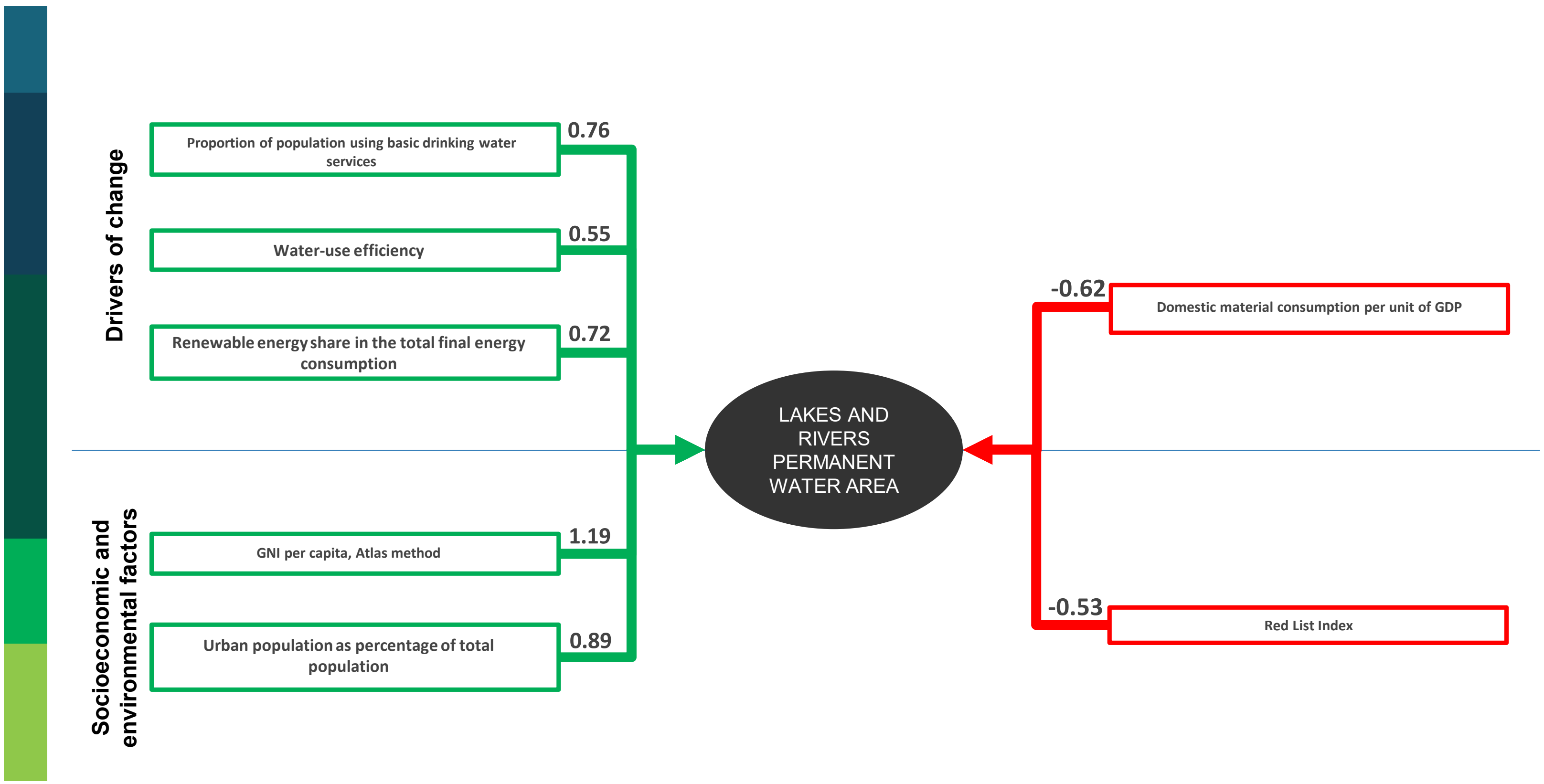
6 CLEAN WATER AND SANITATION

a. SDG 6.6.1 sub-indicators on lakes and rivers water area (permanent and seasonal)

Between 2000 and 2019, SDG 6.6.1 sub-indicator on lakes and rivers permanent and seasonal water area show an increasing trend. Data for SDG 1.4.1 on proportion of population using basic drinking water services, SDG 6.4.1 on water-use efficiency, GNI per capita and urban population as percentage of total population have shown an increase since 2000. On the other hand, SDG 7.2.1 on renewable energy share in the total final energy consumption, SDG 7.3.1 on energy intensity level of primary energy, SDG 8.4.2/12.2.2 on domestic material consumption per unit of GDP, SDG 9.4.1 on CO_2 emissions per unit of GDP and SDG 15.5.1 on Red List Index have exhibited a decreasing trend since 2000.

The statistical analysis reveals a positive relationship between SDG 6.6.1 sub-indicators on lakes and rivers permanent and seasonal water area and (a) SDG 1.4.1 on proportion of population using basic drinking water services, (b) urban population as percentage of total population. In Mongolia, 80 per cent of water supply originates from groundwater due to the cold climate that freezes surface-water area during winter (Dandar 2017). Moreover, the central and northern regions of the country are the most populated, making the reliance on groundwater for water supply imperative, as lakes and rivers permanent or seasonal water area would not receive significant pressure from the increase in urban population or the proportion of population using basic drinking water services. SDG 6.4.1 on water-use efficiency has shown to have a positive relationship with lakes and rivers permanent and seasonal water area (SDG 6.6.1). As this is an efficiency indicator of which data for Mongolia indicate improvement for agriculture and industry water efficiencies (FAO n.d.), which remain the two largest water-consuming sectors in Mongolia, this may imply a positive impact on the water area of lakes and rivers, whether permanent or seasonal.

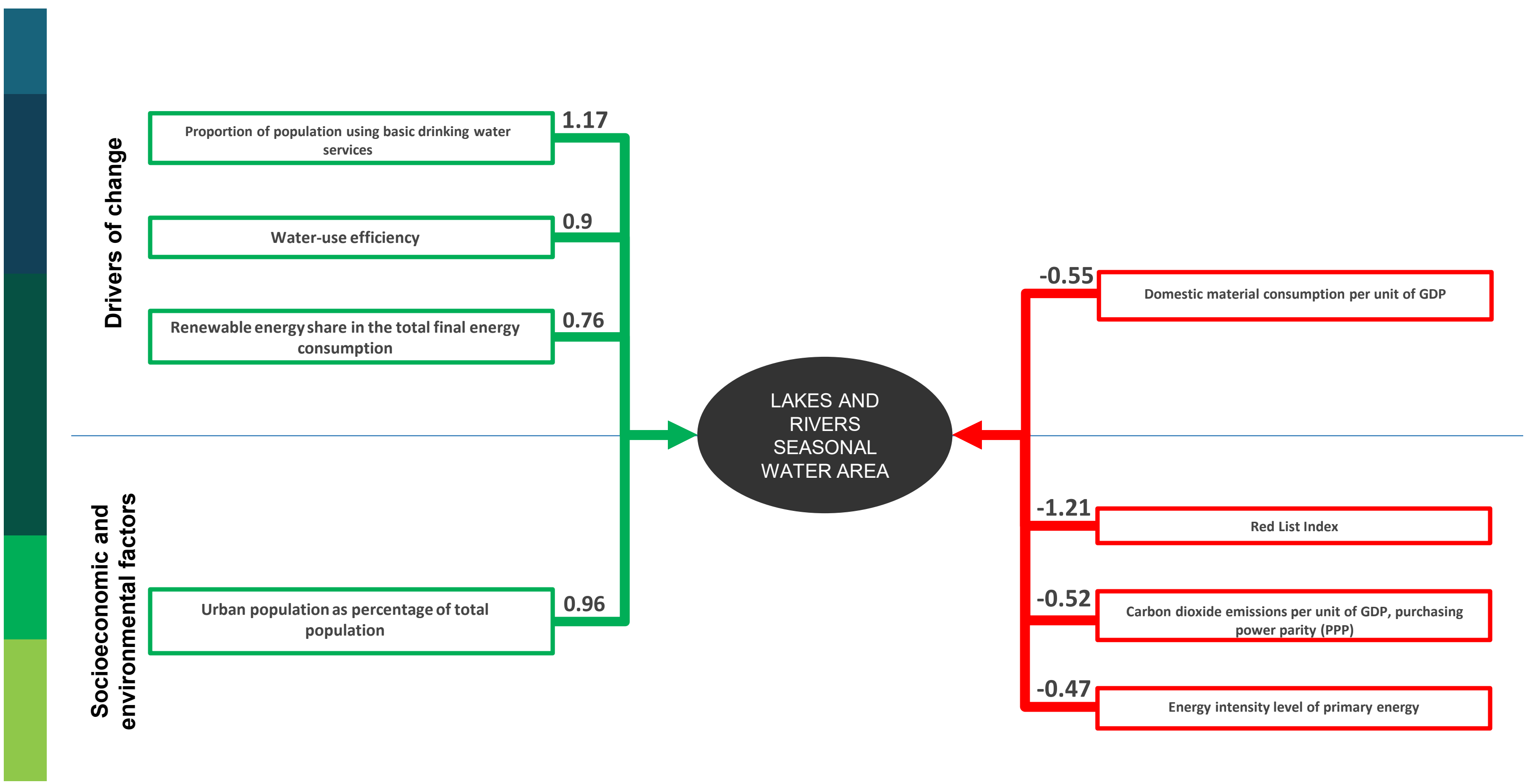
Figure 4.15 General model for lakes and rivers permanent water area, Mongolia



The statistical analysis has indicated a positive relationship between SDG 7.2.1 on renewable energy share in the total final energy consumption and lakes and rivers permanent and season water area (SDG 6.6.1). In Mongolia, most of the energy generated in the country is based on coal, given its richness in natural resources. The current and future decommissioning of some plants, the nation's growing electricity demand and the high level of air pollution from coal energy production have led the Government of Mongolia to shift to renewable energies, against the backdrop of a 2.6 terra-watt potential for the country (IRENA 2016). The Government has committed to increasing the share of renewable energy nationwide to 30 per cent by 2030 by exploiting wind and solar energies in the Gobi Desert region (IRENA 2016). Given that coal energy production is extremely water intensive (Luo et al. 2014), the shift from energy produced by coal to wind and solar impacts positively lakes and rivers permanent and seasonal water area (SDG 6.6.1).

The statistical analysis indicates a negative relationship between SDG 8.4.2/12.2.2 on domestic material consumption per unit of

Figure 4.16 General model for lakes and rivers seasonal water area, Mongolia



GDP and SDG 6.6.1 sub-indicators on lakes and rivers permanent and seasonal water area. In Mongolia, domestic material consumption per unit of GDP has been decreasing for the same period, indicating that less material consumption is required to produce one unit of GDP (UNEP 2021c). Since the greater decrease in domestic material consumption per unit of GDP (SDG 8.4.2/12.2.2) is translated into the use of less water resources to consume materials, this reflects an increase in lakes and rivers water area (SDG 6.6.1), confirmed by the results of the statistical analysis.

The statistical analysis identified a negative relationship between (a) SDG 9.4.1 on CO_2 emissions per unit of GDP PPP, (b) SDG 7.3.1 on energy intensity level of primary energy, and SDG 6.6.1 sub-indicators on lakes and rivers seasonal water area. In Mongolia, 85 per cent of total energy supplied in 2019 originated from coal, with 97 per cent of electricity and heat generation CO_2 emissions attributed to coal and other energy sources (IRENA 2022b). The increase in coal production in Mongolia since 2000, coupled with the water-intensive coal production sector, has had long-lasting impacts on ecosystem processes and ecosystem services; surface coal mining was responsible for the loss of 30 per cent of lakes larger than 10 km^2 in the Mongolian Plateau (Ma et al. 2021). As previously discussed, an improvement in energy intensity level of primary energy (SDG 7.3.1) and CO_2 emissions per unit of GDP PPP (SDG 9.4.1) (less values for energy intensity and CO_2 emissions per unit of GDP) leads to the use of less water and an increase of lakes and rivers water area. The Mongolian data indicate an overall decreasing trend in energy intensity level of primary energy (SDG 7.3.1) and CO_2 emissions per unit of GDP PPP (SDG 9.4.1) while the lakes and rivers seasonal water area (SDG 6.6.1) is overall increasing (UNSD 2022b).

b. SDG 6.6.1 sub-indicators on reservoirs water area (minimum and maximum)

Mongolia's general models for reservoirs minimum and maximum water area (SDG 6.6.1) are almost identical for positive and negative relationship identified, except for the renewable energy share in the total final energy consumption (SDG 7.2.1) that is relevant to reservoir maximum water area only.

As presented in the lakes and rivers water area section, a positive relationship was identified between (a) SDG 1.4.1 on the proportion of population using basic drinking water services, (b) SDG 1.4.1 on urban population as percentage of total population and (c) SDG 6.4.1 on water-use efficiency and reservoirs minimum and maximum water area (SDG 6.6.1). The reliance on groundwater resources to supply communities in Mongolia shifts the pressure from surface-water resources, including reservoirs. In addition, the improvement of water-use efficiencies due to many factors, including more efficient water conveyance systems in urban settings, have been shown to reduce the pressures on freshwater resources (Shi et al. 2015; Onyenankeya, Onyenankeya and Osunkunle 2021; Civitelli and Gruere 2016).

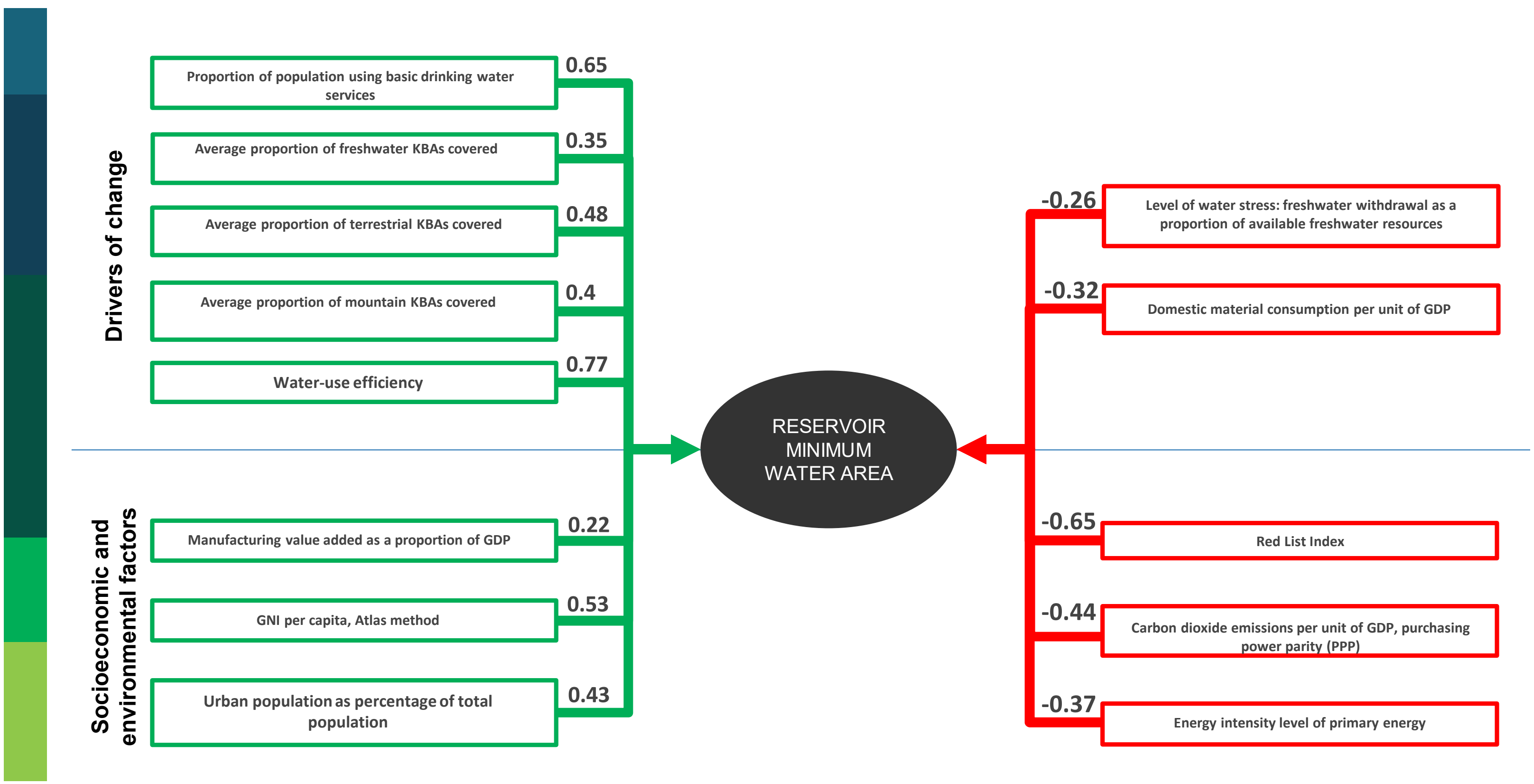
As presented in the lakes and rivers water area section, Mongolia's shift to renewable energy will exert less pressure on water resources and improve the quantities of water available, for example, in reservoirs.

The statistical analysis identified a positive relationship between (a) SDG 15.2.1a on the average proportion of freshwater KBAs covered, (b) SDG 15.2.1b on the average proportion of terrestrial KBAs covered and (c) SDG 15.4.1 on the average proportion of mountain KBAs covered with reservoirs minimum and maximum water area (SDG 6.6.1). These relationships were discussed in detail in previous sections, but in the context of Mongolia, many actions have been taken by the government that may have a positive impact on reservoirs water area from the perspective of biodiversity protection. Many national biodiversity conservation action plans were prepared and implemented to increase the State Special Protected Areas (SPAs) to 30 per cent by 2030 from 17.9 per cent (Mondal et al. 2019). The government has designated sites as World Heritage sites, biosphere reserves as well as Ramsar Sites, Important Bird and Biodiversity Areas and Flyway Network Sites (WSCC n.d.).

A negative relationship was identified between level of water stress (SDG 6.4.2) and SDG 6.6.1 sub-indicator on reservoirs minimum and maximum water area. As the withdrawal of freshwater resources leads to less water available for storage (Weber et al. 2017), an increase in level of water stress will lead to less reservoirs minimum and maximum water area (SDG 6.6.1), which the statistical analysis confirms.

A positive relationship was identified between GNI per capita and reservoirs minimum and maximum water area (SDG 6.6.1). The country's extensive reliance on groundwater coupled with the impact of climate change on temperature makes it likely that Mongolian reservoirs water area have been expanding while the

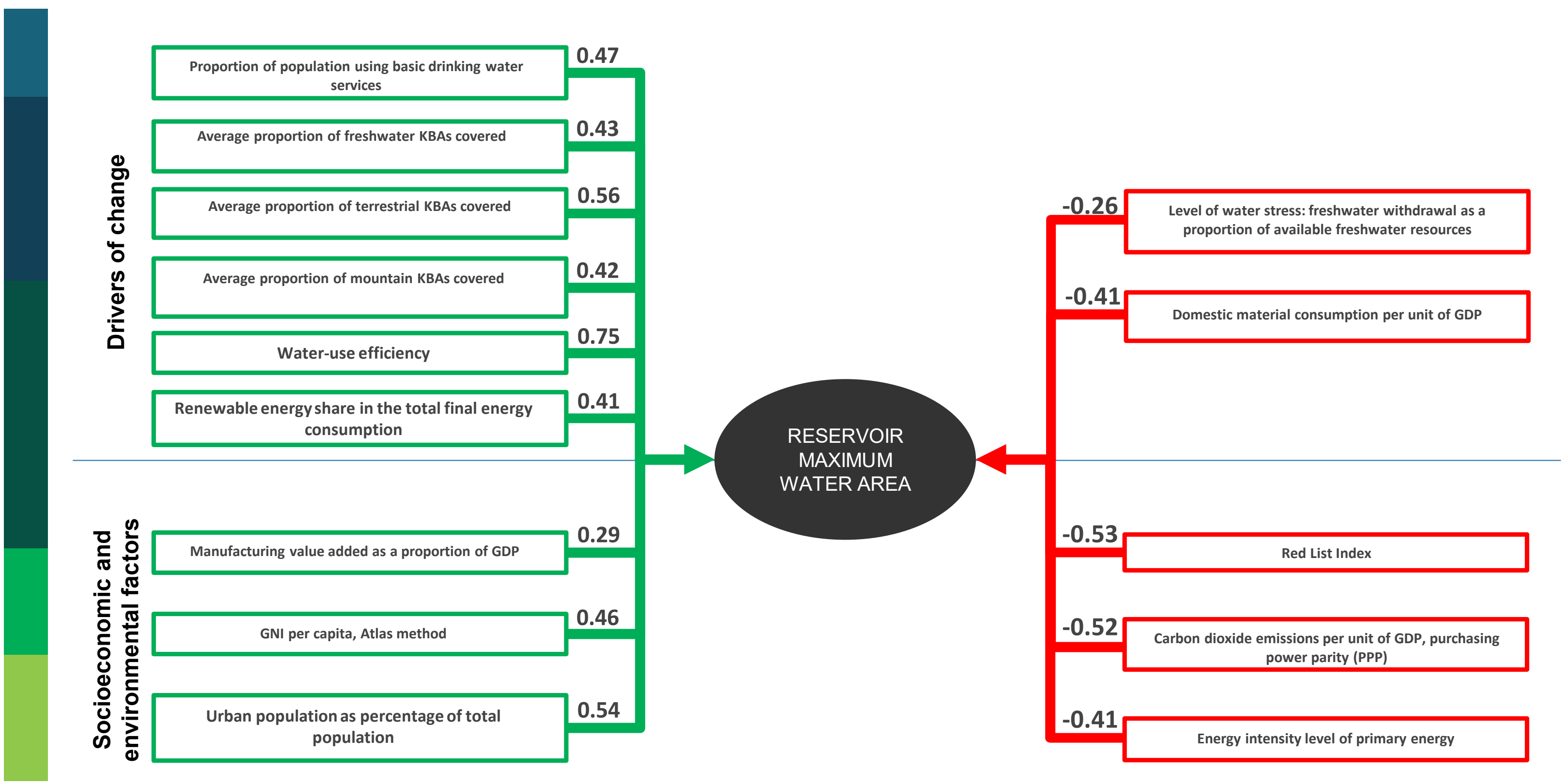
Figure 4.17 General model for reservoir minimum water area, Mongolia



country has been increasing its GNI per capita steadily since 2010. Similarly, the improvement in manufacturing value added as a proportion of GDP (SDG 9.2.1) indicates an expansion of the sector and is expected to be negatively linked to water resource areas, such as reservoirs, unless environmentally sound practices are established.

The statistical analysis identified a negative relationship between (a) SDG 9.4.1 on CO_2 emissions per unit of GDP PPP, (b) SDG 7.3.1 on energy intensity level of primary energy, and SDG 6.6.1 sub-indicators on reservoirs minimum and maximum water area. As presented in the lakes and rivers water area section, the improvement of energy intensity level and CO_2 emissions per unit of GDP in Mongolia (coal represented 85 per cent of total energy supplied in 2019) might have positive implications on the reduction of water use in the energy production sector (Gao et al. 2018) by its potentially leading to an increase in water resources, specifically reservoirs water area. Similarly, the improvement (i.e. decrease) of domestic material consumption per unit of GDP (SDG 8.4.2/12.2.2), leads to decrease in water use, and therefore an increase in reservoirs water area (SDG 6.6.1).

Figure 4.18 General model for reservoir maximum water area, Mongolia



c. Conclusion

The strongest positive relationships with freshwater area in Mongolia were found to be linked to water-use efficiency, urban population, proportion of population with access to basic drinking water services and GNI per capita. The economic situation in Mongolia has been improving. More people are moving to urban areas, causing a shift in water dependency to groundwater resources. At the same time, the manufacturing industry and mining sector, in addition to the weak enforcement of regulations, are exerting pressure on water resources (Banerjee et al. 2014).

The strongest negative relationship was identified with CO_2 emissions per unit of GDP. Given the extent and impact of Mongolia's mining sector – specifically its water-intensive activities – on the country's environment and water resources, laws and regulations to improve the efficiency of CO_2 emissions per unit of GDP are needed, along with policies that encourage or enforce efficient and reduced water use by the sector.

4.2.2.2 State of the freshwater-related ecosystems' impact on the state of human well-being

a. SDG 6.1.1 sub-indicator on proportion of population using safely managed drinking water services

The inequalities in water and sanitation in Mongolia are linked to socioeconomic, climatic and environmental factors, including the geographically sparse population, cold climate with high seasonality, uneven distribution of water resources across the country, limited water and sanitation infrastructure, and the lack of financial resources for the expansion and provision of water and sanitation services. Steep inequalities in access to safe drinking water exist among urban and rural populations. Access to safe water and sanitation facilities is limited mainly to urban and built areas. Similarly, socioeconomic inequalities in access to safe water and sanitation services remain high between different housing types.

Nationally, inhabitants of apartment buildings use safe water from centralized water supply systems (around 29 per cent), whereas those living in detached houses and traditional homes called *"ger"*[11] rely on other drinking water sources and are often not connected to centralized water and sanitation networks (around 64 per cent have access to safely managed drinking water services) (NSO Mongolia 2020). In Ulaanbaatar, more than 90 per cent of the city's population has access to safe drinking water. Ger districts are home to about 60 per cent of the city's population, while the majority of people in small towns and settlements in rural areas live in ger. Sources of drinking water for households in ger districts include public distribution points (kiosks) connected to centralized water supply networks; kiosks with purified water transported by trucks from the centralized water supply system; protected wells, springs and streams; unprotected wells and springs; and open water sources (rivers, lakes and ponds).

Furthermore, there are inequalities in water consumption between residents in apartment buildings and in ger districts due to the accessibility of water and different water tariffs. Water consumption in ger areas is limited to basic needs such as drinking, cooking and hygiene. In contrast, residents in apartment buildings consume as much as 270–350 litres per capita/day (UNESCO 2013). In addition, households in ger districts pay higher water tariffs compared with the tariffs paid by households in apartment buildings.

11 "The Ger is a round structure of walls, poles and a peaked roof covered with canvas and felt, and tightened with ropes." (UNESCO n.d.)

There is a positive link between the state of freshwater resources and ecosystems (SDG 6.6.1) and access to safe drinking water. Water pollution hinders access, while interventions to protect and improve water quality and ecosystem health grant populations better availability and quality of water resources for drinking and other uses. These relationships are particularly evident in Mongolia's case due to the country's diverse ecosystems and highly seasonal climate, as demonstrated by the positive relationships between the permanent and seasonal water area of lakes and rivers (SDG 6.6.1) and the proportion of population using safely managed water services (SDG 6.1.1). Mongolia's surface-water flows and groundwater resources heavily depend on precipitations such as rainfall and snow. With an estimated 85 per cent of precipitation between April and September, the annual precipitation rarely exceeds 400 mm and is much lower in the southern and steppe regions, whereas the annual rainfall in the Gobi Desert is only 40 mm (MET of Mongolia 2018). This makes lakes and rivers highly vulnerable to climate variabilities. Furthermore, located in a cold climatic region, Mongolia's lakes and rivers are seasonal and freeze during the winter months. Consequently, major cities and large human settlements rely on groundwater as a perennial source of drinking water supplies, compared with rural and nomadic populations, who rely on surface water bodies such as rivers, streams and springs for drinking water. Due to the seasonality of lakes and rivers, rural and nomadic populations use snow and ice for drinking water during winter. The impact of these climatic factors on the availability of water resources is demonstrated by the very weak relationship between permanent lakes and rivers and access to safe drinking water, and by a rather stronger relationship with the seasonal surface-water bodies.

Mongolia's total water reserve mainly consists of natural water reservoirs, with only few small-scale artificial reservoirs. The positive relationship between reservoirs minimum and maximum water area (SDG 6.6.1) and access to safe drinking water may be due to the additional water supplies provided by the construction in 2008 of the Taishir Hydropower Project on Zavkhan River in the western region of Mongolia and the completion of the Taishir-Altai Water Supply Project, which provides drinking water supplies for the city of Altai in Gobi-Altai Province (an aimag). Since 2021, inhabitants of Altai use purified water from the reservoir (an artificial lake called Gegeen) of the Taishir Hydropower plant. Thus, Altai has become the first city in Mongolia to use a surface-water reservoir as a drinking water source.

Because of the high seasonal variability of river flows and the tendency of rivers to freeze in winter, groundwater is tapped as Mongolia's main water source for drinking and industrial water supplies. At the same time, the valuable and fragile ecology of the country necessitates the maintenance of high environmental flow requirements. Mongolia needs to prepare for climate change adaptation, as it may become a major challenge (ADB 2020b).

A country's economic development is one of the key factors that defines its level of access to safe drinking water, as economic growth provides financial resources for investments in the water and sanitation sector. Likewise, improvements in socioeconomic conditions of a population, such as increased GDP and GNI per capita, result in better access to safely managed drinking water and sanitation services. Mongolia's GNI per capita has almost doubled in the 2010–2021 period (WB 2022b). Its economic growth is undeniably one of the key factors benefiting its population, particularly those who have lacked access to safe drinking water, as shown by the strong positive relationship between GNI per capita and the proportion of population using safely managed drinking water services (SDG 6.1.1).

The statistical analysis identified a positive relationship between urban population as proportion of total population and the proportion of population using safely managed drinking water services (SDG 6.1.1). Rapid urbanization due to rural-urban migration in Mongolia is another key factor in the increase of access to safe drinking water, as centralized water supply and sewerage services are mainly limited to urban areas, demonstrated by the access of more than 90 per cent of the city's population to safely managed drinking water services.

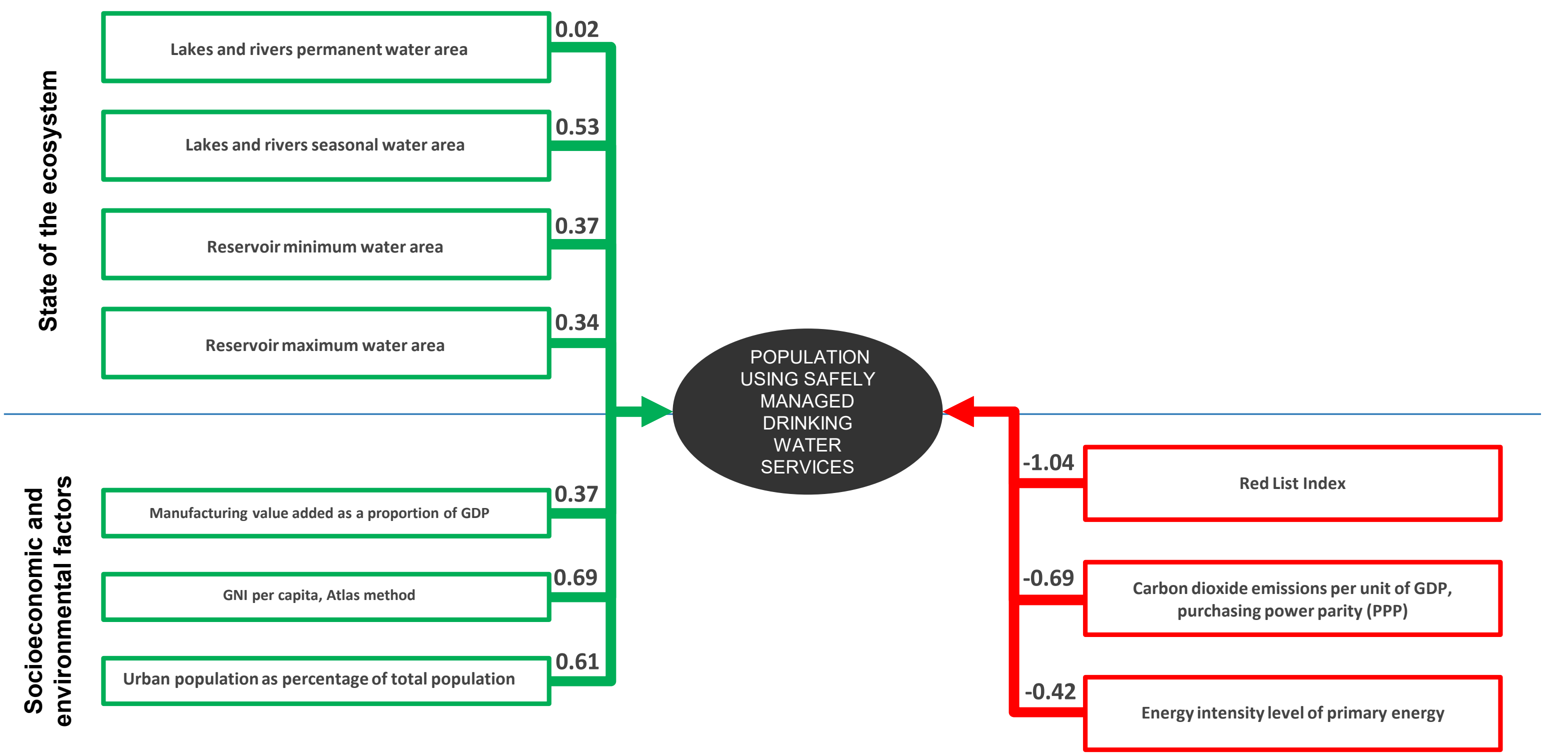
Manufacturing makes a very modest contribution (8 per cent) to the country's GDP (WB 2022b), while mining constitutes the main economic pillar. Nonetheless, an expansion of the sector is expected to carry negative impacts on the water resource areas.

As discussed in the section above, the decrease in CO_2 emissions per unit of GDP (SDG 9.4.1) and in the energy intensity level (SDG 7.3.1) implies the increase in freshwater resources. This increase, coupled with government action to improve the quality of water supplied, may lead to an increase in the proportion of population using safely managed drinking water services (SDG 6.1.1).

b. Conclusion

Mongolia has made progress in providing its population with access to safe drinking water. However, with the current modest rate in the increase of the proportion of population using safely managed drinking water (SDG 6.1.1), the full achievement of SDG

Figure 4.19 General model for population using safely managed drinking water services, Mongolia



target 6.1 by 2030 is unlikely. Scaling up investment in water and sanitation, especially in rural areas, is essential. To address the stark inequalities in access to safe drinking water among urban and rural populations and across social and spatial spheres, human rights-based policies targeting rural populations and ger area residents are equally important to ensuring that no one is left behind. Improvements in water resources management and access to water supply and sanitation services are essential for the same reason, such that no one is left behind when it comes to enjoying the multiple benefits and opportunities that water provides (WWAP 2019).

4.3 Interlinkages analysis of freshwater-related indicators at the subnational level

4.3.1 Impact of drivers of change on the state of freshwater-related ecosystems

a. Basin level: China

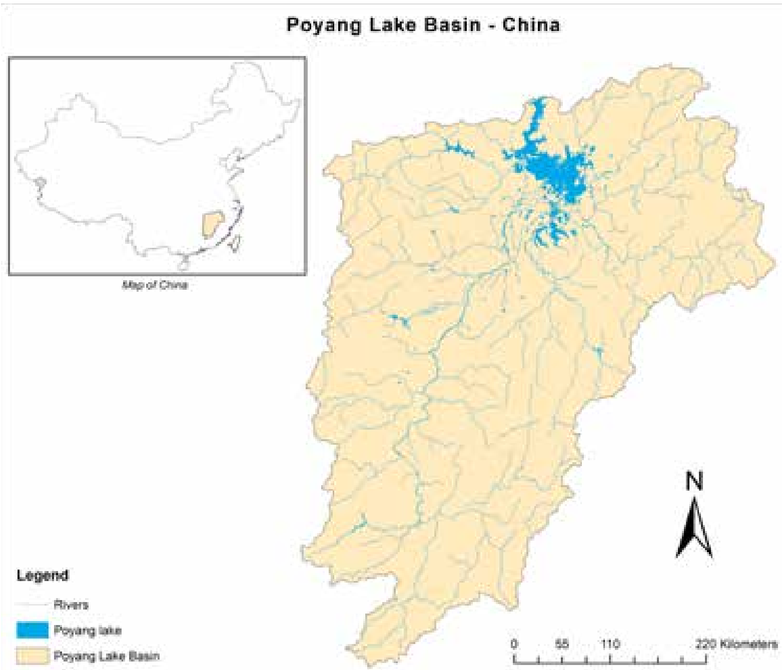
The interlinked nature of the SDGs and targets requires approaches to identify and quantify synergies and trade-offs at the national level (Zhou, Moinuddin and Li 2019; Miola, Borchardt and Neher 2019). For instance, in China, a recent study has shown that companies led by female CEOs are more likely to voluntarily adopt sustainable environmental policies (Zhang, Guo and Nurdazym 2022). However, national-level recognitions are limited in guiding subnational-scale actions. In large countries, subnational considerations are important as climatic, ecosystem, land-use and political subdivisions seldom coincide – their interactions with the goals may differ from those observed at the national scale. Accordingly, national policies may not necessarily serve subnational-level interests and potentially cause unforeseen trade-offs (Renaud et al. 2020).

In the case of freshwater resources, interactions at the basin level are crucial. A river basin is a semi-closed ecological and economic system that plays an important role in global and regional development (Zhao et al. 2018). In such a spatial unit where various elements of the natural ecological environment interact and depend, exploring and understanding its synergies and trade-offs bring considerable value to accurately managing regional problems, ensuring policy coherence and promoting concrete actions (Zhou et al. 2022; Renaud et al. 2020). However, continuous, accurate and reliable time-series data remain an important prerequisite (Adeoti 2020). Considering the perspective of regional representativeness and data availability, this section clarifies the relationship between water-related ecosystems at the watershed scale and SDGs by taking as case study the Poyang Lake basin, the subwatershed of the Yangtze River basin in China.

China is divided into 10 first-level water resources regions or zones, 80 secondary zones and 214 third-level zones. Each water resource region combines watershed and administrative areas, which offer an integrated perspective and information about basin-level water resources. The data used for the basin-level analysis are using the secondary level zoning of national water resources in China, to which the Poyang Lake basin belongs. The Poyang Lake basin is located on the southern bank of the middle and lower reaches of the Yangtze River, which overlaps with the administrative areas of the Jiangxi Province. It consists of Ganjiang River, Fuhe River, Xinjiang River, Raohe River, Xiushui River and its tributaries at all levels, plus Qingfengshan River, Boyang River, ZhangTian River, Tongjin River and other small rivers that flow into the lake alone. The basin is about 620 km long from north to south and 490 km wide from east to west. The basin area is around 162,225 km^2, of which 156,743 km^2 is located in Jiangxi (accounting for 96.6 per cent of the basin area) (Lei et al. 2021). The remaining 5,482 km^2 belongs to Fujian, Zhejiang, Anhui, Hunan, Guangdong and other provinces, accounting for about 3.3 per cent of the basin area.

Poyang Lake is the largest freshwater lake in China and constitutes a major hydrological subsystem of the middle Yangtze basin (Shen et al. 2022). It has been listed as an ecoregion in World Wildlife Fund's Global 200 (Huang, Wu and Li 2013). Therefore, Poyang Lake plays a crucial role in maintaining and supplementing the aquatic biodiversity of the Yangtze River (Jin et al. 2012).

Map 4.3 Official map of China (United Nations, 2022)



The proportion of waterbodies with good ambient water quality (SDG 6.3.2) is used as the dependent variable to reflect the state of freshwater-related ecosystems. The 27 indicators are used as drivers of the freshwater-related ecosystem change, which are tested with the 11 socioeconomic and environmental factors. Between 2004 and 2019, SDG 6.3.2 shows an increasing trend, as do the seven driver indicators (freight volume, passenger traffic, railway passenger traffic, road freight volume, road passenger traffic, water freight volume, and harmless treatment rate of domestic waste) and six socioeconomic and environmental factors (GDP per capita, industrial waste gas treatment facilities, forest cover rate, urban population as percentage of total population, comprehensive utilization rate of industrial solid waste, and freight volume). However, a decreasing trend can be seen in the rail freight volume, waterway passenger traffic, industrial wastewater discharge, average level of particulate matter and industrial sulfur dioxide emissions.

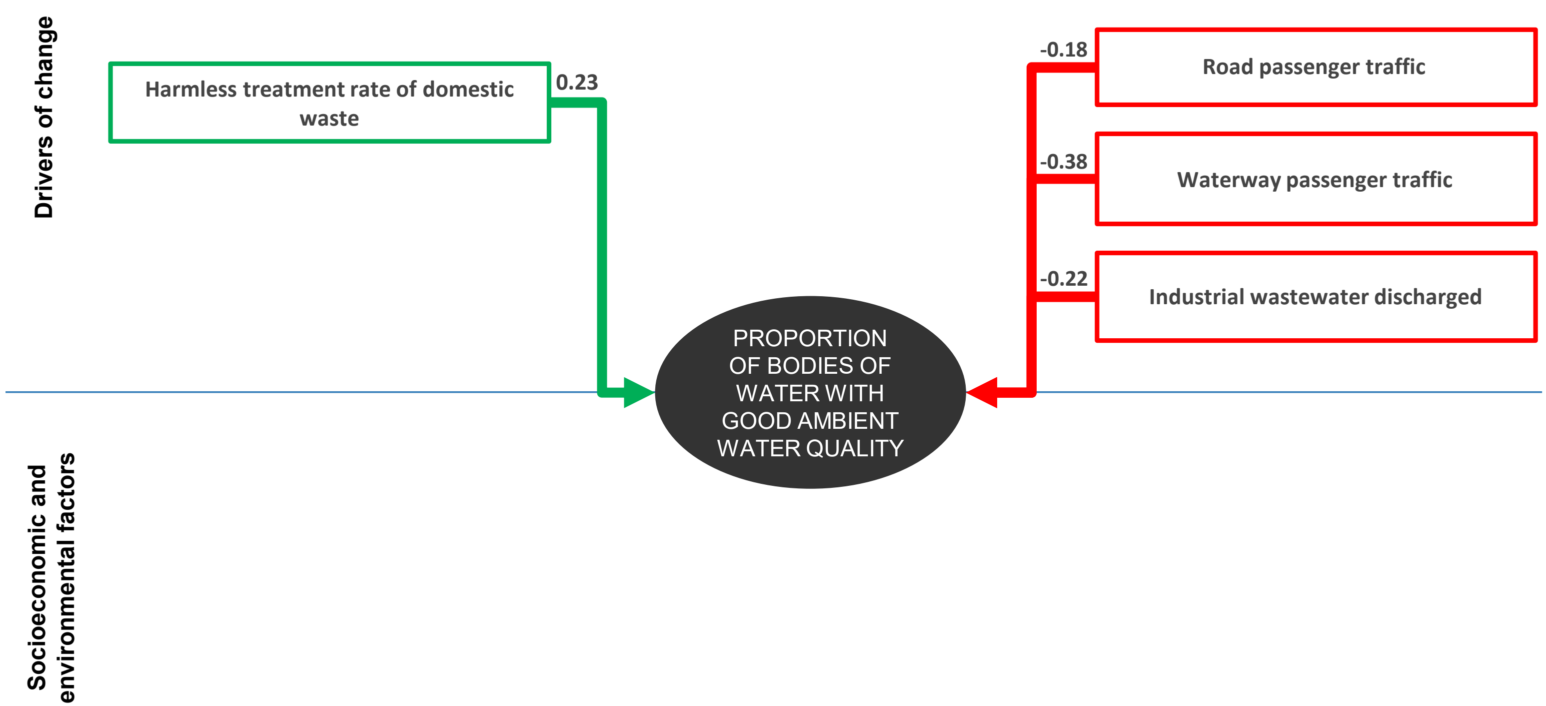
Out of the 27 indicators of drivers of change, only four have shown a statistically significant relationship with SDG 6.3.2 on the proportion of waterbodies with good ambient water quality.

The harmless treatment rate of domestic waste has a positive relationship with SDG 6.3.2 on the proportion of bodies of water with good ambient water quality. Water pollution in China is generally considered significant as it impacts the health of ecosystems and humans (Ma et al. 2020). In the Poyang basin in 2016, wastewater treatment was below national average (Jiangxi Provincial Development and Reform Commission 2016). As domestic waste is a key source of water pollution, its reduction and harmless treatment is vital for improving water quality (Arum, Harisuseno and Soemarno 2019). According to Jiangxi's Province Domestic Waste Classification and Treatment Facility Development Plan (2021–2025), the harmless or environmentally sound treatment rate of domestic waste in cities and counties across the province is higher than the national average. This is an important environmental governance initiative for the improvement of water quality in the Poyang Lake basin.

On the other hand, the waterway passenger traffic has a negative relationship with SDG 6.3.2 on the proportion of bodies of water with good ambient water quality. The statistical analysis implies that an increase in waterway passenger traffic would lead to a decrease in the proportion of waterbodies with good ambient water quality. The same is implied for road passenger traffic. Inland waterway traffic, based on the literature, is found to be more efficient than road transport, as it consumes less energy, costs less, emits less CO_2 and has larger freight capacities compared with other modes of transport (Li et al. 2022; de Barros et al. 2022). A study on the impact of inland waterway transport was conducted for the Yangtze River, of which Poyang Lake is a part. The study reveals that ecological functions (including biodiversity) of the various reaches of the Yangtze River (upper, middle, middle-lower and lower) were all assessed between bad, poor and fair, alongside identified threats such as habitat loss, water pollution, overexploitation and alternations of hydrological regimes (Li et al. 2022). In addition, sanitary sewage, oily wastewater and domestic solid wastes discharged from ships impact the quality of the waterways (Jiao and Liu 2018). This is confirmed by the negative relationship between waterway passenger traffic and SDG 6.3.2 and by the data, which shows that between 2004 and 2019, the waterway passenger traffic has been decreasing while the quality of the waterbodies has been improving since.

In addition to waterway passenger traffic, the statistical analysis indicates a negative relationship between road passenger traffic

Figure 4.20 General model for proportion of bodies of water with good ambient water quality, Poyang Lake basin, China



and SDG 6.3.2 on water quality. Generally, the increase of road passenger traffic will have a negative impact on the surface-water and groundwater environment (Kalman and Laszlo 1997; Uliasz-Misiak et al. 2022). Although road traffic is usually positively linked to air pollution in cities and urban areas, a study in Canada found that chemical compounds found in vehicle fluids, tyres and paints are major causes of water pollution in nearby streams due to heavy traffic. This is due to the deposition of such chemicals on roads that end up in river streams after raining, causing water degradation (Awonaike et al. 2022).

There is a negative relationship between industrial wastewater discharge and SDG 6.3.2 on water quality. Industrial wastewaters are known to be toxic and are a major cause of irreversible damage to the ecosystem. They not only pollute groundwater, but also major waterbodies. They include a variety of compounds toxic to freshwater species and humans, including chemicals, heavy metals, oils, pesticides, silt, pharmaceuticals and other industrial by-products (Ahmed, Thakur and Goyal 2021). There can be no doubt that the relationship is negative. In the Poyang Lake basin, the industrial wastewater discharge decreased from 2004 to 2019, which has improved the quality of the water.

4.4 Comparison between the results of stakeholders and statistical analyses

Since the adoption of the SDGs, attempts to identify interlinkages between the SDGs and targets were made mainly based on expert opinion and stakeholder consultation. For instance, in 2016, UN-Water published a report on the potential synergies and trade-offs between the water-related targets and other SDG targets at the global level (UN-Water 2016), while the Stockholm Environment Institute (SEI) proposed a new tool, entitled "SDG Synergies", to map the interactions between SDGs or targets at the national and subnational levels (Nilsson, Griggs and Visbeck 2016), piloted in Colombia and Mongolia. Although experts' opinions were provided for relationships at the target level and the statistical analysis targeted the relationship between individual indicators, an attempt to compare both results will be made, as many targets are monitored by single indicators.

4.4.1 Global-level analysis

While analysing the relationships identified between SDG target 6.6 and other targets, a total of 37 potential relationships were identified by the UN-Water report (UN-Water 2016), of which 20 potential relationships were in common with this statistical analysis. Since the statistical analysis is based on data, 5 out of the 20 potential relationships could not be compared due to lack of data. When comparing stakeholders' opinions to the results of the statistical analysis, 64 per cent of the results at the global level have identified the same type of relationship. Those relationships cover access to basic services, improvement in energy efficiency, sustainable economic growth, improvement of global resource efficiency, promoting sustainable industrialization, upgrading infrastructure and industries, and conservation of freshwater, terrestrial and mountain ecosystems.

At the global level, experts' opinions indicate a synergistic relationship between achieving the environmentally sound management of chemicals and wastes (SDG target 12.4) and water resources, while the statistical analysis has implied a potentially conflicting relationship pertaining to the generation of electronic waste per capita (SDG 12.4.2). Although waste generation is not considered waste management, SDG 12.4.2 on the generation and treatment of waste is considered as part of target 12.4 on the sound management of waste. Nevertheless, waste generation conflicts with the conservation and protection of water-related ecosystems, necessitating adequate waste management. Similarly, ensuring universal access to energy services and increasing the share of renewable energy (SDG targets 7.1 and 7.2) were identified by experts as potentially conflicting with water-related ecosystems, while the relationship was not identified (non-statistically significant) by the statistical analysis. However, reducing the degradation of natural habitats (SDG target 15.5) is expected to be synergetic with water-related ecosystems (experts' opinions) while the statistical analysis has identified a potential conflict. Such statistical results demand further investigation to understand why such a conflicting relationship was identified from the statistics related to the Red List Index (SDG 15.5.1).

From the perspective of the impact of freshwater-related ecosystems (SDG 6.6) on the state of human well-being, experts identified conflicting relationships between eradicating extreme poverty (SDG target 1.1) and ending hunger and ensuring sufficient food for all (SDG target 2.1). The statistical analysis has identified a synergetic relationship with the proportion of employed people below the international poverty line (SDG 1.1.1) and prevalence of undernourishment (SDG 2.1.1). Although food availability and security are a priority and are resource intensive – including water – innovative techniques, improved water-use efficiencies and sustainable agricultural practices are shifting the impact towards the conservation of freshwater-related ecosystems.

4.4.2 National-level analysis

The SDG Synergies tool was piloted in Colombia and Mongolia, where national experts took part in completing national and/or regional matrices by mapping relationships between targets. In Colombia, SDG targets were mapped, while in Mongolia, targets from the Sustainable Development Vision (2030) were mapped (SEI 2019). The tool uses a seven-point rating system based on the types of interactions (Nilsson, Griggs and Visbeck 2016), which vary from indivisible (score of +3), reinforcing (score of +2), enabling (score of +1), consistent (score of 0), constraining (score of -1), counteracting (score of -2) and cancelling (score of -3) (Nilsson, Griggs and Visbeck 2016).

The implementation of the SDG Synergies tool in Colombia began in 2018 to better understand the national and regional levels between the SDGs as part of the Colombian National Development Plan 2018–2022. The analysis of policies and instruments in Colombia formed the basis for the selection of goals and targets of priority to the country and the region of Antioquia. This has led to the development of two cross-impact matrices, the first focused on national interactions while the second focused on interactions relevant to Antioquia (SEI-PNUMA 2020). As water resources were essential to Colombia, targets 6.1 on achieving equitable access to safe and affordable drinking, target 6.3 on improving the water quality by reducing pollution and the release of untreated wastewater, and 6.4 on increasing water-use efficiency and addressing water scarcity were all considered for the interaction analysis at the national level. Unfortunately, target 6.6 on restoring water-related ecosystems was not considered as part of the national analysis (considered for subnational instead), hence further analysis for Colombia to understand the similarities or differences between experts' opinions and the statistical analysis results is not possible.

In Mongolia in 2017, experts mapped the interactions between 17 out of 43 targets derived from the Sustainable Development Vision (2030) of Mongolia (SEI 2019). Out of the 17 mapped targets, five showed significant alignment with SDG targets: 2.4 on ensuring sustainable food production systems and resilient agriculture, 6.1 on improved drinking water services, 6.6 on water-related ecosystems, 7.2 on renewable energy and 15.1 on the conservation and restoration of terrestrial and freshwater-related ecosystems. Since data for SDG indicator 2.4.1 on productive and sustainable agriculture are not available, this target has not been further considered in the comparison below.

Two out of three identified relationships using the SDG Synergy tool were aligned with the statistical analysis results for Mongolia, that is, enabling, reinforcing or indivisible relation between water-related ecosystems and (a) increase of drinking water services and (b) conservation and restoration of terrestrial and freshwater-related ecosystems. One relationship between the share of water-related ecosystems and renewable energy presented unaligned results, with the SDG Synergy tool identifying the relationship as counteracting (conflicting) and the results of the statistical analysis finding it synergetic. In Mongolia, wind and solar power for electricity production is more than double that of hydropower (Mondal et al. 2019), while the country's main electricity source comes from coal. The shift to renewable energy sources, especially wind and solar, represents a reduced impact on water-related ecosystems.

4.5 Key findings

The analysis at the global, national and basin levels has shown similarities and divergence in indicators impacting freshwater-related ecosystems. Some direct drivers and socioeconomic and environmental factors were exclusively statistically relevant to the global context, while others were specific to the national context. Three direct drivers related to conservation efforts (average proportions of terrestrial KBAs, mountain KBAs and freshwater KBAs covered) were found to be greatly impacting global and national settings. This also aligns with stakeholders' analysis of the type of relationship. Socioeconomic and environmental indicators related to urban population as a percentage of total population and the proportion of population with access to basic drinking water services were found to impact freshwater-related ecosystems at the global and national settings. The results imply that conservation actions by national and local governments are needed to expand the extent of lakes, rivers and reservoirs water area. In addition, factoring the percentage of urban population and the proportion of population accessing basic drinking water services is a necessity for the preservation of freshwater-related ecosystems.

Some direct drivers were found to be relevant to national settings only, and not global. Water-use efficiency (SDG 6.4.1) and renewable energy share (SDG 7.2.1) positively impact national freshwater-related ecosystems. In addition, GNI per capita (positive impact), energy intensity per unit of GDP (SDG 7.3.1) (negative impact) and domestic material consumption per unit of GDP (SDG 8.4.2/12.2.2) (negative impact) were found to impact freshwater-related ecosystems. Given the relevance of these indicators to the energy sector, the results imply a significant fossil fuel component of the energy portfolio. As this sector is water dependent, policies targeting improved efficiencies (i.e. water, energy intensity or domestic material consumption) along with diversifying the energy mix in countries to include renewable energies (wind and solar) would carry a positive impact on freshwater-related ecosystems.

In addition, the predominance in Colombia and Mongolia of the relationship between water-use efficiency and water resource indicators might suggest that, in these countries, water management strategies are insufficient to decouple economic activities from resource use. This relationship has not been found at the global level.

As the basis of the statistical analysis is data availability, freshwater-related ecosystems extent indicators were available for global and national settings but not for the basin level. Similarly, freshwater quality-related indicators were not available at global or national levels, which meant data availability was restrained to a basin-level analysis. Therefore, comparing global and national results with basin-level results is not yet possible. However, at the basin level, the highest negative impact on freshwater quality was waterway passenger traffic while the highest positive impact came from the treatment rate of domestic waste. Therefore, it is imperative to consider waste recycling and waterway traffic while developing targeted policies for the improvement of freshwater quality.

Regarding the impact of freshwater-related ecosystems on the state of human well-being, the statistical analysis has identified different direct drivers and socioeconomic and environmental factors for the global compared with national settings. At the national level, lakes and rivers seasonal water area (SDG 6.6.1) and GNI per capita were found to positively impact the proportion of population using safely managed drinking water services (SDG 6.1.1), while CO_2 emissions (SDG 9.4.1) and energy intensity (SDG 7.3.1) per unit of GDP both had a negative impact. The formulation of targeted policies for the economic development and improvement in efficiencies for CO_2 and energy intensities per unit of GDP might consider their impacts on populations' access to basic drinking water services.

At the global level, all state of human well-being indicators were negatively impacted by lakes and rivers seasonal water area, and reservoirs minimum and maximum water area (SDG 6.6.1). This indicates the role that freshwater area plays in alleviating poverty (SDG 1.1.1), reducing unemployment (SDG 8.5.2) and the impact they exert on children's health (malnutrition and undernourishment). Freshwater resource extent could be an important factor in developing policies that target the reduction of poverty as well as children's health.

The statistical analysis has shed light on relationships once thought to be significant but now found to be non-statistically significant by the statistical model employed in this report. For instance, SDG 6.2.1 on the proportion of population using safely managed sanitation services was found to be non-statistically significant with freshwater-related ecosystems. Although household water use was estimated to be around 10 per cent of total water use, and basic personal and domestic needs represented a fraction of household water use (OHCHR n.d.), the absence of such a relationship requires further investigation.

The extinction status of species was found to have an odd relationship with freshwater extent. This relationship was identified at the global and national levels and, in some instances, was found to be strong. Since the Red List Index indicator varies between zero and one and includes many taxonomic groups of species (terrestrial, freshwater and marine), the possibility of having a proxy indicator for the variation of the number of these groups, along with removing species that are specific to marine settings, may be more indicative to the analysis. Additionally, human understanding of how ecosystems respond to biodiversity loss remains basic. Despite the wealth of information about how the addition or removal of a single species can alter the basic ecosystem properties of lakes and rivers, little research has attempted to understand how these ecosystems respond to biodiversity loss (Schindler 2007). As this relationship is challenging to interpret, additional research might be needed to better grasp the link between the various taxonomic groups of species and freshwater extent.

In conclusion, the statistical analysis has identified various positively and negatively impacting relations between freshwater extent, state of human well-being, and socioeconomic and environmental factors. Simultaneously, the comparison of the results from stakeholders and statistical analyses has shown a significant portion of alignment, whether at the global or national level. While some impacting factors are common for global and national settings, it remains imperative to identify other national factors considered to have synergies or trade-offs with freshwater-related ecosystems so that targeted policies and interventions can be formulated to protect freshwater-related ecosystems.

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Chapter 5: Marine-related ecosystems

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SDG 14 is the dedicated goal towards the conservation and sustainable use of the oceans, seas and marine resources. This goal includes 10 targets and 10 indicators related directly to marine-related ecosystems. Yet only three indicators represent a picture of how the state of the environment is evolving: (a) SDG 14.1.1 on coastal eutrophication and plastic debris density, (b) SDG 14.3.1 on the average marine acidity measured at agreed suites and (c) SDG 14.4.1 on the proportion of fish stocks within biologically sustainable levels. However, only SDG 14.1.1a on coastal eutrophication, and more precisely the sub-indicator on chlorophyll-a deviations, had data compliant with the requirements of the statistical analysis. The following analysis focuses on the interlinkages of chlorophyll-a deviations with identified drivers of change and state of human well-being indicators.

5.1 Introduction: Chlorophyll-a deviation measurements

Chlorophyll-a, the predominant type of chlorophyll found in algae and green plants, reflects the quantity of algae growing in a waterbody. Consequently, it can be used as a metric for some aspects of the trophic condition of a waterbody. Although eutrophication (the excessive enrichment of water by different nutrients), is a natural process in virtually all aquatic systems (Smith, Joye and Howarth 2006; Aber et al. 2001), it can be accelerated by the effluents generated by humans' domestic, agricultural and industrial activities (Cai et al. 2011) (Rabalais et al. 2009). This process, called cultural eutrophication (Smith 1998), is responsible for rises in primary productivity (algae biomass), which can result in decreased levels of dissolved oxygen or increased levels of toxins, in turn affecting human and ecosystem health.

Due to the high correlation between chlorophyll-a and nutrient concentrations, this pigment can be used as an indicator of some bottom-up aspects of the trophic status for various waterbodies. Although measurements of water quality through in situ sampling methods demand considerable time, money and human resources, chlorophyll-a can be quantified with remote sensing technologies, offering a novel and powerful source for large-scale monitoring of surface-water quality in both freshwater and marine environments.

Over the last 30 years, there has been a tenfold increase in the number and area of oxygen dead zones in coastal waters worldwide, strongly associated with excessive nutrient effluence from the river to the ocean (Pitcher et al. 2021). In 1995, 44 hypoxic areas were identified globally; by 2007 they increased to 169 (Díaz and Rosenberg 2008), and currently 479 sites have been identified as experiencing hypoxia globally. Human activities are a major cause of oxygen decline in both the open ocean and coastal waters. Fossil fuel burning and the discharges from agriculture and human waste, which result in climate change and increased nitrogen and phosphorus inputs, are the primary causes. Eutrophication triggers a rapid growth of marine plants, animals and bacteria, and favours the decomposition of organic matter, all of which consume dissolved oxygen. Agriculture, septic systems, sewage treatment plants and urban run-off are significant sources of nutrient overload. (UNEP 2021d).

As the concentration of dissolved oxygen varies negatively with temperature, the negative impact of climate change persists. According to recent studies, the global ocean oxygen inventory is estimated to have decreased by around 2 per cent between 1960 and 2010, while oceanographic models predict a further 1–7 per cent decline by the end of the century (Stramma and Schmidtko 2019). Together, these factors make national-scale changes in chlorophyll-a deviations (SDG 14.1.1a) an important signal regarding the corresponding changes in ecosystems and potentially human health. However, it is unlikely that the impact of these factors is perceptible at the individual watershed scale, which is the first contact point with the outcomes of human activities.

Chlorophyll-a deviation measurements are derived from the European Space Agency's "Ocean Colour Climate Change Initiative" project and generated for each individual pixel (4 km resolution, monthly products) within a country's exclusive economic zone (EEZ) (Groom et al. 2019). In order to generate a climatological baseline, results were averaged by month between 2000 and 2004. The percentage of pixels in a country's EEZ and/or territorial waters identified as deviating from the baseline (falling in the ninetieth percentile) were calculated for each national EEZ and/or territorial waters by month. Finally, the annual average of these monthly values was calculated.

However, analysing chlorophyll-a deviations has some limitations. The indicator itself (context and geographical scale) has been accepted as a good proxy for the trophic status of several water-related ecosystems. This is valid when values obtained for this variable are analysed in the right local context and on a suitable geographical scale. The consideration of key variables of the sampling area – such as catchment proximity and discharge flow of rivers, quality (degree and type of pollution) of these watercourses, existence of urban, agricultural or industrial effluent discharge points, and local water circulation and marine currents – is a fundamental factor that must be taken into account when interpreting results obtained from satellite images. In line with this, the choice of an appropriate scale of observation, which allows the identification, weighting and analysis of all these factors, is another essential factor. It is central that the inclusion of these variables is methodologically incompatible with a global-scale analysis.

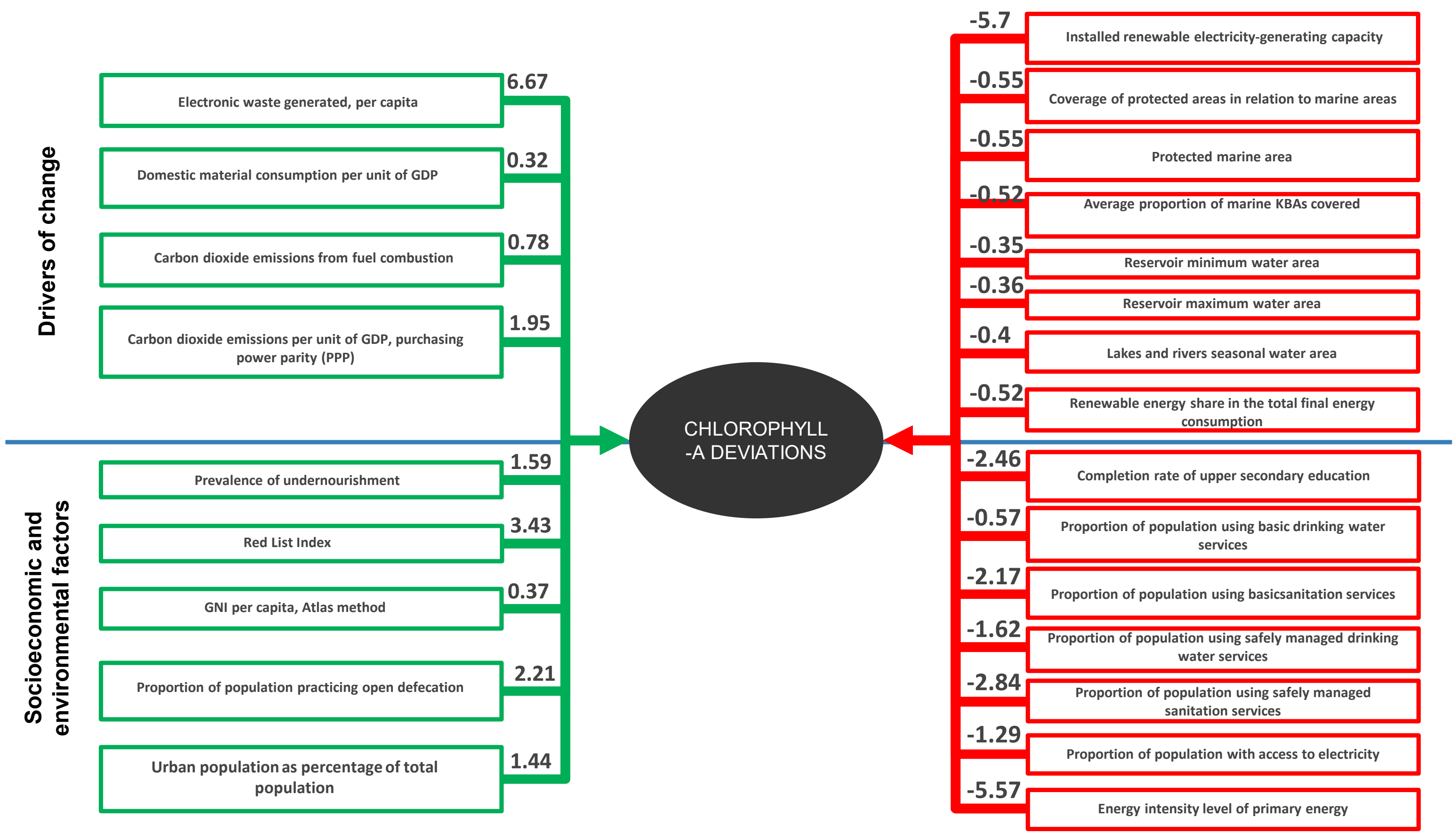
5.2 Interlinkages analysis of marine-related indicators at the global level

The statistical analysis results indicated a negative relationship between chlorophyll-a deviations (SDG 14.1.1a) and SDG 14.5.1 sub-indicators: (i) coverage of protected areas in relation to marine areas (EEZ), (ii) protected marine areas (EEZ) and (iii) average proportion of marine KBAs covered by protected areas (SDG 14.5.1). The negative relationship suggests that the increase in the coverage of protected areas in relation to marine areas may correspond to a decrease in chlorophyll-a deviation.

Factors such as sedimentation, plastic pollution, oil spills, climate change, eutrophication and the risk of introduced pests are only rarely addressed in the context of marine protected areas (MPAs) (Kriegl et al. 2021). It would be problematic if MPAs collectively had any impact on measured changes in chlorophyll-a or on the risk of eutrophication in a nation's coastal waters. In addition, there is no literature suggesting that MPAs have induced any changes in planktonic primary production although some studies indicate an increase in macroalgae abundance after some MPAs have been established (Gilby and Stevens 2014). Thus, these correlations are unlikely to reflect causality, but could reflect other underlying patterns. For example, jurisdictions, with the policies and resources to effectively reduce nutrient loading in watersheds and estuaries, may also be likely to have policies and resources sufficient to also establish more or larger MPAs.

The statistical analysis indicated a negative relationship between chlorophyll-a deviations (SDG 14.1.1a) and SDG 6.6.1 sub-indicators: (i) lakes and rivers seasonal water area, (ii) reservoir minimum water area and (iii) reservoir maximum water area. From the point of view of coastal eutrophication, building dams may impede transmission of excess nutrients and be beneficial, or it may change the chemical balance of nutrients and cause a coastal eutrophication problem. Two thirds of rivers globally are now

Figure 5.1 General model for chlorophyll-a deviations, global



dammed and no longer free flowing (Grill et al. 2019). The situation in every river catchment must be separately analysed to know if the dam is associated with a change in aquatic nutrient levels, and if so, develop targeted actions to address any downstream issues with excess nutrients. The impact of dams and reservoirs on coastal eutrophication depends on the timing of the release of the water stored in dams. The timing of delivery is changed in cases where dams withhold water for human use and release water when it is not needed. This results in the river's natural flow, which may have seasonal peaks and troughs, becoming smoothed and more uniform all year round (Maavara et al. 2020).

For instance, nutrients dissolved or suspended as particulate matter in freshwater streams and rivers eventually make their way to coastal and estuarine environments. In cases where the natural water flow is disrupted by building dams, canals for irrigation or other water management systems, then the natural timing of delivery, composition and concentration of water and nutrients can be perturbed. Under natural conditions, nutrients such as carbon, nitrogen, phosphorus and silicon are transported along the river and to the sea. Building a dam slows the water flow down and results in the nutrients being used within the dam reservoir by algae and aquatic plants, transforming dissolved nutrients into particulate matter (sediments). The dam reservoir may itself become eutrophic if the nutrient load is too high (Li et al. 2011). In such situations, the dam may be beneficial to the marine downstream environment, since the excess nutrients have been turned into sediment stored in the dam reservoir.

However, the reservoir may also promote chemical transformation of dissolved nutrients such that, once released, the river may promote eutrophication once it reaches the sea (Maavara et al. 2020). This can occur in cases where the ratios of the limiting nutrient received by the marine environment are altered by the upstream reservoir. The ratio of different nutrients (mainly nitrogen, phosphorus and silicon) affects different groups of species. In many marine environments it is silicon, not nitrogen, that limits the growth of diatoms. So, if the reservoir results in the preferential removal of silicon, the result can favour the growth of toxic algae downstream (species that are not dependent on silicon (Howarth and Marino 2006)).

A common feature of many coastal systems experiencing hypoxia is an elevated supply of organic matter, either through direct input from external sources (e.g. sewage) or internal photosynthetic production stimulated by inorganic nutrients, often stemming from anthropogenic sources. Human population growth is commonly associated with an increased intensity and/or frequency of coastal eutrophication and formation of dead zones. People are attracted to live in coastal settings, and as a consequence, inputs from sewage treatment plants, household septic systems and urban run-off increase (Tuholske et al. 2021).

The Second World Ocean Assessment acknowledges a link between excessive nutrient loads from sewage discharge and the reduction of oxygen content in the water (hypoxia), causing loss in marine life and the destruction of habitats and ecosystems (UN 2021b). For instance, in South Africa, the state of municipal wastewater and sewage treatment management has deteriorated in recent decades, leading to coastal eutrophication becoming an increasingly common problem. Adams et al. (2020) note that half of the country's estuaries are now affected by nutrient pollution resulting in hypoxia, fish death and a loss of ecosystem services.

In China, Wang et al. (2008) described two phases of growth in the occurrence of eutrophication in coastal estuaries, with one phase of slow development from the 1970s to the 1990s and a fast development phase after 2000. Eutrophication is considered the key stimulus in the occurrence of harmful algal blooms, which cause economic loss and human health issues (Wang et al. 2008). It is often difficult to determine which source of nutrients is most responsible for the onset of eutrophication, as most regions are susceptible to outflows of combinations of sewage and wastewater, industrial discharges, farm effluents (including aquaculture) and fertilizer washed into rivers and streams from farmland. However, Ke et al. (2020) used isotopes of carbon and nitrogen to identify that sewage from urban rivers was the major pollution source in Jiaozhou Bay in northern China. Globally, sewage and wastewater are estimated to contribute an amount of nitrogen that is equal to about 40 per cent of the amount from agriculture (Tuholske et al. 2021). This reflects the results of the statistical analysis that indicate that an increase in sanitation use corresponds to a decrease in chlorophyll-a deviation. Conversely, the increase in practising open defecation corresponds to an increase in chlorophyll-a deviation (SDG 14.1.1a).

In the coastal zone of the Baltic Sea, around 35 per cent of all coastal ecosystems have experienced hypoxia between 1955 and 2009 (Conley et al. 2009), with the overall frequency of hypoxia increasing. Terrestrial-derived organic carbon that is not derived from sewage treatment plants plays only a minor role in the Stockholm archipelago, for example, because no major rivers discharge into the system, and surface rainwater run-off is low (Sawicka and Brüchert 2017), meaning that nearly all of the excess nutrient load is attributed to sewage outflow. The environment was improved and hypoxic conditions reduced after the sewage treatment was upgraded in the inner Stockholm Archipelago (Norkko et al. 2012), but the problem persists.

The results of the statistical analysis suggest that an increase in access to electricity (SDG 7.1.1), renewable share of energy in the total final energy consumption (SDG 7.2.1) and installed renewable energy-generating capacity (SDG 7.b.1) would imply a decrease in chlorophyll-a deviations (SDG 14.1.1a), which favours a non-eutrophic state for the marine environment. The previously conducted research in this area tends to favour similar results.

Renewable energy sources are being considered as alternative sources of energy, as fossil fuel sources are linked to the increase in greenhouse gas emissions and climate change (UN 2021b). Renewable energy sources can be land based, e.g. solar and geothermal energies, as well as marine (marine renewable energy [MRE]), e.g. offshore wind energy, marine biomass energy, salinity and thermal gradient energy, wave energy, and tidal and ocean current energy. There are emerging MRE sources: (a) offshore solar energy based on floating solar systems, which are considered as potential alternatives to the solar industry and are more efficient than land-based solar systems, and (b) ocean floor geothermal energy, which is still in its conceptual stages (UN 2021b).

Although MRE contributes to the reduction of greenhouse gas emissions, water pollution, particulate matter, waste products and climate change mitigation, its full environmental impact requires further study (UN 2021b). Environmental impact assessments are needed at the project level to better understand the interactions among the environmental stressors introduced by installations and minimize their negative impact on the physical environment (UN 2021b). For instance, 399 offshore wind turbines were installed in the Belgian side of the North Sea by the end of 2020. A 10-year monitoring programme was in place to monitor the construction and operational phases of the farms from an environmental perspective. It has shown that the exclusion of fisheries from the wind farms coupled with increased food availability next to the turbines has served as a refuge for some fish species and the reef effect created by the turbines' foundations attracted sea floor communities, including worms, shellfish, crustaceans and starfish (Moreau 2020). The increased availability of fish species next to wind farms implies the weak potential of eutrophication and favours a balanced marine environment in close proximity.

The results of the statistical analysis showed a positive relationship between the proportion of urban population as percentage of total population and chlorophyll-a deviations (SDG 14.1.1a). Urban populations have been increasing for years. In 2018, around 55 per cent of the world's population was estimated to live in urban areas and is expected to rise to 68 per cent by 2050 (UNDESA 2018). In addition, in 2017, 2.4 billion people were estimated to live in areas within 100 km of a coast (UN 2017). On the other hand, only around 16 per cent of global coastal regions are ecologically intact, while 48 per cent are heavily affected by human activities and 84 per cent of countries saw more than 50 per cent of their coastal regions degraded (Williams et al. 2022). Degraded ecosystems do not impact everyone equally. Adverse impacts are felt by groups based on their gender and socioeconomic status. These vulnerable populations face significant hardships that may have been caused by others who are more economically empowered.

Effluents from large cities are entering large riverine inputs of freshwater, nutrients and organic matter, causing heavy eutrophication in tropical coastal areas (Canadell et al. 2021). The global urban discharge of nutrients into surface water increased about 3.5- to 4.5-fold during the twentieth century because of wastewater discharge, land-use change and fertilizer consumption (Kroeze et al. 2013). Depending on the distance between urban discharges and coastal zones, such urbanized areas could cause the high nutrient levels to be transported into the sea or ocean and cause coastal eutrophication (Kroeze et al. 2013).

The statistical analysis has identified relationships between chlorophyll-a deviations (SDG 14.1.1a) and several indicators: SDG 12.4.2 on electronic waste generated per capita, SDG 8.4.2/12.2.2 on domestic material consumption per unit of GDP, SDG 2.1.1 on prevalence of undernourishment, SDG 15.5.1 on Red List Index, SDG 4.1.2 on the completion rate of upper secondary education, SDG 6.1.1 on proportion of population using safely managed drinking water services, SDG 7.3.1 on energy intensity level of primary energy and GNI per capita. As per the experts' opinions and extensive literature review, there was no information to explain the relationship between chlorophyll-a deviations and these indicators. For instance, the statistical analysis showed a positive impact relationship between chlorophyll-a and SDG 9.4.1 on CO_2 emissions per unit of value added. Although the literature indicates a relationship between CO_2 as a greenhouse gas and ocean acidification, there is no research around the impact of CO_2 emissions on eutrophication or chlorophyll-a deviations.

5.3 Sri Lanka: Interlinkages analysis of marine-related indicators at the national level

The tropical island nation of Sri Lanka has 1,620 km of coastline, an EEZ of 517,000 km^2 in the Indian Ocean and is globally recognized for its outstanding biological diversity (WB n.d.). In addition to its heat and humidity, the climate features four distinct rainy seasons influenced by the monsoon winds of the Indian Ocean and the Bay of Bengal (Weerasekara et al. 2021). Sri Lanka's marine- and freshwater-related ecosystems are rich and diverse, offering a wide range of essential ecosystem services for its population as well as for the millions of tourists visiting the country each year. The country's fishery sector plays an indispensable role in the economy, contributing to around 1.3 per cent of its entire GDP (WB 2021b). This figure masks the importance of the sector to the people's livelihoods. Overall, the sector supports around 1 million fishers, workers and their families, and the annual per capita consumption of fish ranges from 12 to 15 kg annually (Herath et al. 2019), constituting around 50 per cent of the annual per capita animal protein intake (WB n.d.). It is therefore essential for the country to safeguard its water environments and increase resilience of interlinked social and ecological systems from any human-induced or naturally occurring stressors. Environmental depletion and climate-induced changes increase the pressure on women's time, income, health, nutrition and social support systems in Sri Lanka (UNESCAP 2017). Women in Sri Lanka may face additional barriers to participating in decision-making processes related to the environment and natural resources, which limit their ability to advocate for their own needs and the needs of their communities (UN WOMEN 2022b).

In the context of this report, three marine indicators were identified from the SDG indicator framework to describe the state of the country's marine-related ecosystems (see Annex D, table D.3), with only SDG indicator 14.1.1a on index of coastal eutrophication having sufficient data availability.

Map 5.3 Official map of Sri Lanka, (United Nations, 2022)

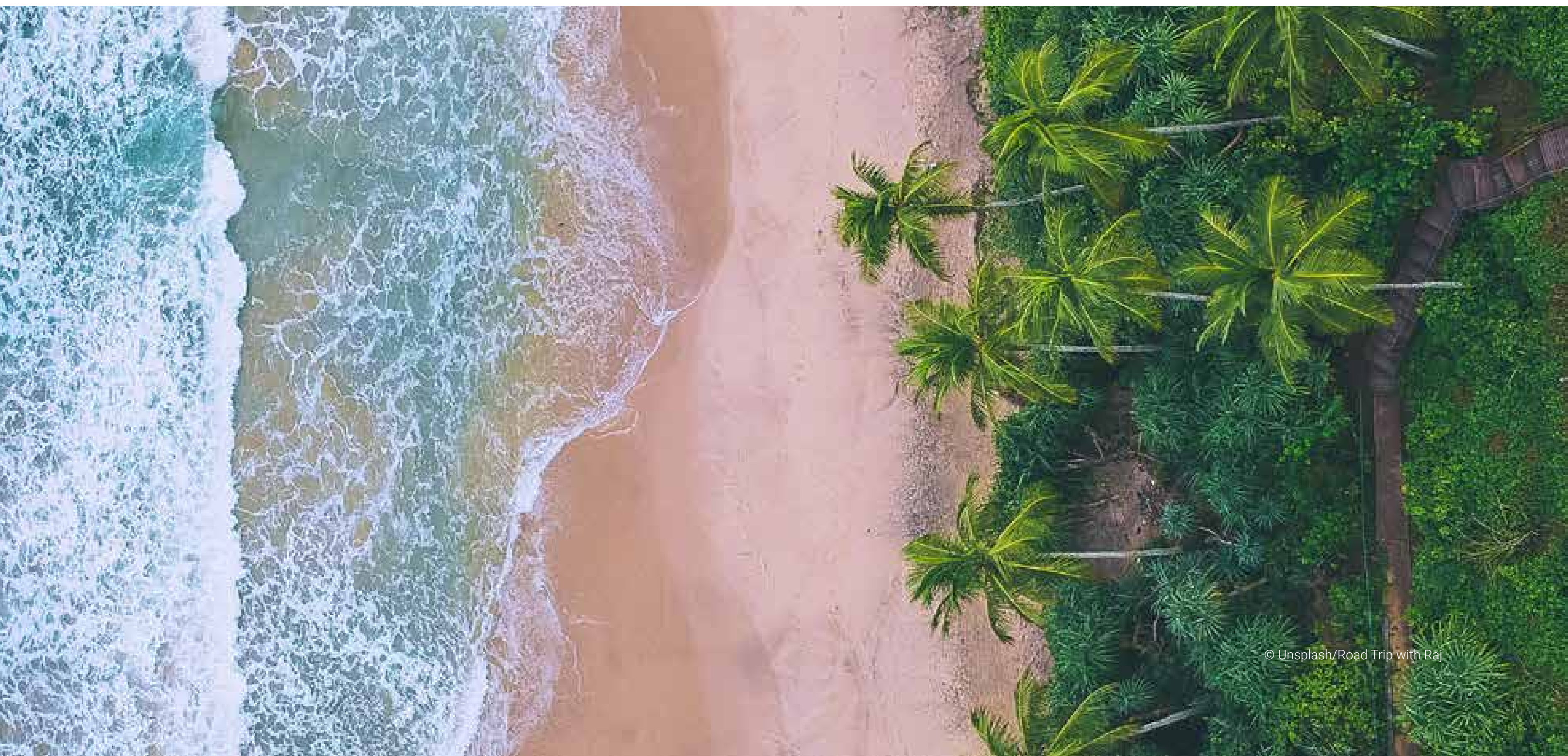
Many sub-indicators (more than 100) were considered for analysing the potential relationships on a national level that may impact the levels of coastal eutrophication in a positive or negative way, and secondary relationships between the state of marine-related ecosystems and their impact on human well-being indicators. A total of 18 sub-indicators (10 indicators as drivers of change, one indicator as state of marine-related ecosystems and seven indicators as socioeconomic and environmental factors) were eventually included in the primary analysis of drivers of change for Sri Lanka, and nine indicators for the secondary analysis on the state of human well-being (one indicator as state of marine-related ecosystems, one indicator as state of human well-being and seven socioeconomic and environmental factors), as the rest of the indicators did not fit the minimum requirements for the analysis. As a result, there was no statistically significant relationships identified by the statistical model.

There are several reasons that could explain the non-existence of statistically significant results by the current model. One relates to the availability of data at the national level. The resulting indicators of the available data may not correspond to the factors that actually impact the state of marine-related ecosystems in Sri Lanka, nor the state of human well-being. In addition, there might be a need for additional research that includes more in-depth and fine-grained information on Sri Lanka's national context to be able to capture statistically significant results for marine-related ecosystems in Sri Lanka.

5.4 Conclusion

The aggregation of chlorophyll-a deviations data to the global level blurs any causal linkages between human activities on land and the responses of plankton growth in the coastal zone. This absence of significant relationships in Sri Lanka currently makes it impossible to provide a better understanding of the type of interlinkage at the national level. In addition, the unavailability of data (SDG 14.1.1b on plastic debris density and SDG 14.3.1 on average marine acidity) or time series (SDG 14.4.1 on the proportion of fish stocks within biologically sustainable levels) for SDG marine-related ecosystem indicators limits one's understanding about how marine-related ecosystems are impacted by the various drivers and pressures, hindering the development of targeted policy interventions. Although data availability for SDG 14 has improved, the current availability of data does not provide an understanding robust enough to formulate policies.

On the other hand, although coastal dead zones can usually be linked directly to activities within particular river catchments, the aggregation of chlorophyll-a data to the country level means that chlorophyll-a data at the national scale represent the combination of the status of all watersheds emptying into each country's coastline. The national value may or may not reflect changes for a particular river system (or group of river systems) depending on the size and geography of the individual country. This challenge in interpreting the indicator increases as the length of the coastline increases and is very serious for large countries such as Canada, the Russian Federation and the United States of America. A further disaggregation to and reporting of SDG 14.1.1a at the subnational level (i.e. local watersheds) is needed to provide a better understanding about the source of these dead zones (source-to-sea approach) (UN 2021b) and transport routes (i.e. identification of water streams).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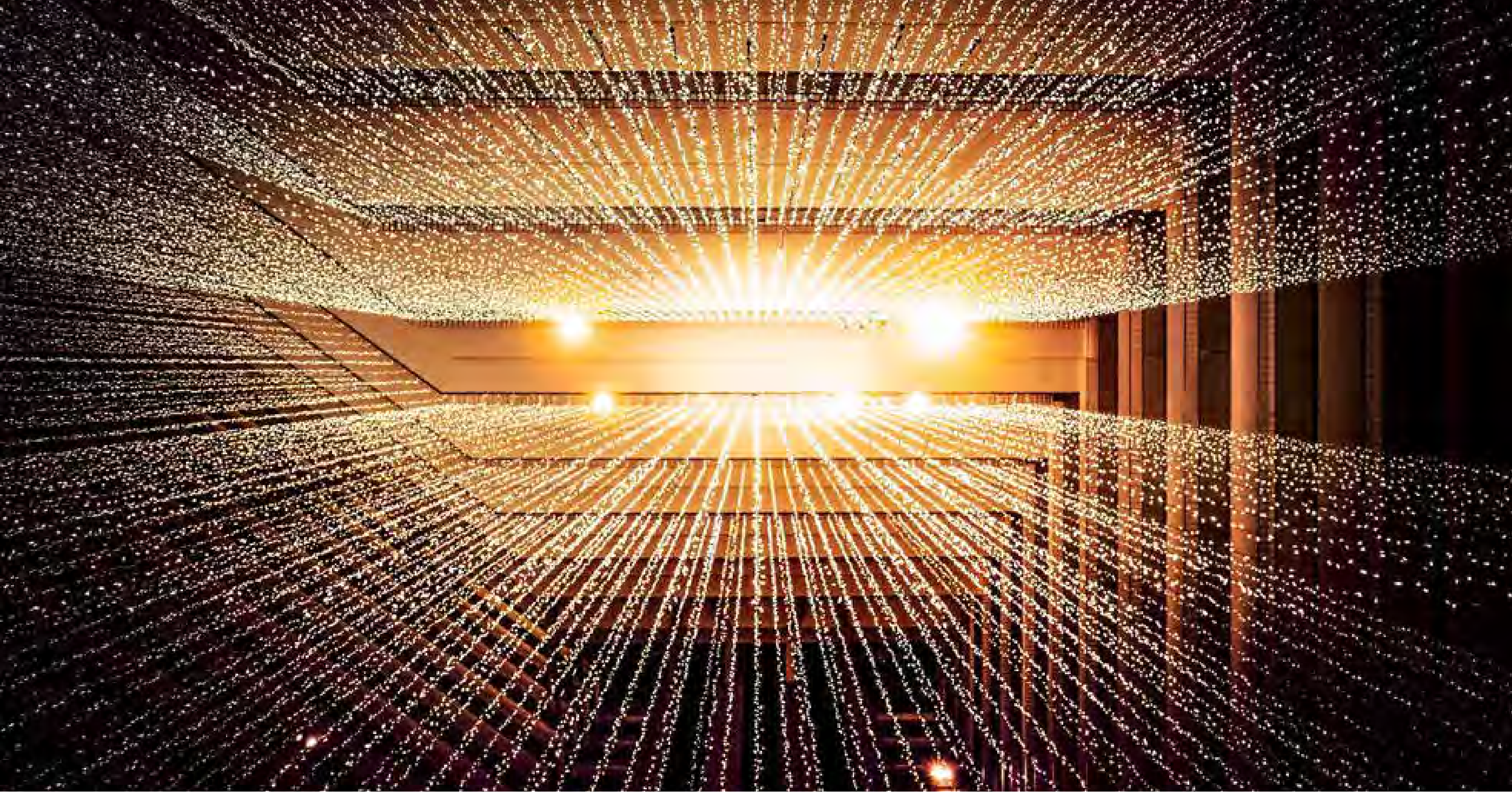

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Chapter 6: Data opportunities

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6.1 Current use of big data in the SDGs

The fulfilment of the SDGs is hindered by the lack of data for effective monitoring and implementation. The official framework of indicators for monitoring the SDGs has undergone several revisions since its adoption in 2015 (UNGA 2017b), and has adopted a tier system to assist in evaluating data availability at the global level. As at 4 February 2022, 136 indicators were categorized as Tier I, 91 indicators as Tier II and four indicators as multiple tiers (IAEG-SDGs 2022). This indicates that, seven years after adoption, a significant number of indicators lack data for more than half of the countries. The gaps are even greater for environment-related SDGs, where insufficient data to report progress were around 58 per cent of indicators at the global level (UNEP 2021b).

Data collected from traditional sources by national statistical offices (NSOs), government ministries and international organizations currently provide the main input to the SDG indicator framework (UNSDSN 2015). Although valuable and necessary, these traditional sources of data fall short due to high costs, poor timeliness and coarse spatial granularity. In recent years, big data sources are increasingly being recognized as new and innovative information sources for SDGs (MacFeely 2019; IAEG-SDGS 2019; Tam and Van Halderen 2020). Many NSOs are already experimenting with big data in the production of official statistics, with initiatives catalogued by the United Nations Global Working Group on Big Data and the United Nations Global Pulse. Currently, the dominant big data types include Earth Observation (EO) data, citizen science, other sensor network data, commercial data, tracking data, administrative data, and opinion and behavioural data. Combined with advanced analytical techniques (e.g. machine learning, geospatial modelling and geostatistical modelling), they could contribute to the monitoring of 15 goals, 51 targets and 69 indicators (Allen et al. 2021), particularly those related to health and biodiversity.

6.2 Potential use of big data in other environment-related SDG indicators

In general, big data would play a key role in the monitoring and reporting of SDGs through addressing the remaining gaps (e.g. in terms of providing new data sets for Tier II indicators), allowing for more timely and disaggregated data sets to fill gaps in time series and spatial coverage for Tier I indicators and contributing disaggregated information to official indicators. For instance, big data has shown great potential in water-related and other environment-related SDG indicators, among which EO data and citizen science were most widely exploited (UNESCAP 2021b). Big data may be used in conjunction with or as a replacement for traditional data sources to improve, enhance and complement existing statistics.

6.2.1 Satellite and other EO data

Satellite and other EO data hold huge potential for monitoring indicators describing the environmental aspects of the planet and to support the aim of the 2030 Agenda to leave no one behind as, by nature, space-borne observations are borderless, impartial and inclusive of all. In 2018, the Committee on Earth Observation Satellites (CEOS) with the support of the European Space Agency (ESA) pointed out that 73 targets and 29 indicators in total could be supported by EO data sets and that UNEP was one of the custodians whose indicators could benefit the most from EO (CEOS 2018). SDG 2 on zero hunger, SDG 6 on clean water and sanitation, SDG 11 on sustainable cities and communities, SDG 13 on climate action, SDG 14 on life below water and SDG 15 on life on land are mostly appropriate for EO since their targets and indicators require information on land cover, land productivity, above-ground biomass, water extent, greenhouse gas emissions or air pollution.

Many agencies and initiatives are spearheading efforts to support the monitoring of the SDGs with EO: (a) The EO4SDG initiative was launched in 2016 by the Group on Earth Observations (GEO) (GEO 2022); (b) in 2016, CEOS established the CEOS Ad Hoc Team on SDGs (CEOS n.d.), dedicated to improving coordination between the world's space agencies in support of satellite data provision for the 2030 Agenda; (c) the development of a series of reports by the International Research Center of Big Data for SDGs (CBAS) on how EO could facilitate many goals at the local and global scales (CBAS n.d.a); (d) the Sustainable Development Science Satellite (SDGSAT-1) Open Science Program, launched in 2021 (CBAS n.d.b), consists of a sharing platform for SDGSAT-1 data; (e) UNESCO's World Water Quality Portal monitors water quality by using satellite EO data (UNESCO 2022).

Satellite data combined with advanced analytical methods (e.g. machine learning and geospatial modelling) could provide new global data sets for monitoring official SDG indicators. Currently, several SDG indicators have satellite-based data and are summarized in Table 6.1.

Table 6.1 Satellite data used in total or partial in SDG indicators

SDG indicator	Total or partial use	Type of data	Reference
2.4.1 on sustainable agricultural practices	Partial	Landsat or Sentinel images were employed to map cropland distribution and cropping index distribution	(Zhang et al. 2020; Potapov et al. 2022)
6.3.2 on water quality	Partial	Multiple EO data sets were used to monitor total suspended solids, chlorophyll-a, phycocyanin and cyanobacteria	(Wang et al. 2022)
		EO satellite-derived combined with in situ data for measuring water turbidity, suspended particulate matter, chlorophyll-a, cyanobacteria and harmful algal blooms, dissolved organic matters and water surface temperature	(UNESCO 2022)
6.6.1 on the extent of water-related ecosystems	Partial	Gravity satellites (GRACE and GRACE-FO) were used to assess the dynamic changes of groundwater to assess water shortage and guide necessary response actions	(Sun 2013)
6.6.1 on the extent of water-related ecosystems	Total	Global Surface Water Explorer data set, developed by the European Commission Joint Research Centre	(EC 2019)
11.1.1 on population living in slums	Partial	High-resolution satellite imagery and deep learning methods were applied to identify the extent of urban slums in selected major cities	(Stark et al. 2020; Wurm et al. 2019)
11.3.1 on ratio of land consumption to population growth	Total	Global open and free data (Global Human Settlement Layer, GHSL)	(Schiavina et al. 2019)
11.6.2 on fine particulate matter mean levels in cities	Partial	Satellite data and the Data Integration Model for Air Quality (DIMAQ) were used to model particulate matter ($PM_{2.5}$ and PM_{10}) concentrations and population exposure	(Shaddick et al. 2020)
13.1.1 on people affected by disasters	Partial	Satellite data can be used to monitor and forecast extreme weather such as droughts, floods, heatwaves and storms, provide global space-time information on losses caused by natural disasters and prepare for disasters	(UNDRR 2022)
13.2.2 on greenhouse gas emission	Partial	Satellite data can provide basic data such as ground cover distribution, human activities and greenhouse gas concentrations	(Lamb et al. 2021; UNEP and CCAC 2021)

SDG indicator	Total or partial use	Type of data	Reference
14.3.1 on ocean acidification	Partial	CoastWatch, developed by NASA, produces daily chlorophyll-a data from Copernicus S-3A OLCI and Copernicus S-3B OLCI	(NOAA 2023)
14.1.1b on plastic debris density	Partial	Automated method for detection and classification of floating plastic materials from Sentinel-2 multispectral imagery using the Naïve Bayes classification algorithm	(Biermann et al. 2020)
15.1.1 on forest area	Total	Use of freely available geospatial data and products by countries for reporting as part of the Global Forest Resources Assessment	(FAO 2020)
15.1.1 on forest area	Partial	Two data products were developed: the Forest Structural Condition Index and the Forest Structural Integrity Index to monitor forest quality	(Hansen et al. 2019)
15.2.1 on sustainable forest management	Partial	Global forest height was mapped by integrating Global Ecosystem Dynamics Investigation and Landsat data	(Potapov et al. 2021)
15.3.1 on land degradation	Total	Open software and global data sets	(Giuliani et al. 2020)
15.4.2 on the Mountain Green Cover Index	Total	Land cover, vegetation indices and topographic data sets	(Bian et al. 2020)
15.5.1 on threatened species	Partial	Satellite imagery and machine learning methods are used to develop global data sets	(Jung et al. 2020)

6.2.2 Citizen science

Citizen science can be broadly defined as public participation in scientific research and knowledge production (Fraisl et al. 2022a). Citizen science activities can take diverse forms, from hypothesis-driven projects led by scientists where volunteers are only involved in data contribution to initiatives designed by scientists and volunteers together where volunteers participate in more or all aspects of the project, for example, identifying the research questions, collecting data, analysing the data and disseminating the results. Sharing observations related to biodiversity, classifying galaxies, collecting plastics and other litter and relevant data from rivers, seas and oceans, and measuring water or air quality are just a few examples from environmental citizen science activities. Citizen science has great potential in SDG monitoring and reporting. A review showed that the reporting of 76 indicators could benefit from citizen science, specifically SDG 15 on life on land, SDG 11 on sustainable cities and communities and SDG 6 on clean water and sanitation (Fraisl et al. 2020).

Citizen science data are already being used to report on several SDG indicators. For instance, the Ghana Statistical Service and the Environmental Protection Agency have recently integrated citizen science beach litter data into their official statistics. Ghana has become the first country to use citizen science data on marine plastic litter in their official monitoring and reporting of SDG indicator 14.1.1b. The initiative has helped bridge local data-collection efforts by citizen scientists with global monitoring processes and policy agendas by leveraging the SDG framework. The results have been used in Ghana's latest voluntary national review for the SDGs and have reported on the United Nations Global SDG Indicators Database, helping to inform relevant policies in Ghana (Olen 2022; NDPC 2022). Biodiversity and conservation are also areas with a strong citizen science presence. For example, SDG indicator 15.5.1 on the Red List Index uses BirdLife International's network of scientists and more than 2 million birders and local volunteers to compile data on birds (BirdLife International 2022). Another example is the contribution of citizen science to the establishment of protected areas of important terrestrial, freshwater and mountain sites (SDG indicators 15.1.2 and 15.4.1). More than 13,000 Important Bird and Biodiversity Areas in global KBAs were established by BirdLife International using data from their volunteer network (Donald et al. 2019). FreshWater Watch is a global citizen science project and platform for monitoring freshwater quality, which has empowered tens of thousands of people around the world to become citizen scientists since 2012. These citizen scientists are improving monitoring, management and idea-sharing about freshwater-related ecosystems in their local areas (FreshWater Watch 2022). Air and water quality are two other important areas that benefit from citizen science. Several citizen projects have included citizens in measuring $PM_{2.5}$ and PM_{10} related to SDG indicator 11.6.2 by using low-cost pollution monitoring sensors, such as the CITI-SENSE project, hackAIR, AirCasting and AirVisual (Fraisl et al. 2020). These citizen projects are valuable for detecting changes in previous levels of $PM_{2.5}$ and PM_{10} and provide detailed spatial distributions across cities, which cannot be produced with the current density of official air monitoring stations.

In addition to supporting the existing system of SDGs, citizen science provides opportunities to contribute to the generation of additional goals and targets where gaps can be identified. Air quality monitoring demonstrates this potential. Currently, two SDG indicators are directly linked to air quality: (i) SDG indicator 3.9.1 on mortality rate attributed to household and ambient air pollution and (ii) SDG indicator 11.6.2 on annual mean levels of fine particulate matter (e.g., $PM_{2.5}$ and PM_{10}) in cities (population-weighted). Citizen science can fill this gap through the novel application of traditional sensors such as Palmes diffusion tubes (Haklay and Eleta 2019) and the ongoing efforts to develop reliable low-cost electrochemical sensors (Clements et al. 2017). CurieuzeNeuzen (Curious Noses) is a citizen science project involving the use of diffusion tubes to monitor air quality in Antwerp, Belgium. Engaging 2,000 participants, the project resulted in positive behavioural change in the participants while simultaneously driving political debate on air pollution and mobility measures (Van Brussel and Huyse 2019). Therefore, the opportunity exists to build a global network of projects that could be linked to a new indicator, which in turn could be used for future global environmental monitoring efforts.

6.2.3 Other forms of big data

Different sensor networks have been utilized for monitoring SDG indicators. For instance, air pollution monitoring stations are used by the World Health Organization to model particulate matter for SDG indicator 11.6.2, which then feeds into SDG indicator 3.9.1. The Global Ocean Acidification Observing Network[12] is used for monitoring ocean acidification for SDG indicator 14.3.1 on marine acidification.

Mobile phones can support the estimation of human mobility after disasters by using SIM card locators, which indirectly contribute to the measurement of SDG indicator 1.5.1/11.5.1/13.1.1 on people affected by disasters. Mobile phones can also inform population hotspots, social events and home locations, origin-destination flows and geo-social radiuses, which feed into SDG indicator 11.2.1 on the proportion of population that has convenient access to public transport.

6.3 Potential use of big data for disaggregated environment-related SDG indicators

Improving data disaggregation is fundamental for the complete implementation of the SDG indicator framework as it fulfils the 2030 Agenda pledge to leave no one behind. For environment-related indicators, the disaggregation would be extremely useful

12 For more information, please visit: http://goa-on.org/.

since most environmental variables do not follow national boundaries, and different groups of people have obvious differences in vulnerability, adaptability and responses to environmental problems (UNEP 2021b; Delli Paoli and Addeo 2020).

Understanding environment-related SDG indicators in different geographic locations can provide important information at the subnational, subadministrative, river basin and/or grid levels for realizing the SDGs. EO data, location-based survey or sensor network data combined with advanced analytical methods (e.g. machine learning, geospatial modelling) can be used for these types of disaggregation. For example, Fehri et al. (2019) used administrative data combined with irrigation data estimated by remote sensing to present a data-driven method allowing to disaggregate SDG indicator 6.4.1 on water stress to higher spatial and temporal resolution. In addition, satellite-based data are used as input climate data to global hydrological models (Sood and Smakhtin 2015). Fitoka et al. (2020) conducted an Object-Based Image Analysis approach based on Sentinel-2 and Landsat 5 TM satellite images to extract changes in the spatial extent of water-related ecosystems in the Greek Ramsar sites and their catchments in support of the basin-level disaggregation for SDG indicator 6.6.1. Leasure et al. (2020) developed a Bayesian modelling framework to produce a 10-metre spatial resolution national population data set that combined population data from recently conducted microcensuses with several geospatial covariates.

Environment-related SDG indicators disaggregated by demography carry great potential for understanding how different groups of people interact with the environment. For such types of disaggregation, survey data, citizen science, opinion (e.g. social media data) or behavioural data combined with statistical, cloud computing or deep learning methods can be used. For example, cell phone communications and airtime credit purchase history could assist in estimating the relative income of individuals, the diversity and inequality of incomes and an indicator for socioeconomic segregation for fine-grained regions, and then disaggregate indicators by different income levels (Blumenstock, Cadamuro and On 2015). Statistics Indonesia (2020) and a range of partners are using mobile positioning data to increase coverage and granularity for tourism statistics (12.b.1).

6.4 Challenges and possibilities

Big data offer a wide range of potential opportunities: cost savings, improved timeliness, greater granularity, link ability and scalability, improved international comparability, new dynamic indicators and more. Big data may offer solutions to data deficits in the developing world where traditional approaches have so far not reached the target of full data availability. But of course, big data also present risks and challenges for reporting on the SDG indicator framework.

a. Relevance

Until now, big data-based data sets have provided only partial or complementary data sets for monitoring official SDG indicators. Although these data sets have improved granularity and timeliness, their lower relevance has not been able to meet the demand of the NSOs in charge of reporting on the SDG indicator framework. In addition, other big data types, such as opinion and behavioural data, commercial data and administrative data, are mainly used for social and economic related SDG indicators, whose utilization for environment-related indicators is not well covered. Therefore, identifying big data-based data sets that have a clear link with SDG indicators will be of greater utility to national SDG monitoring institutions.

Policy relevance and operational application are imperative, as is the relevance to official indicator definition. The successful practices link global open access data sets with tools and e-learning courses to improve the practical skills of users. The World Bank's Light Every Night open data repository provides open access to standardized and analysis-ready geospatial data combined with code, tools and training for countries or stakeholders to discover, process and analyse (WB 2020b). The global FreshWater Ecosystems Explorer (UNEP n.d.e) is being tested by countries to support national monitoring for SDG indicator 6.6.1 on freshwater extent. CBAS developed a suite of online calculation tools for SDG indicators (including 11.1.1 on urban population living in slums, 15.1.1 on forest area and 15.3.1 on degraded land, among others), which could support monitoring the global indicator framework and reporting for user-specified regions (CBAS n.d.c).

b. Accessibility

Many big data are proprietary, that is, commercially or privately owned and not publicly available. Consequently, many big data are not currently accessible, either because costs are prohibitive or proprietary ownership makes it difficult. For example, data generated from the use of credit cards, search engines, social media and mobile phones are all proprietary and often inaccessible. Most projects listed in the Big Data Inventory of the United Nations Global Working Group on Big Data for Official Statistics are pilot studies or remain in planning stages because of data inaccessibility (MacFeely 2019), except for those projects using EO and citizen science as data sources.

In this context, the introduction of FAIR (Findable, Accessible, Interoperable and Reusable) principles to SDG data management is imperative, requiring special focus on the future interoperability of data and data platforms. The geospatial community has embraced FAIR data principles and has long appreciated the need for accessible and interoperable data. Therefore, the provision of open-source and freely available satellite images and citizen science tools holds considerable potential (Fraisl et al. 2022b). Big data can be used through cloud computing and cloud-based data engines, which allow users to conduct analyses online without the need to download or upload any large data sets. Some global initiatives exist for improving the access and application of EO data (GEO, CEOS, UN-GGIM, EO4SDG and SDGSAT-1), along with citizen science initiatives that help accelerate SDG data acquisition and analysis. Organizations such as the Citizen Science Global Partnership, citizen science association, their working groups and current communities of practice in citizen science have worked actively with NSOs to bring citizen science into the scope of official reporting. For example, the communities of practice on citizen science and the SDGs mapped existing contributions of citizen science to SDG indicators and explored further contributions to additional indicators, as part of the WeObserve project (Fraisl et al. 2022b).

c. Validity and veracity

Big data face the uncertainty of long-term stability or maturity as well as their practicality as a data source for reporting on the SDG indicator framework. For instance, social media may tweak their services to test alternative layouts, colours or design, which in turn may mutate or distort the underlying data, making data inconsistent across users and/or time.

Another key challenge relates to methodologies used for big data (Struijs, Braaksma and Daas 2014), including representativeness and stability to be used in official statistics (MacFeely 2019). For instance, mobile or social media data comprise observational data and are not deliberately designed for data analysis. They do not have a well-defined target population, structure or quality, which makes it difficult to apply traditional statistical methods based on sampling theory; the unstructured nature makes it difficult to extract meaningful statistical information.

Concerns about veracity arise from the concentration of data platforms. For example, Reich (2015) notes that in 2010, the top 10 websites in the United States accounted for 75 per cent of all page views. Similarly, market dominance by a few companies introduces obvious risks of abuse and manipulation, raising serious questions for the continued veracity of any resultant data. Even for the EO data sets applications, predictions vary depending on the classifier and set of training and testing data used (Mondal et al. 2019). While these near-automated approaches can be applied to support decision-making across large regions, they also need to include uncertainty analyses, particularly in heterogeneous landscapes.

The development of best practice standards pertaining to methodology, quality and validation are urgently needed. The United Nations Global Working Group on Big Data for Official Statistics is investigating these issues. Currently, 10 rules of engagement exist for NSOs which can guide decisions around the use of big data sources in national official statistics (Tam and Van Halderen 2020). An outline is available about leading practice validation procedures and accuracy assessment for EO data used in big data analyses based on response design, sampling design and accuracy analysis (Marconcini et al. 2020). These provide potential frameworks and guidance for future consideration and validation of data sets to support national monitoring of the SDGs.

6.5 Conclusion

Data for SDG indicators are largely populated by traditional data from NSOs, other government ministries, official agencies and international organizations. However, data revolution carries great potential by using already available data sets in a structured manner and alongside traditional data. Such data can respond to the increasing demand for high-resolution spatial and temporal data and can be timely for decision-making. The development of principles on the use of big data is imperative to set the grounds for identifying usable, comparable, relevant and accessible data. This needs to be done in collaboration with NSOs and the international statistical community to identify and organize the potential use of big data to complement traditional data. The adoption of such principles by the international community needs to be followed by national policies to regulate and organize such a sector. This will require resource mobilization, partnership with the private sector as well as public engagement by consenting on the use of private data for the development of national statistics.

The development of new models that use big data and cutting-edge technologies for monitoring SDG indicators is needed. Based on methodological standards and validation procedures, these models ensure data set quality, thus addressing data gaps by providing high-quality and spatiotemporally consistent global SDG indicators data.

Utilizing big data for reporting on the SDG indicator framework requires improved skills and capacities to work with such cumbersome data sets, which in turn would require national capacity-building to acquire, process and utilize big data sources through tools, scalable applications and training or guidance for governments, users and manuals.

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Chapter 7: Conclusions and recommendations

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This report focuses on evaluating interlinkages and trends between major global drivers and marine and freshwater indicators within the SDG indicator framework. Although the progress made in relation to the 92 environment-related SDG indicators is presented, the overall progress towards attaining the SDG targets is not, as those findings are reported elsewhere (for instance (UN 2022b)). This work represents a major step forward in using analytical methods to explore well-known and lesser-known interlinkages between water indicators and other environmental, social and economic factors.

7.1 Progress on environmental SDG indicators

Global analysis of the progress of the 92 environment-related SDG indicators indicates an improvement in data availability. A total of 59 per cent of the 92 environment-related SDG indicators have sufficient data to analyse, compared with 42 per cent in 2020 and 32 per cent in 2018 (UNEP 2021b; UNEP 2019c).

While more indicators have sufficient data for analysing progress, the number of both indicators showing positive and negative or little change has increased. Among the SDG environment-related indicators, 38 per cent show positive change indicating environmental improvement, an increase from 28 per cent reported in the previous report (UNEP 2021b). In parallel, 21 per cent of SDG environment-related indicators are showing negative or little change, an increase from 14 per cent reported for 2020.

Global policy discussions benefit not only from improved data availability for SDG indicators but also from new analytical approaches to understanding the underlying linkages and drivers of indicator trends. This report represents one new analytical approach that has the potential to contribute to a more policy-relevant integrated analysis. The relationships explored in this report provide a global-scale confirmation of relationships between SDGs and their indicators that have been explored at smaller scales elsewhere. Further, the analysis has helped identify critical gaps in indicator data and challenges with disaggregated data that ought to be resolved to achieve more meaningful policy analyses in the future.

7.2 Integrating SDG indicators: Piloting new analytical approaches through water data and indicator

Global assessments of water resources have always been challenged by the availability of global data sets that can provide meaningful trends of changes in both freshwater- and marine-related ecosystems. It has been even more difficult to link the state and trends of water-related ecosystems to policy interventions at all scales using data-driven and scientifically defensible methods.

The international community accepted the challenge of increasing the consistency, scientific defensibility and policy relevance of environmental data to inform global trends and policy through the development of the SDG indicator framework. This report represents one of the first attempts to identify statistically based interlinkages between environmental, social and economic drivers and freshwater- and marine-related ecosystem indicators.

This undertaking has exposed the need for even better and more innovative approaches to developing global data sets and to refining global water indicators. Of the 22 freshwater and marine indicators included in the SDG framework, five have been classified as representing change to ecosystems (two for freshwater and three for marine). These indicators represent the heart of the analysis presented in this report. However, only one indicator for each of the marine and freshwater trends had sufficient data to conduct a linkage analysis with other indicator data sets, so the indicator that was used to evaluate change in the freshwater ecosystem was "change in the extent of water-related ecosystems over time" (SDG indicator 6.6.1) for which 22 data points were available. In the marine environment, the index of coastal eutrophication and floating plastic debris density (SDG indicator 14.1.1) was assessed through the single sub-indicator of chlorophyll-a deviations with 17 data points available.

The challenge of analysing SDG indicators due to a lack of data cuts across the environment-related SDG indicators set as mentioned above. Data tracking gender equality and the inclusion of vulnerable groups in water management and governance are not available. The linkages between water and gender need to be addressed, as women's gender roles often mean that they interact with natural resources, especially in developing countries. Understanding these inextricable linkages can lead to the formulation of gender-responsive plans, policies and strategies in line with international frameworks and agreements. Monitoring and tracking such data ensure that all key stakeholders are involved and such an inclusive approach is more likely to lead to environmental sustainability while contributing to the environmental SDGs as well as cross-cutting SDGs such as SDG 5.

Thus, a key conclusion from this report is the need to bolster data collection for other environment-related indicators and to re-evaluate the suitability of the current indicator methodologies to parse true change in the environment from data and methodological artefacts.

7.3 Key findings: Global freshwater-related ecosystems

Freshwater-related ecosystems continue to be degraded at an alarming rate. Estimates of over 85 per cent of wetlands have been lost over the past 300 years, and the effect on other freshwater ecosystems is accelerating (UN 2022b). This is despite 62 per cent of indicators indicating a positive change at the global scale representing the 22 freshwater-related indicators including ecosystems and human uses and activities.

The analysis presented in Chapter 4 of this report indicates that land conservation indicators are tightly linked to freshwater-related ecosystem status, emphasizing the importance of land management practices in supporting healthy lakes, streams and wetlands. The analysis also identified a strong negative relationship between GNI per capita and the extent of freshwater area. Economic activity continues to have a direct impact on the degradation of freshwater systems. This emphasizes the need to carefully evaluate the optimal locations for water-intensive industries and to place value on the services provided by healthy freshwater-related ecosystems.

The analysis also identified the impact on freshwater resources of developing drinking water infrastructure without attention to water-use efficiencies. At the global level, all state of human well-being indicators were negatively related to freshwater area both seasonally and as annual minimums and maximums. Experts deduce that this could be related to the role that freshwater plays in supporting public health and economic prosperity. Many jobs are found in water-intensive sectors such as energy production, manufacturing and agriculture, creating a strong link between human well-being and freshwater resources. Investments in new water infrastructure should focus on developing water resources for human use in ways that provide a sustainable supply of clean water without causing irreversible harm to freshwater streams. Further, infrastructure investments should include provision for both drinking water and proper treatment of wastewater especially in urban settings and be linked to the circular economy. Water is uniquely positioned to become circular if proper infrastructure is designed to improve efficiency, water reuse (especially in the energy and mining sectors), the integration of grey water into urban landscapes and improved agricultural water sustainability.

Some linkages between freshwater indicators and other SDG indicators do not have a certain causal mechanism. For example, a decline in the status of species listed as threatened by extinction appears to be related to improvements in freshwater area. However, additional investigation would be needed to determine if this link is more than an artefact of the data and/or analysis methods and what underlying mechanisms may be at play.

7.4 Key findings: Marine-related ecosystems

Stresses on marine-related ecosystems are well documented both in scope and magnitude. Increased plastic pollution, eutrophication and overfishing (including from illegal, unregulated and unreported sources) as well as climate-driven increases in water temperature and acidification all continue to degrade the health of coastal and other marine-related ecosystems (UN 2022b).

In 2017, 2.4 billion people lived in areas within 100 km of the coast (UN 2017), and recent assessments estimate that only around 16 per cent of global coastal regions are ecologically intact, while 48 per cent are heavily affected by human activities and 84 per cent of countries had more than 50 per cent of their coastal regions degraded (Williams et al. 2022).

The analysis summarized in Chapter 5 attempted to link the eutrophication component of marine-related ecosystem status to various potential drivers. The strongest positive linkage was found between the proportion of population living in an urban area and increased chlorophyll-a deviations. This finding is consistent with the literature documenting eutrophication of coastal areas that receive effluents from large cities or are linked to large riverine inputs of freshwater and nutrients draining large areas of agricultural and urban land uses.

Unfortunately, the aggregation of the chlorophyll-a data makes linkages difficult to detect, and so, although the analytical approach has merit and the linkages are generally consistent with the literature, no new conclusions can be made about coastal eutrophication and catchment-based human activities at the global scale. Disaggregation of data to a catchment scale, rather than a national one, would be necessary for exploring new relationships in this arena.

7.5 Importance of scale: Global versus national findings

A unique aspect of the analysis presented in this report is the inclusion of both global- and national-level linkages. This approach provides an opportunity to verify global linkages with national case studies, which also helps explore the impact of data aggregation on the ability to detect meaningful linkages between indicators. Each of the countries included in this report have more data on water resources, which can help explore the soundness of the linkages discovered through the global-level analysis.

Indicators related to conservation efforts were the most consistently positively linked to freshwater-related ecosystem indicators at both the global and national scales. This includes measures of terrestrial, mountain and freshwater KBAs. Further, indicators related to urbanization and drinking water infrastructure were also closely linked with freshwater-related ecosystem area at both scales. GNI per capita was also negatively linked with freshwater-related ecosystem outcomes at both the global and national levels. These findings emphasize the importance of policies related to conservation, water infrastructure and the mitigation of impacts associated with economic activity in protecting freshwater-related ecosystems.

Interestingly, linkages between water-use efficiency indicators and freshwater-related ecosystems were found at the national level but were not identified in the global-level analysis. The predominance in Colombia and Mongolia of the relationship between water-use efficiency and water resource indicators might suggest that, in these countries, water management strategies are not sufficient to decouple economic activities from resource use, even though this relationship has not been found at the global level.

Regarding the impact of freshwater-related ecosystems on the state of human well-being, the statistical analysis has identified different direct drivers and socioeconomic and environmental factors for global compared with national settings. Only at the national level were lakes and rivers seasonal areas directly linked with proportion of population accessing basic drinking water services and GNI per capita.

Unfortunately, no national-level analyses were possible for the marine-related ecosystem indicators, so a comparison cannot be made between the global and national levels.

The various positive and negative relationships identified between the state of the ecosystem, direct drivers of change, state of human well-being and socioeconomic and environmental factors highlighted the importance of considering the impact of indirectly related factors. While some impacting factors are common for global and national settings, identifying other national factors considered to have synergies or trade-offs with freshwater-related ecosystems is imperative to be able to formulate targeted policies and interventions to protect freshwater-related ecosystems.

While some linkages were detected at both the global and national scales, others were only identified at the more granular national scale. While global-level trends are critical to assessing overall progress in achieving the SDGs, the importance of also evaluating indicators at the national scale, as demonstrated in this report, will provide a more comprehensive and actionable interpretation of key linkages.

Data and indicators are key for informed decision-making and policy design to know how realistic options are, what inconsistencies might result from decisions, how the cost of such inconsistencies can be mitigated and how trade-offs can be explained. The SDG indicator framework represents a critical advancement towards international goals in increasing the consistency, scientific defensibility and policy relevance of environmental data to inform global trends and policies at all scales. National, subnational and international perspectives should be integrated to ensure policy coherence. Considering that most environmental policies, including water policy, are developed at the national or subnational scale, it is crucial that the successes of the SDG indicator framework be translated into disaggregated data that can inform subnational policies while maintaining compatibility at the global scale.

7.6 Policy recommendations

This report represents the first attempt to use statistical tools to link a broad suite of SDG indicators representing socioeconomic, environmental and human well-being indicators with freshwater- and marine-related ecosystems status. Generally, the strongest linkages are supported by other literature and provide more robust support for policies that integrate land and water conservation, ensure suitable water infrastructure in urban areas, provide mitigation of pollution and address impacts from water withdrawals associated with economic activity. These policies broadly cross the targets identified in SDG 6, SDG 14 and SDG 15 (UNESCO and UN-Water 2020; UNEP 2019d).

Integrated water resources management is an optimal policy response to water resources and ecosystems. This requires the incorporation of scientific analysis of the most relevant external drivers of ecosystem and resource issues and a comprehensive planning approach used in integrated water resources management, in addition to the traditional approach which focuses on stakeholder input. This is critical to achieving policy coherence and recommendations that are both policy relevant but also scientifically defensible. This concept is well represented in SDG target 17.14, which highlights the importance of mechanisms to enhance policy coherence in sustainable development.

Sustainable development and the 2030 Agenda can only be achieved through an all-sectoral approach. Its interlinked nature calls for policy coherence for sustainable development through an integrated approach to ensure the production of complementary policies and avoidance of trade-offs.

7.7 Data and indicator recommendations

Measuring the progress of the 92 environment-related SDG indicators generally evaluated trends but did not assess their magnitude or progress towards meeting targets identified for specific indicators. Although this report provides statistical support for a suite of policy recommendations that have been outlined elsewhere (UNESCO and UN-Water 2020; UNEP 2019d), the analytical approach outlined herein also exposes some of the critical data gaps on water-related ecosystems and has challenged the suitability of some indicators to detect meaningful change in the health of freshwater- and marine-related ecosystems.

The freshwater-related ecosystem assessment was limited to linkages between various metrics of the area of freshwater within each country. While these data sets benefit from the ability to provide consistent measurement using remote sensing across the globe, they are limited in their ability to measure the water quality, volume or ecosystem health of waterbodies. There may be opportunities to further utilize citizen science, satellite imagery or low-cost in situ monitoring to produce measures of water quality and/or volume for reservoirs, lakes and even aquifers. The standardization of water data across agencies that currently collect and publish this information is a major hurdle that will need to be addressed to make good use of existing robust data sets. Currently, citizen science contributes to the monitoring of five SDG indicators (i.e., SDG 14.1.1b on marine litter or SDG 6.3.2 on water quality) with a potential to directly or, through supplementary information, contribute to 76 indicators (Fraisl et al. 2020).

There is also a clear need to continue to scale up consistent water quality monitoring that can be used to inform national- and global-level assessments. Reliable water quality monitoring data are required to assess the status and trends of water quality for human and ecosystem health as well as to inform policymakers in taking appropriate decisions conducive to water resource protection and restoration, both in terms of waterbodies and water-related ecosystems. However, during the 2017 data drive, only 52 Member States reported on their ambient water quality, and some of the submissions contained very few data points (UN-Water 2018a).

Data availability limited the analysis of marine-related ecosystems. Data on plastic debris density (SDG 14.1.1b) was unavailable and time-series data were not yet available for another state of the marine-related ecosystem indicator. Although data availability for SDG 14 has improved, the current availability of data does not provide an understanding robust enough to statistically support policy formulation. Although chlorophyll-a data were available to evaluate coastal eutrophication, the aggregation of chlorophyll-a data to the country level means that the aggregate value may or may not reflect changes for a particular river system (or group of river systems) depending on the size and geography of individual countries. Interpreting the indicator becomes more difficult as the length of the coastline increases, making it a serious challenge for large countries. Disaggregation of chlorophyll-a data at the subnational level (major river basins) is needed to provide a better understanding about the drivers of coastal eutrophication globally. Future revisions of the indicator methodology for coastal eutrophication are recommended to evaluate alternative spatial boundaries for aggregation that represent catchment-scale linkages and/or natural boundaries associated with ecosystem type and function rather than national boundaries.

The statistical model used in this report confirmed many known linkages between freshwater- and marine-related ecosystems and variable drivers. It also identified several new linkages that cannot be easily explained with the existing literature. While authors attempt to postulate potential mechanisms for these linkages, further investigations are needed to identify whether there are covariates or drivers that may help to develop new innovative policies to protect freshwater- and marine-related ecosystems.

As the SDG indicator framework continues to undergo review and revision especially in preparation of the post-2030 Agenda, this report demonstrates the importance of incorporating more ecologically relevant spatial groupings. Catchment-based or ecosystem-based aggregations may provide more insight into the ecological dimension of many of the linkages identified in this report. However, methods and tools used are expected to be concomitantly developed to facilitate actionable use of data by policymakers working within political or geographical boundaries. Further, although remote sensing has provided comprehensive data for the analysis of global trends, there are some clear drawbacks of relying solely on a remote sensing approach. Other methodologies and data are necessary to understand underlying trends in freshwater-related ecosystem health and water quality that cannot be measured with remote sensing.

Finally, the challenges associated to the analysis of economic-socio-environmental interlinkages for freshwater- and marine-related ecosystems exist across the environmental dimension of the SDGs, particularly as related to the lack of sufficient data and the need for additional disaggregated data. An effort to deploy novel sources of data and to assess their reliability and consequent value to policy formulation is critical to the goal of developing science-based action to achieve sustainable development.

References

Aber, J., Neilson, R., McNulty, S., Lenihan, J., Bachelet, D. and Drapek, R. (2001). *Forest processes and global environmental change: predicting the effects of individual and multiple stressors: we review the effects of several rapidly changing environmental drivers on ecosystem function, discuss interactions among them, and summarize pr. 51*(9), 735-751. doi:https://doi.org/10.1641/0006-3568(2001)051[0735:FPAGEC]2.0.CO;2

Adams, J. B., Taljaard, S., Van Niekerk, L. and Lemley, D. A. (2020). Nutrient enrichment as a threat to the ecological resilience and health of South African microtidal estuaries. *African Journal of Aquatic Science, 45*(1-2), 23-40. doi:https://doi.org/10.2989/16085914.2019.1677212

Adeoti, O. (2020). Constraints on data collection implementation at the river basin level in Nigeria. *Journal of Hydrology: Regional Studies, 32*. doi:https://doi.org/10.1016/j.ejrh.2020.100738

African Development Bank Group (2022a). *African Economic Outlook 2022*. Abidjan: African Development Bank Group. Retrieved from https://www.afdb.org/en/documents/african-economic-outlook-2022

African Development Bank Group (2022b). *Water Strategy 2021 - 2025: Towards a Water Secure Africa.* The African Development Bank Group. Retrieved from https://www.afdb.org/en/documents/water-strategy-2021-2025-towards-water-secure-africa

Ahmed, J., Thakur, A. and Goyal, A. (2021). Industrial Wastewater and Its Toxic Effects. In *Biological Treatment of Industrial Wastewater* (pp. 1-14). Royal Society of Chemistry. doi:https://doi.org/10.1039/9781839165399

Akram, R., Fahad, S., Hashmi, M., Wahid, A., Adnan, M., Mubeen, M., . . . Nasim, W. (2019). Trends of electronic waste pollution and its impact on the global environment and ecosystem. *Environmental Science and Pollution Research*, 26, 16923-16938. doi:https://doi.org/10.1007/s11356-019-04998-2

Allen, C., Smith, M., Rabiee, M. and Dahmm, H. (2021). A review of scientific advancements in datasets derived from big data for monitoring the Sustainable Development Goals. *Sustainability Science*, 16(5), 1701–1716. doi:https://doi.org/10.1007/s11625-021-00982-3

Alonso, J. (2020, February 01). *World Wetlands Day: "Wetlands feed humanity"*. Retrieved September 30, 2022, from Science and Ecology: https://www.dw.com/es/d%C3%ADa-mundial-de-los-humedales-los-humedales-alimentan-a-la-humanidad/a-52224354

Anselm, N., Brokamp, G. and Schutt, B. (2018). Assessment of Land Cover Change in Peri-Urban High Andean Environments South of Bogota, Colombia. *Land, 7*(2). doi:https://doi.org/10.3390/land7020075

Asian Development Bank (2020a). *Asian Water Development Outlook 2020: Advancing Water Security across Asia and the Pacific.* Manila: Asian Development Bank. doi:https://dx.doi.org/10.22617/SGP200412-2

Asian Development Bank (2020b). *Overview of Mongolia's Water Resources System and Management: A Country Water Security Assessment*. Manila: Asian Development Bank. Retrieved from https://www.adb.org/sites/default/files/institutional-document/704211/mongolia-country-water-security-assessment.pdf

Asian Development Bank (2022, November 8). *ADB Announces $200 Million Goal for Water Resilience Program*. Retrieved December 17, 2022, from Reliefweb: https://reliefweb.int/report/world/adb-announces-200-million-goal-water-resilience-program

Asia-Pacific Water Forum (2017). *Third Asia-Pacific Water Summit: Water Security for Sustainable Development.* Yangon Declaration: The Pathway Forward. Yangon: Asia-Pacific Water Forum. Retrieved from https://apwf.org/apwf_wp/wp-content/uploads/2017/12/Yangon-Declaration.pdf

Asia-Pacific Water Forum (2022). *4th Asia-Pacific Water Summit: Water for Sustainable Development. Best Practices and the Next Generation. Kumamoto Declaration.* Kumamoto: Asia-Pacific Water Summit. Retrieved from https://apwf.org/apwf_wp/wp-content/uploads/2022/04/Kumamoto-Declaration.pdf

Asia-Pacific Water Summit (2018, January 11). *The 3rd APWS adapted "Yangon Declaration: The Pathway Forward"*. Retrieved September 30, 2022, from Asia-Pacific Water Forum: https://apwf.org/the-3rd-apws-adapted-yangon-declaration-the-pathway-forward/

Archer, E., Dziba, L., Mulongoy, K., Maoela, M. A., Walters, M. and Biggs, R. (2018). *Summary for Policymakers of the Regional Assessment Report on Biodiversity and Ecosystem Services for Africa of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Bonn: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Arum, S., Harisuseno, D. and Soemarno, S. (2019). Domestic Wastewater Contribution to Water Quality of Brantas River at Dinoyo Urban Village, Malang City. *Indonesian Journal of Environment and Sustainable Development, 10*(2). doi:https://doi.org/10.21776/ub.jpal.2019.010.02.02

Awonaike, B., Parajulee, A., Lei, Y. and Wania, F. (2022). Traffic-related sources may dominate urban water contamination for many organic contaminants. *Environmental Research Letters, 17*(4). doi:https://doi.org/10.1088/1748-9326/ac5c0e

Aydin, M., Aydin, S., Beduk, F. and Bahadir, M. (2016). Reuse of wastewater for irrigation in MENA region and Konya experiences. *International Workshop on Wastewater Treatment And Reuse For Metropolitan Regions And Small Cities In Developing Countries.* Recife. Retrieved from https://www.researchgate.net/publication/343914460_REUSE_OF_WASTEWATER_FOR_IRRIGATION_IN_MENA_REGION_AND_KONYA_EXPERIENCES

Banerjee, R., Moller-Gulland, J., van der Linden, W., Khardaeva, O., Retter, M., Subramanian, S. and Eickmann, C. (2014). *Mongolia: Targeted Analysis on Water Resources Management Issues*. The 2030 Water Resources Group. Retrieved from https://2030wrg.org/wp-content/uploads/2014/07/2030WRG_MONGOLIA.pdf

Baranyai, G. (2019). Transboundary water governance in the European Union: the (unresolved) allocation question. *Water Policy, 21*(3), 496-513. doi:https://doi.org/10.2166/wp.2019.033

Bellanger, M., Speir, C., Blanchard, F., Brooks, K., Butler, J., Crosson, S., . . . Le Gallic, B. (2020). Addressing marine and coastal governance conflicts at the interface of multiple sectors and jurisdictions. *Frontiers in Marine Science, 7,* 544440.

Bian, J., Li, A., Lei, G., Zhang, Z. and Nan, X. (2020). Global high-resolution mountain green cover index mapping based on Landsat images and Google Earth Engine. *ISPRS Journal of Photogrammetry and Remote Sensing, 162,* 63-76. doi:https://doi.org/10.1016/j.isprsjprs.2020.02.011

Biermann, L., Clewley, D., Martinez-Vicente, V. and Topouzelis, K. (2020). Finding plastic patches in coastal waters using optical satellite data. *Scientific reports, 10*(1), 1-10. doi:https://doi.org/10.1038/s41598-020-62298-z

BirdLife International (2022). *About us: Who we are.* Retrieved September 30, 2022, from BirdLife International: https://www.birdlife.org/who-we-are/

Blumenstock, J., Cadamuro, G. and On, R. (2015). Predicting poverty and wealth from mobile phone metadata. *Science, 350*(6264), 1073-1076. doi:https://doi.org/10.1126/science.aac4420

Boesch, D. (2019). Barriers and bridges in abating coastal eutrophication. *Frontiers in Marine Science, 6,* 123.

Borja, S., Kalantari, Z. and Destouni, G. (2020). Global Wetting by Seasonal Surface Water Over the Last Decades. *Earth's Future, 8*(3). doi:https://doi.org/10.1029/2019EF001449

Bouchard, R., Hayford, B. and Ferrington, L. (2022). Diversity of Chironomidae (Diptera) along a salinity gradient in lakes of the endorheic Great Lakes region of western Mongolia. *Hydrobiologia*, 849, 2161-2175. doi:https://doi.org/10.1007/s10750-022-04856-2

Bruckner, B., Hubacek, K., Shan, Y., Zhong, H. and Feng, K. (2022). Impacts of poverty alleviation on national and global carbon emissions. *Nature Sustainability, 5*, 311-320. doi:https://doi.org/10.1038/s41893-021-00842-z

Cai, W., Hu, X., Huang, W., Murrell, M., Lehrter, J., Lohrenz, S., . . . Zhao, P. (2011). Acidification of subsurface coastal waters enhanced by eutrophication. *Nature geoscience, 4*(11), 766-770.

Campuzano Ochoa, C., Roldan, G., Torres Abello, A., Lara Borrero, J., Galarza Molina, S., Giraldo Osorio, J., . . . Ruiz, C. (2015). Urban Water in Colombia. In *Urban Water Challenges in the Americas: Aprespective from the Academies of Sciences* (pp. 169-202). Tlalpan: IANAS and UNESCO. Retrieved from https://www.researchgate.net/publication/274006901_Urban_Water_in_Colombia

Canada, Statistics Canada (2017a). *World Water Day...by the numbers.* Retrieved 11 01, 2022, from Statistics Canada: https://www.statcan.gc.ca/en/dai/smr08/2017/smr08_215_2017

Canada, Statistics Canada (2017b). *Section 2: Freshwater supply and demand.* Retrieved 09 30, 2022, from Statistics Canada: https://www150.statcan.gc.ca/n1/pub/16-201-x/2017000/sec-2-eng.htm

Canada, Statistics Canada (2021). *Environmental Thematic Maps and Graphics: Accounting for ecosystem change.* Retrieved 09 30, 2022, from Statistics Canada: https://www150.statcan.gc.ca/n1/pub/38-20-0001/382000012021001-eng.htm

Canadell, J., Monteiro, P. M., Costa, M. H., Cotrim da Cunha, L., Cox, P. M., Eliseev, A. V., . . . Zickfeld, K. (2021). Global Carbon and other Biogeochemical Cycles and Feedbacks. In Climate Change 2021: *The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University.

Candelise, C., Saccone, D. and Vallino, E. (2021). An empirical assessment of the effects of electricity access on food security. *World Development,* 141. doi:https://doi.org/10.1016/j.worlddev.2021.105390

Carpenter, S., Stanley, E. and Vander Zanden, M. (2011). State of the world's freshwater ecosystems: physical, chemical, and biological changes. *Annual review of Environment and Resources,* 36, 75-99. doi:https://doi.org/10.1146/annurev-environ-021810-094524

Castaño-Vinyals, G., Cantor, K., Villanueva, C., Tardon, A., Garcia-Closas, R., Serra, C., . . . Kogevinas, M. (2011). Socioeconomic status and exposure to disinfection by-products in drinking water in Spain. *Environmental Health*, 10(1), 1-6.

Castle, S., Thomas, B., Reager, J., Rodell, M., Swenson, S. and Famiglietti, J. (2014). Groundwater depletion during drought threatens future water security of the Colorado River Basin. *Geophysical research letters, 41*(16), 5904-5911. doi:https://doi.org/10.1002/2014GL061055

Center of Big Data for Sustainable Development Goals (n.d.a). *Reports*. Retrieved September 30, 2022, from International Research Center of Big Data for Sustainable Development Goals: http://www.cbas.ac.cn/en/publications/reports/

Center of Big Data for Sustainable Development Goals (n.d.b). SDGSAT-1 *Open Science Program.* Retrieved September 30, 2022, from International Research Center of Big Data for Sustainable Development Goals: http://www.sdgsat.ac.cn/

Center of Big Data for Sustainable Development Goals (n.d.c). *SDGs Data Analysis*. Retrieved November 10, 2022, from International Research Center of Big Data for Sustainable Development Goals: https://sdg.casearth.cn/en/onlineTools/indicatorCalculate

Chapman, C., Abernathy, K., Chapman, L., Downs, C., Effiom, E., Gogarten, J., . . . Omeja, P. (2022). The future of sub-Saharan Africa's biodiversity in the face of climate and societal change. *Frontiers in Ecology and Evolution*, 744. doi:https://doi.org/10.3389/fevo.2022.790552

Chase, C., Bahuguna, A., Chen, Y., Haque, S. and Schulte, M. (2019). *Water and Nutrition: A Framework for Action*. Washington, DC.: World Bank. Retrieved from https://gdc.unicef.org/resource/water-and-nutrition-framework-action-0

Civitelli, F. and Gruere, G. (2016). Policy options for promoting urban-rural cooperation in water management: a review. *International Journal of Water Resources Development*, 33(6), 852-867. doi:https://doi.org/10.1080/07900627.2016.1230050

Clements, A., Griswold, W., Abhijit, R. S., Johnston, J., Herting, M., Thorson, J., . . . Hannigan, M. (2017). Low-cost air quality monitoring tools: from research to practice (a workshop summary). *Sensors*, 17(11), p.2478. doi:https://doi.org/10.3390/s17112478

Colombia, Ministry of Environment and Sustainable Development (2017). *Biodiversity Action Plan for the Implementation of the National Policy for the Integral Management of Biodiversity and its Ecosystem Services / 2016 - 2030*. Ministry of Environment and Sustainable Development. Retrieved from https://www.cbd.int/doc/world/co/co-nbsap-oth-en.pdf

Committee on Earth Observation Satellites (2018). *Satellite Earth Observations in Support of the Sustainable Development Goals, Special 2018 Edition*. ESA. Retrieved from http://eohandbook.com/sdg/files/CEOS_EOHB_2018_SDG.pdf

Committee on Earth Observation Satellites (n.d.). *CEOS and the UN Sustainable Development Goals*. Retrieved September 30, 2022, from Committee on Earth Observation Satellites: https://ceos.org/sdg/

Conley, D. J., Bonsdorff, E., Carstensen, J., Destouni, G., Gustafsson, B. G., Hansson, L. A., . . . Zillén, L. (2009). Tackling hypoxia in the Baltic Sea: is engineering a solution? *Environ. Sci. Technol.*, 43(10), 3407–3411. doi:https://doi.org/10.1021/es8027633

Constable, A., Harper, S., Dawson, J., Holsman, K., Mustonen, T., Piepenburg, D. and Rost, B. (2022). *Cross-Chapter Paper 6: Polar Regions. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York, NY, USA: Cambridge University Press. doi:doi:10.1017/9781009325844.023

Convention on Biological Diversity (n.d.). *Implications of biofuels on water resources*. Convention on Biological Diversity. Retrieved from https://www.cbd.int/doc/biofuel/Bioversity%20IWMI-Report-Biofuels.pdf

Cooley, S., Schoeman, D., Bopp, L., Boyd, P., Donner, S., Ito, S. I., . . . et al. (2022). *Oceans and Coastal Ecosystems and Their Services. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge UK and New York, NY, USA: Cambridge University Press. doi:doi:10.1017/9781009325844.005

Coordinating Body on the Seas of East Asia (2018). *COBSEA Strategic Directions 2018-2022*. Bangkok: Secretariat of the Coordinating Body on the Seas of East Asia (COBSEA) and United Nations Environment Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/31820/COBSEA2022.pdf?sequ%E2%80%A6

Coordinating Body on the Seas of East Asia (2019). *COBSEA Regional Action Plan on Marine Litter 2019*. Bangkok: Secretariat of the Coordinating Body on the Seas of East Asia (COBSEA) and United Nations Environment Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/30162/RAPMALI_19.pdf?sequence=1&isAllowed=y

Cosgrove, W. and Loucks, D. (2015). Water management: Current and future challenges and research directions. *Water Resources Research, 51*(6), 4823-4839.

Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S., Kubiszewski, I., . . . Turner, R. (2014). Changes in the global value of ecosystem services. *Global environmental change, 26,* 152-158. Retrieved from https://doi.org/10.1016/j.gloenvcha.2014.04.002

Crook, D., Lowe, W., Allendorf, F., Eros, T., Finn, D., Gillanders, B., . . . Hughes, J. (2015, April 25). Human effects on ecological connectivity in aquatic ecosystems: Integrating scientific approaches to support management and mitigation. *Science of the Total Environment, 534,* 52-64. doi:http://dx.doi.org/10.1016/j.scitotenv.2015.04.034

Dandar, E. (2017). *Water resources assessment in cold regions: the Upper Tuul River basin, Mongolia.* Barcelona. Retrieved from https://www.tesisenred.net/bitstream/handle/10803/454981/TED1de1.pdf?sequence=1&isAllowed=y

Dangui, K. and Jia, S. (2022). Water Infrastructure Performance in Sub-Saharan Africa: An Investigation of the Drivers and Impact on Economic Growth. *Water*. doi:https://doi.org/10.3390/w14213522

DataShift (2017). *Using Citizen-Generated Data to Monitor the SDGs. A Tool for the GPSDD Data Revolution Roadmaps Toolkit.* DataShift. Retrieved from https://www.data4sdgs.org/sites/default/files/2017-09/Making%20Use%20of%20Citizen-Generated%20Data%20-%20Data4SDGs%20Toolbox%20Module.pdf

de Barros, B., de Carvalho, E., Pinho, A. and Junior, B. (2022). Inland waterway transport and the 2030 agenda: Taxonomy of sustainability issues. *Cleaner Engineering and Technology, 8*. doi:https://doi.org/10.1016/j.clet.2022.100462

Delli Paoli, A. and Addeo, F. (2020). Big Data to support Sustainable Development Goals (SDGs). In C. Bevilacqua, F. Calabrò and L. Della Spina, *INTERNATIONAL SYMPOSIUM: New Metropolitan Perspectives* (pp. 738-748). Springer, Cham. doi:https://doi.org/10.1007/978-3-030-48279-4_69

Desforges, J., Clarke, J., Harmsen, E., Jardine, A., Robichaud, J., Serré, S., . . . et al. (2022). The alarming state of freshwater biodiversity in Canada. *Canadian Journal of Fisheries , 79*(2), 352-365. doi:https://doi.org/10.1139/cjfas-2021-0073

Diaz, R. J. and Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science, 321*(5891), 926-929. doi:https://doi.org/10.1126/science.1156401

Dickens, C. and McCartney, M. (2019). Water-Related Ecosystems. *Clean Water and Sanitation*, 1-10. doi:https://doi.org/10.1007/978-3-319-70061-8_100-1

Dieter, C., Maupin, M., Caldwell, R., Harris, M., Ivahnenko, T., Lovelace, J., . . . Linsey, K. (2018). *Estimated use of water in the United States in 2015: U.S. Geological Survey Circular 1441*. USGS. doi:https://doi.org/10.3133/cir1441

D'Odorico, P., Davis, K., Orsa, L., Carr, J., Chiarelli, D., Dell'Angelo, J., . . . Rulli, M. (2018). The Global Food-Energy-Water Nexus. *Reviews of Geophysics, 56*(3), 456-531. doi:https://doi.org/10.1029/2017RG000591

Donald, P., Fishpool, L., Ajagbe, A., Bennun, L., Bunting, G., Burfield, I., . . . et al. (2019). Important Bird and Biodiversity Areas (IBAs): the development and characteristics of a global inventory of key sites for biodiversity. *Bird Conservation International, 29*(2), 177-198. doi: https://doi.org/10.1017/S0959270918000102

Dushanbe Water Process (2022). *Second High-Level International Conference on the Internatonal Decade for Action "Water for Sustainable Development", 2018-2028 - Final Declaration, From Dushanbe to New York 2023.* Dushanbe. Retrieved from https://dushanbewaterprocess.org/wp-content/uploads/2022/09/2022-final-declaration-final-draft-0608-en-final.pdf

Ebi, K. and Ziska, L. (2018). Increases in atmospheric carbon dioxide: Anticipated negative effects on food quality. *PLOS Medicine, 15*(7). doi:https://doi.org/10.1371%2Fjournal.pmed.1002600

Economic and Social Commission for Western Asia (2019). Water Action Decde 2018-2028: *Water for Sustainable Development - Arab Region Engagement.* Beirut: United Nations Economic and Social Commission for Western Asia. Retrieved from https://www.unescwa.org/sites/default/files/inline-files/water-action-decade-booklet_en.pdf

Environmental Protection Agency (n.d.). *National Coastal Condition Assessment.* Retrieved 09 30, 2022, from United States Environmental Protection Agency: https://www.epa.gov/national-aquatic-resource-surveys/ncca

Environmental Protection Agency (2022, May 11). *Statistics and Facts*. Retrieved December 15, 2022, from United States Environmental Protection Agency: https://www.epa.gov/watersense/statistics-and-facts#:~:text=The%20average%20family%20can%20waste,gallons%20of%20water%20annually%20nationwide.

European Commission (2019). *Monitoring our Blue Planet: First SDG Indicator Platform Launched by Google, the JRC and UN Environment*. Retrieved 09 11, 2022, from European Commission: https://joint-research-centre.ec.europa.eu/jrc-news/monitoring-our-blue-planet-first-sdg-indicator-platform-launched-google-jrc-and-un-environment-2019-03-15_en

European Commission (2020, December 17). *Recovery plan for Europe*. Retrieved September 30, 2022, from European Commission: https://ec.europa.eu/info/strategy/recovery-plan-europe_en

European Commission (2021a). The *EU Blue Economy Report*. Luxembourg: Publications Office of the European Union. doi:https://10.2771/8217

European Commission (2021b). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a New Approach for a Sustainable Blue Economy in the EU Transforming the EU's Blue Economy for a Sust*. Brussels: European Commission. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0240&from=EN

European Environmental Agency (2018, October 10). *Use of freshwater resources*. Retrieved October 18, 2022, from European Environmental Agency: https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-3

European Environmental Agency (2019, November 4). *Water abstraction by source*. Retrieved October 18, 2022, from European Environment Agency: https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/is-water-abstraction-by-source-sustainable

European Environmental Agency (2021a, November 18). *Ecological status of surface waters in Europe*. Retrieved September 30, 2022, from European Environment Agency: https://www.eea.europa.eu/ims/ecological-status-of-surface-waters

European Environmental Agency (2021b, November). *Publications*. Retrieved from Europe's marine biodiversity remains under pressure: https://www.eea.europa.eu/publications/europes-marine-biodiversity-remains-under-pressure

European Environmental Agency (2022, April 12). *Industrial pollutant releases to water in Europe*. Retrieved September 30, 2022, from European Environment Agency: https://www.eea.europa.eu/ims/industrial-pollutant-releases-to-water

European Environmental Agency and United Nations Environment Programme/ Mediterranean Action Plan (2020). *Technical assessment of progress towards a cleaner Mediterranean: Monitoring and reporting results for Horizon 2020 regional initiative.* Luxembourg: European Environment Agency. Retrieved from https://www.eea.europa.eu/publications/technical-assessment-of-progress-towards

Fehri, R., Khlifi, S. and Vanclooster, M. (2019). Disaggregating SDG-6 water stress indicator at different spatial and temporal scales in Tunisia. *Science of the Total Environment, 694,* 133766. doi:https://doi.org/10.1016/j.scitotenv.2019.133766

Feldman, D. (2022). Adaptive governance: new solutions to new challenges. In *The Governance of Water Innovations* (pp. 96-126). Edward Elgar Publishing. doi:https://doi.org/10.4337/9781800882058

Ferreira, D., Graziele, I., Marques, R. and Gonçalves, J. (2021). Investment in drinking water and sanitation infrastructure and its impact on waterborne diseases dissemination: The Brazilian case. *Science of the Total Environment, 779,* 146279.

Fitoka, E., Tompoulidou, M., Hatziiordanou, L., Apostolakis, A., Höfer, R., Weise, K. and Ververis, C. (2020). Water-related ecosystems' mapping and assessment based on remote sensing techniques and geospatial analysis: The SWOS national service case of the Greek Ramsar sites and their catchments. *Remote Sensing of Environment,* 111795. doi:https://doi.org/10.1016/j.rse.2020.111795

Food and Agriculture Organization of the United Nations (2020). *Global Forest Resources Assessment 2020: Main report.* Rome: Food and Agriculture Organization. doi:https://doi.org/10.4060/ca9825en

Food and Agriculture Organization of the United Nations (2022a, June 24). *Indicators. In: Sustainable Development Goals.* Retrieved from United Nations Food and Agriculture Organization: www.fao.org/sustainable-development-goals/indicators/en

Food and Agriculture Organization of the United Nations (2022b). *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation.* Rome: FAO. doi:https://doi.org/10.4060/cc0461en

Food and Agriculture Organization of the United Nations (n.d.). *Aquastat - FAO's Global Information System on Water and Agriculture.* Retrieved September 30, 2022, from Food and Agriculture Organization of the United Nations: https://tableau.apps.fao.org/views/ReviewDashboard-v1/country_dashboard?%3Aembed=y&%3AisGuestRedirectFromVizportal=y

Forslund, A., Renöfält, B., Barchiesi, S., Cross, K., Davidson, S., Farrell, T., . . . Smith, M. (2015). Securing water for ecosystems and human well-being: The importance of environmental flows. *Swedish Water House Report,* 24, 1-52.

Forti, V., Baldé, C., Kuehr, R. and Bel, G. (2020). *The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential.* Bonn/Geneva/Rotterdam: United Nations University (UNU)/United. Retrieved from https://ewastemonitor.info/wp-content/uploads/2020/11/GEM_2020_def_july1_low.pdf

Fosse, J., Kosmas, I. and Gonzalez, A. (2021). *The future of Mediterranean tourism in a (post) covid world.* Eco-union. doi:https://doi.org/10.5281/zenodo.4616983

Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., . . . Masó, J. (2020). Mapping citizen science contributions to the UN sustainable development goals. *Sustainability Science,* 15(6), 1735–1751. doi:https://doi.org/10.1007/s11625-020-00833-7

Fraisl, D., Hager, G., Bedessem, B., Gold, M., Hsing, P.-Y., Danielsen, F., . . . Haklay, M. (2022a). Citizen science in environmental and ecological sciences. *Nature Reviews Methods Primers, 2*. doi:https://doi.org/10.1038/s43586-022-00144-4

Fraisl, D., See, L., Sturn, T., MacFeely, S., Bowser, A., Campbell, J., . . . Fritz, S. (2022b). Demonstrating the potential of Picture Pile as a citizen science tool for SDG monitoring. *Environmental Science and Policy,* 128, 81-93. doi:https://doi.org/10.1016/j.envsci.2021.10.034

FreshWater Watch (2022). *Citizen science.* Retrieved September 30, 2022, from FreshWater Watch: https://fww-earthw.hub.arcgis.com/pages/citizen-science

Fromherz, N. and Lyman, E. (2021). *Colombia Freshwater Resource Rights Report.* Retrieved from https://programme.worldwaterweek.org/Content/ProposalResources/PDF/2021/pdf-2021-9644-2-Colombia%20FWR%20Rights%20Report_FINAL_ENG.pdf

Gao, J., Zhao, P., Zhang, H., Mao, G. and Wang, Y. (2018). Operational Water Withdrawal and Consumption Factors for Electricity Generation Technology in China - A Literature Review. *Sustainability,* 10(4). doi:https://doi.org/10.3390/su10041181

Garzillo, J., Poli, V., Leite, F., Steele, E., Machado, P., Louzada, M., . . . Monteiro, C. (2022). Ultra-processed food intake and diet carbon and water footprints: a national study in Brazil. *Revista de Saude Publica, 56:6.* doi:https://doi.org/10.11606%2Fs1518-8787.2022056004551

Ghana, National Development Planning Commission (2022). *Ghana's Voluntary National Review Report on the Implementation of the 2030 Agenda for Sustainable Development.* Accra: National Development Planning Commission. Retrieved from https://hlpf.un.org/sites/default/files/vnrs/2022/VNR%202022%20Ghana%20Report_0.pdf

Gil-Agudelo, D., Cintra-Buenrostro, C., Brenner, J., González-Díaz, P., Kiene, W., Lustic, C. and Pérez-España, H. (2020). Coral reefs in the Gulf of Mexico large marine ecosystem: conservation status, challenges, and opportunities. *Frontiers in Marine Science, 6,* 807. doi:https://doi.org/10.3389/fmars.2019.00807

Gilby, B. L. and Stevens, T. (2014). Meta-analysis indicates habitat-specific alterations to primary producer and herbivore communities in marine protected areas. *Global Ecology and Conservation, 2,* 289-299. doi:https://doi.org/10.1016/j.gecco.2014.10.005

Giuliani, G., Mazzetti, P., Santoro, M., Nativi, S., Van Bemmelen, J., Colangeli, G. and Lehmann, A. (2020). Knowledge generation using satellite earth observations to support sustainable development goals (SDG): A use case on Land degradation. *International Journal of Applied Earth Observation and Geoinformation, 88,* 102068. doi:https://doi.org/10.1016/j.jag.2020.102068

Gleick, P. and Cooley, H. (2021). Freshwater Scarcity. *Annual Review of Environment and Resources, 46*, 319-348. doi:https://doi.org/10.1146/annurev-environ-012220-101319

Global Water Partnership (2021, February 10). *Continental Africa Water Investment Programme (AIP).* Retrieved September 30, 2022, from Global Water Partnership Southern Africa: Towards a water secure world: https://www.gwp.org/en/GWP-SouthernAfrica/WE-ACT/continental-africa-water-investment-programme-aip/

Government of China (2022, August). *Urgent Responses to Drought Level IV in the Yangtze River Basin (in Chinese)*. Retrieved from The State Council of the People's Republic of China: http://www.gov.cn/xinwen/2022-08/11/content_5705059.htm

Government of India (2015). *Integrated Water Resource Management: Guidelines for integrated water resource Development and Management.* Retrieved September 30, 2022, from Government of India: http://nwm.gov.in/?q=integrated-water-resource-management

Government of Mongolia (1997, April 7-25). *Mongolia: Country Profile.* Retrieved October 18, 2022, from National Implementation of Agenda 21: https://www.un.org/esa/earthsummit/mong-cp.htm

Grill, G., Lehner, B., Thieme, M., Geenen, B., Tickner, D., Antonelli, F., . . . et al. (2019). Mapping the world's free-flowing rivers. *Nature, 569*(7755), 215 - 221. doi:https://doi.org/10.1038/s41586-019-1111-9

Groom, S., Sathyendranath, S., Ban, Y., Bernard, S., Brewin, R., Brotas, V., . . . Lavender, S. (2019). Satellite ocean colour: Current status and future perspective. *Frontiers in Marine Science, 6*(485). doi:10.3389/fmars.2019.00485

Group on Earth Observations (2022). *Earth Observations for the Sustainable Development Goals.* Retrieved September 30, 2022, from Group on Earth Observations: https://eo4sdg.org/

Haklay, M. and Eleta, I. (2019). On the front line of community-led air quality monitoring. In M. Nieuwenhuijsen and H. Khreis, *Integrating Human Health into Urban and Transport Planning* (pp. 563-580). Springer, Cham. doi:https://doi.org/10.1007/978-3-319-74983-9_27

Hansen, A., Barnett, K., Jantz, P., Phillips, L., Goetz, S. J., Hansen, M., . . . De Camargo, R. (2019). Global humid tropics forest structural condition and forest structural integrity maps. *Scientific Data, 6*(1), 1-12. doi:https://doi.org/10.1038/s41597-019-0214-3

Hartig, H., Krantzberg, G. and Alsip, P. (2020). Thirty-five years of restoring Great Lakes Areas of Concern: Gradual progress, hopeful future. *Journal of Great Lakes Research, 46*(3), 429 - 442. doi:https://doi.org/10.1016/j.jglr.2020.04.004

Hasumi, M., Hongorzul, T. and Terbish, K. (2011). Animal species diversity at a land-water ecotone in Mongolia. *Limnology, 12,* 37-45. doi:https://doi.org/10.1007/s10201-010-0319-z

He, X., Feng, K., Li, X., Craft, A., Wada, Y., Burek, P., . . . Sheffield, J. (2019). Solar and wind energy enhances drought resilience and groundwater sustainability. *Nature Communications, 10.* doi:https://doi.org/10.1038/s41467-019-12810-5

Herath, H., Hewapathirana, H., Gunawardane, N. and Friedman, K. (2019). Understanding food security, incomes and livelihoods in a chaning shark and ray fisheries sector in Sri Lanka. *Fisheries and Aquaculture Circular,* 1185. Retrieved from https://www.fao.org/3/ca5641en/CA5641EN.pdf

Hofste, R., Reig, P. and Schleifer, L. (2019, August 6). 17 *Countries, Home to One-Quarter of the World's Population, Face Extremely High Water Stress*. Retrieved October 18, 2022, from World Resources Institute: https://www.wri.org/insights/17-countries-home-one-quarter-worlds-population-face-extremely-high-water-stress

Holland, R., Darwall, W. and Smith, K. (2012, April). Conservation priorities for freshwater bodiversity: The Key Biodiversity Area approach refined and tested for continental Africa. *Biological Conservation, 148*(1), 167-179. Retrieved from https://doi.org/10.1016/j.biocon.2012.01.016

Howarth, R. W. and Marino, R. (2006). Nitrogen as the limiting nutrient for eutrophication in coastal marine ecosystems: evolving views over three decades. *Limnology and oceanography, 51*(1part2), 364-376. doi:https://doi.org/10.4319/lo.2006.51.1_part_2.0364

Huang, L., Wu, Z. and Li, J. (2013). Fish fauna, biogeography and conservation of freshwater fish in Poyang Lake Basin, China. *Environmental Biology of Fishes, 96*, 1229-1243. doi:https://doi.org/10.1007/s10641-011-9806-2

Hubacek, K., Baiocchi, G., Feng, K. and Patwardhan, A. (2017). Poverty eradication in a carbon contrained world. *Nature Communications, 8.* doi:https://doi.org/10.1038/s41467-017-00919-4

Indonesia, Statistics Indonesia (2020). *Using Big Data for SDGs: Mobile Data for Tourism and Commuting. Presentation prepared for the prepared for the 6th International Conference on Big Data for Official Statistics. 31 August–2 September. Virtual conference.* Retrieved 11 10, 2022, from Statistics Indonesia: https://unstats.un.org/unsd/bigdata/conferences/2020/presentations/day1/session3/Use%20of%20Mobile%20Phone%20for%20SDGs_rev2.0.pdf

Intergovernmental Oceanographic Commission of UNESCO (2021). *The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) Implementation plan - Summary.* Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000376780

Intergovernmental Oceanographic Commission of UNESCO (2022a). *Ocean Decade Progress Report 2021-2022*. Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000381708

Intergovernmental Oceanographic Commission of UNESCO (2022b). *The United Nations Decade of Ocean Science for Sustainable Development 2021-2030*. Paris: United Nations Educational, Scientific and Cultural Organisation. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000381488/PDF/381488eng.pdf.multi

Intergovernmental Oceanographic Commission of UNESCO (2022c). *The United Nations Decade of Ocean Science for Sustainable Development 2021-2030. Ocean Decade Africa Roadmap.* Paris: United Nations Educational, Scientific and Cultural Organisation. Retrieved from https://oceandecade.org/wp-content/uploads/2022/06/Ocean-Decade-Africa-Roadmap.pdf

Intergovernmental Oceanographic Commission of UNESCO (2022d, September 28). *Over fifty new endorsed Actions strengtehn the Ocean Decade global movement.* Retrieved September 30, 2022, from United Nations Decade of Ocean Science for Sustainable Development: https://www.oceandecade.org/news/over-fifty-new-endorsed-actions-strengthen-the-ocean-decade-global-movement/

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2018a). *Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Africa of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.* Bonn: IPBES Secretariat. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi88eiMqIX8AhWRYMAKHfUbB5gQFnoECDkQAQ&url=https%3A%2F%2Fipbes.net%2Fresource-file%2F18406&usg=AOvVaw1LacYghkwnyKNwQ2BymzaY

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2018b). The *IPBES regional assessment report on biodiversity and ecosystem services for Asia and the Pacific.* Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: Karki, M., Senaratna Sellamuttu, S., Okayasu, S., and Suzuk.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019). *Summary for policymakers of the global assessment report on biodiversity and ecosystem services (summary for policy makers)*. Paris: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. doi:https://doi.org/10.5281/zenodo.3553579

International Labour Organization (2021). *About the ILO, Newsroom.* Retrieved from Fewer women than men will regain employment during the COVID-19 recovery says ILO: https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_813449/lang--en/index.htm

International Monetary Fund (2020). *Regional Economic Outlook: Sub-Saharan Africa.* International Monetary Fund. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiv263Pivv7AhWPhFwKHTkzCZEQFnoECAoQAQ&url=https%3A%2F%2Fwww.imf.org%2F-%2Fmedia%2FFiles%2FPublications%2FREO%2FAFR%2F2020%2FApril%2FEnglish%2Fch2.ashx&usg=AOvVaw1yXfu0WCGt0JtZK6BjP_9

International Renewable Energy Agency (2016). *Mongolia Renewables Readiness Assessment.* International Renewable Energy Agency. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj-9sLTnPT6AhUBGewKHQyqBtYQFnoECDIQAQ&url=https%3A%2F%2Fwww.irena.org%2Fpublications%2F2016%2FMar%2FRenewables-Readiness-Assessment-Mongolia&usg=AOvVaw0DgbgP3tInWlkinc

International Renewable Energy Agency (2022a). *Statistics Time Series.* Retrieved October 20, 2022, from International Renewable Energy Agency: https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Statistics-Time-Series

International Renewable Energy Agency (2022b). *Energy Profile: Mongolia.* Abu Dhabi: International Renewable Energy Agency. Retrieved from https://www.irena.org/IRENADocuments/Statistical_Profiles/Asia/Mongolia_Asia_RE_SP.pdf

Inter-Agency and Expert Group on the Sustainable Development Goal Indicators (2019). *Working Group on Geospatial Information: Terms of Reference.* Retrieved 11 09, 2022, from Inter-Agency and Expert Group on the Sustainable Development Goal Indicators: https://ggim.un.org/documents/WGGI_Terms%20of%20Reference_updated%20July%202019.pdf

Inter-Agency and Expert Group on the Sustainable Development Goal Indicators (2022). *Tier Classification for Global SDG Indicators*. Retrieved 09 11, 2022, from Inter-agency and Expert Group on SDG Indicators: https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/

Ishiwatari, M. and Surjan, A. (2019). Good enough today is not enough tomorrow: Challenges of increasing investments in disaster risk reduction and climate change adaptation. *Progress in Disaster Science, 1.* doi:https://doi.org/10.1016/j.pdisas.2019.100007

Jamaliah, F. (2016). The Effect of Investment to Value Added Production, Employment Absorption, Productivity, And Employees' Economic Welfare in Manufacturing Industry Sector in West Kalimantan Province. *Procedia Social and Behavioral Sciences, 219*, 387-393. Retrieved from https://pdf.sciencedirectassets.com/277811/1-s2.0-S1877042816X00055/1-s2.0-S1877042816301215/main.pdf?X-Amz-Security-Token=IQoJb3JpZ2luX2VjEEcaCXVzLWVhc3QtMSJHMEUCIQC0H7xLvvWD7TBaa8YIUtYHkU%2BVEUoYzSVuX0a6FylIDAIgTbwMlFOqcRKbzr7GV3GxSnw9fDBOxNHwIBt2MHJAjR

Jiangxi Provincial Development and Reform Commission (2016). *Poyang Lake Basin Town Tower Environment Management Project - Environmental and Social Impact Assessment.* World Bank. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiN3f2O-IT8AhVTZ8AKHUxvDbYQFnoECDsQAQ&url=https%3A%2F%2Fdocuments.worldbank.org%2Fcurated%2Fpt%2F852721482178505838%2FNo-1-EA-summary-draft-for-Poyang-Lake-Basin-Town-

Jiao, F. and Liu, J. (2018). Study on inland ship water pollution control policy strategy based on Game thoery. *IOP Conference Series Earth and Environmental Science, 191*(1). doi:http://dx.doi.org/10.1088/1755-1315/191/1/012128

Jiménez, A., Saikia, P., Giné, R., Avello, P., Leten, J., Liss Lymer, B., . . . Ward, R. (2020). Unpacking water governance: A framework for practitioners. *Water, 12*(3), 827. doi:https://doi.org/10.3390/w12030827

Jin, B., Nie, M., Li, Q., Chen, J. and Zhou, W. (2012). Basic characteristics, challenges and key scientific questions of the Poyang Lake basin. *Resources and Environment in the Yangtze Basin, 21*, 268-275.

Jung, M., Dahal, P. R., Butchart, S. H., Donald, P. F., De Lamo, X., Lesiv, M., . . . Visconti, P. (2020). A global map of terrestrial habitat types. *Scientific data,* 7(1), 1-8. doi:https://doi.org/10.1038/s41597-020-00599-8

Kalman, B. and Laszlo, S. (1997). Impacts of Road Traffic on Water Quality. *Periodica Polytechnica Ser. Civil Eng., 41*(2), 95-106. Retrieved from https://core.ac.uk/download/pdf/236623822.pdf

Kayatz, B., Harris, F., Hillier, J., Adhya, T., Dalin, C., Nayak, D., . . . Dangour, A. (2019). "More crop per drop": Exploring India's cereal water use since 2005. *Science of the Total Environment, 673*, 207-217. doi:https://doi.org/10.1016/j.scitotenv.2019.03.304

Ke, Z., Chen, D., Liu, J. and Tan, Y. (2020). The effects of anthropogenic nutrient inputs on stable carbon and nitrogen isotopes in suspended particulate organic matter in Jiaozhou Bay, China. *Continental Shelf Research, 208*, 104244. doi:https://doi.org/10.1016/j.csr.2020.104244

Khalil, A., Moeller-Gulland, J., Ward, C., Al'Afghani, M., Perwitasari, T., Octaviani, K., . . . Khan, A. (2021). I*ndonesia Vision 2045: Toward Water Security. Water Security Diagnostic.* Washington, DC.: World Bank. Retrieved from http://hdl.handle.net/10986/36727

Khan, N., Westfall, D., Jones, A., Sinn, M., Bottin, J., Perrier, E. and Hillman, C. (2019). A 4-d Water Intake Intervention Increases Hydration and Cognitive Flexibility among Preadolescent Children. *The Journal of Nutrition, 149*(12), 2255-2264. doi:doi:10.1093/jn/nxz206

Kitamura, Y., Yamazaki, E., Kanie, N., Edwards, B. J., Shivakoti, B., Mitra, B., . . . Stevens, C. (2015). *Linking Education and Water in the Sustainable Development Goals - Policy Brief #2*. Tokyo: United Nations University. Retrieved from https://collections.unu.edu/eserv/UNU:1824/Post2015_UNUIAS_PolicyBrief2.pdf

Kriegl, M., Elías Ilosvay, X. E., von Dorrien, C. and Oesterwind, D. (2021). Marine protected areas: at the crossroads of nature conservation and fisheries management. *Frontiers in Marine Science, 8*(676264). doi:10.3389/fmars.2021.676264

Kroeze, C., Hofstra, N., Ivens, W., Lohr, A., Strokal, M. and van Wijnen, J. (2013). The links between global carbon, water and nutrient cycles in an urbanizing world-the case of coastal eutrophication. *Current Opinion in Environmental Sustainability, 5*(6), 566-572. doi:https://doi.org/10.1016/j.cosust.2013.11.004

Lamb, R., Hurtt, G., Boudreau, T., Campbell, E., Carlo, E., Chu, H.-H., . . . Hultman, N. (2021). Context and future directions for integrating forest carbon into sub-national climate mitigation planning in the RGGI region of the US. *Environmental Research Letters, 16*(6). doi:DOI 10.1088/1748-9326/abe6c2

Large Marine Ecosystems (2022). *Large Marine Ecosystems Hub.* Retrieved September 30, 2022, from A Regional Perspective on the World's Ocean: https://lmehub.net/

Leasure, D., Jochem, W., Weber, E., Seaman, V. and Tatem, A. (2020). National population mapping from sparse survey data: A hierarchical Bayesian modeling framework to account for uncertainty. *Proceedings of the National Academy of Sciences,* 117(39), 24173-24179.

Lebedeva, D., Mendsaikhan, B., Yakovleva, G. and Zaytsev, D. (2020). Parasites of Oreoleuciscus potanini (Cyprinidae) from lakes of Khar Us Nuur National Park (Mongolia). *Nature Conservation Research.* doi:http://dx.doi.org/10.24189/ncr.2020.042

Lei, X., Gao, L., Wei, J., Ma, M., Xu, L., Fan, H., . . . Fang, W. (2021). Contributions of climate change and human activities to runoff variations in the Poyang Lake Basin of China. *Physics and Chemistry of the Earth, 123*. doi:https://doi.org/10.1016/j.pce.2021.103019

Leibniz Institute of Freshwater Ecology and Inland Fisheries (2021). *News*. Retrieved from Infrastructure policy: waterway development puts ecosystems and its services at risk: https://www.igb-berlin.de/en/news/infrastructure-policy-waterway-development-puts-ecosystems-and-its-services-risk

Li, P., Xue, J., Xia, W. and Li, T. (2022). Health Assessment of the Waterway from Chongqing to Yibin in the Upper Yangtze River, China. *Water*, *14*(19). doi:https://doi.org/10.3390/w14193007

Li, Y., Cao, W., Su, C. and Hong, H. (2011). Nutrient sources and composition of recent algal blooms and eutrophication in the northern Jiulong River, Southeast China. *Marine pollution bulletin, 63*(5-12), 249-254.

Linke, S. and Hermoso, V. (2022). Biodiversity Conservation of Aquatic Ecosystems. *Encyclopedia of Inland Waters, 2.* doi:https://doi.org/10.1016/B978-0-12-819166-8.00202-4

Liu, C., Wu, F., Jiang, X., Hu, Y., Shao, K., Tang, X., . . . Gao, G. (2022). Salinity is a Key Determinant for the Microeukaryotic Community in Lake Ecosystems of the Inner Mongolia Plateau, China. *Front. Microbiol.* doi:https://doi.org/10.3389/fmicb.2022.841686

Loudyi, D. and Kantoush, S. (2020). Flood reisk management in the Middle East and North Africa (MENA) region. *Urban Water Journal, 17*(5). doi:http://dx.doi.org/10.1080/1573062X.2020.1777754

Luo, T., Otto, B., Shiao, T. and Maddocks, A. (2014, April 15). *Identifying the Global Coal Industry's Water Risks.* Retrieved September 30, 2022, from World Resources Institute: https://www.wri.org/insights/identifying-global-coal-industrys-water-risks#:~:text=As%20with%20most%20energy%20sources,create%20steam%20and%20for%20cooling.

Ma, Q., Wu, J., He, C. and Fang, X. (2021, October). The speed, scale, and environmental and economic impacts of surface coal mining in the Mongolian Plateau. *Resources, Conservation and Recycling, 173*. doi:https://doi.org/10.1016/j.resconrec.2021.105730

Ma, T., Sun, S., Fu, G., Hall, J., Ni, Y., He, L., . . . Zhou, C. (2020). Pollution exacerbates China's water scarcity and its regional inequality. *Nature Communications, 11*. doi:https://doi.org/10.1038/s41467-020-14532-5

Maavara, T., Chen, Q., Van Meter, K., Brown, L. E., Zhang, J., Ni, J. and Zarfl, C. (2020). River dam impacts on biogeochemical cycling. *Nature Reviews Earth & Environment, 1*(2), 103-116. doi:https://doi.org/10.1038/s43017-019-0019-0

MacDicken, K. G. (2015). Global forest resources assessment 2015: what, why and how? *Forest Ecology and Management, 352,* 3-8. doi:https://doi.org/10.1016/j.foreco.2015.02.006

MacFeely, S. (2019). The big (data) bang: Opportunities and challenges for compiling SDG indicators. *Global Policy, 10*, 121-133. doi:https://doi.org/10.1111/1758-5899.12595

Madaka, H., Babbitt, C. and Ryen, E. (2022). Opportunities for reducing the supply chain water footprint of metals used in consumder electronics. *Resources, Conservation and Recycling, 176*. doi:https://doi.org/10.1016/j.resconrec.2021.105926

Maftouh, A., El Fatni, O., Fayiah, M., Liew, R., Lam, S., Bahaj, T. and Butt, M. (2022). The application of water-energy nexus in the Middle Ease and North Africa (MENA) region: a structured review. *Applied Water Science, 12*. doi:https://doi.org/10.1007/s13201-022-01613-7

Mahjabin, T., Garcia, S., Grady, C. and Mejia, A. (2018). Large cities get more for less: Water footprint efficiency across the US. *PLOS ONE*. doi:https://doi.org/10.1371/journal.pone.0202301

Máiz-Tomé, L., Darwall, W., Numa, C., Barrios, V. and Smith, K. (2017). *Freshwater Key Biodiversity Areas in the north-western Mediterranean sub-region.* Gland: International Union for Conservation of Nature and Natural Resources. Retrieved from https://portals.iucn.org/library/sites/library/files/documents/SSC-OP-no.64.pdf

Mallapaty, S. (2022). Why are Pakistan's floods so extreme this year? *Springer Nature*. Retrieved from https://www.nature.com/articles/d41586-022-02813-6

Marconcini, M., Metz-Marconcini, A., Üreyen, S., Palacios-Lopez, D., Hanke, W., Bachofer, F., . . . Paganini, M. (2020). Outlining where humans live, the World Settlement Footprint 2015. *Scientific Data, 7*(1), 1-14. doi:https://doi.org/10.1038/s41597-020-00580-5

Maxwell, S., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A., Stolton, S., . . . Watson, J. (2020). Area-based conservation in the twenty-first century. *Nature, 586,* 217-227. Retrieved from https://www.nature.com/articles/s41586-020-2773-z

Mbow, C., Rosenzweig, C., Barioni, L., Benton, T., Herrero, M., Krishnapillai, M., . . . Xu, Y. (2019). Food Security. In *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/4/2021/02/08_Chapter-5_3.pdf

McIntyre, P., Reidy Liermann, C. and Revenga, C. (2016). Linking freshwater fishery management to global food security and biodiversity conservation. *PNAS, 113*(45), 12880-12885. Retrieved from https://www.jstor.org/stable/10.2307/26472403

Mekong River Commission for Sustainable Development (2022). *Mekong river monitoring and forecasting.* Retrieved from Mekong River Commission for Sustainable Development: https://www.mrcmekong.org/

Michaux, B., Hannula, J., Rudolph, M., Reuter, M., van den Boogaart, K., Mockel, R., . . . Remes, A. (2019). Water-saving strategies in the mining industry - The potential of mineral processing simulators as a tool for their implementation. *Journal of Environmental Management, 234,* 546-553. doi:https://doi.org/10.1016/j.jenvman.2018.11.139

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Sythesis.* Washington, DC.: World Resources Institute. Retrieved from https://www.millenniumassessment.org/documents/document.356.aspx.pdf

Miola, A., Borchardt, S. and Neher, F. (2019). *Interlinkages and policy coherence for the Sustainable Development Goals Implementation: An operational method to identify trade-offs and co-benefits in a systemic way.* Luxembourg: European Union. doi:doi:10.2760/472928

Mondal, P., Liu, X., Fatoyinbo, T. and Lagomasino, D. (2019). Evaluating combinations of sentinel-2 data and machine-learning algorithms for mangrove mapping in West Africa. *Remote Sensing, 11*(24), 2928. doi:https://doi.org/10.3390/rs11242928

Mongolia, Ministry of Environment and Tourism of Mongolia (2018). *Third National Communication of Mongolia, Under the United Nations Framework Convention on Climate Change. Ulaanbaatar:* Ministry of Environment and Tourism of Mongolia. Retrieved from https://unfccc.int/sites/default/files/resource/06593841_Mongolia-NC3-2-Mongolia%20TNC%202018%20pr.pdf

Mongolia, National Statistics Office of Mongolia (2020). *2020 Population and Housing Census of Mongolia: National Report.* Ulaanbaatar: National Statistics Office of Mongolia. Retrieved from https://1212.mn/BookLibraryDownload.ashx?url=Census2020_Main_report_Eng.pdf&ln=En

Mongolia, State Housing Corporation of Mongolia (2022). *State Housing Corporation of Mongolia: Housing Programmes*. Retrieved October 15, 2022, from Government of Mongolia: https://mcud.gov.mn

Morales Martínez, D. and Gori Maia, A. (2021). The Effect of Social Behavior on Residential Water Consumption. *Water, 13*(4), 1184.

Moreau, K. (2020, June 15). *Offshore Wind Farms And The Marine Ecosystem: 10 Year of Monitoring.* Retrieved September 30, 2022, from Royal Belgian Institute of Natural Sciences: https://www.naturalsciences.be/en/news/item/19116

Mughal, M. and Sers, C. (2020). *Cereal Production, Undernourishment and Food Insecurity in South Asia.* HAL. Retrieved from https://hal.archives-ouvertes.fr/hal-02089616v2

Myers, S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A., Bloom, A., . . . et al. (2014). Increasing CO_2 threatens human nutrition. *Nature, 510,* 139-142. doi:https://doi.org/10.1038/nature13179

National Geographic (2022). *Marine Ecosystems*. Retrieved September 30, 2022, from National Geographic: https://education.nationalgeographic.org/resource/marine-ecosystems

Ngoile, M. (1997). Coastal zone issues and ICM initiatives in Sub-Saharan Africa. *Ocean&Coastal Management, 37*(3), 269-279. Retrieved from https://www.sciencedirect.com/sdfe/pdf/download/eid/1-s2.0-S0964569197000586/first-page-pdf

Nilsson, M., Griggs, D. and Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature, 534,* 320-322. doi:https://doi.org/10.1038/534320a

Norwegian Institute for Water Research (2020). ICP Waters Report 142/2020: *Trends and patterns in surface water chemistry in Europe and North America between 1990 and 2016, with particular focus on changes in land use as a confounding factor for recovery.* Oslo: Norwegian Institute for Water Research. Retrieved from http://www.icp-waters.no/2020/03/16/2020-report-trends-and-patterns-in-surface-water-chemistry/

Norkko, J., Reed, D. C., Timmermann, K., Norkko, A., Gustafsson, B. G., Bonsdorff, E., . . . Conley, D. J. (2012). A welcome can of worms? Hypoxia mitigation by an invasive species. *Global Change Biology, 18*(2), 422-434. doi:https://doi.org/10.1111/j.1365-2486.2011.02513.x

Office of the United Nations High Commissioner for Human Rights (n.d.). *Frequently Asked Questions.* Retrieved December 15, 2022, from Special Rapporteur on the Human Right to Safe Drinking Water and Sanitation: https://sr-watersanitation.ohchr.org/en/rightstowater_5.html

Olen, S. (2022). Citizen science tackles plastics in Ghana. *Nature Sustainability, 5*, 814-815. doi:https://doi.org/10.1038/s41893-022-00980-y

Onyenankeya, K., Onyenankeya, O. and Osunkunle, O. (2021). Barriers to water use efficiency in rural and peri-urban areas of South Africa. *Water and Environment Journal, 35*(4), 1164-1173. doi:https://doi.org/10.1111/wej.12707

Organisation for Economic Cooperation and Development (2012). *OECD Studies on Water: Water Governance in Latin America and the Caribbean - A Multi-level Approach.* Organisation for Economic Cooperation and Development. doi:https://doi.org/10.1787/9789264174542-en

Organisation for Economic Cooperation and Development (2015). *OECD Principles on Water Governance*. Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd.org/cfe/regionaldevelopment/OECD-Principles-on-Water-Governance.pdf

Organisation for Economic Cooperation and Development (2018). *OECD Water Governance Indicator Framework*. Retrieved from https://www.oecd.org/regional/OECD-Water-Governance-Indicator-Framework.pdf

Organisation for Economic Cooperation and Development (2020). *Agriculture and Water Policies: Main Characteristics and Evolution from 2009 to 2019*. Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd.org/colombia/oecd-water-policies-country-note-colombia.pdf

Organisation for Economic Cooperation and Development (2021). *OECD Regional Development Papers - Water Governance in Asia-Pacific*. Paris: Organisation for Economic Co-operation and Development. doi:https://doi.org/10.1787/b57c5673-en

Organisation for Economic Cooperation and Development (2022). *Latin American Economic Outlook 2022: Towards a Green and Just Transition*. Paris: Organisation for Economic Co-operation and Development. doi:https://doi.org/10.1787/3d5554fc-en

Organisation for Economic Cooperation and Development/Economic Commission for Latin America and the Caribbean (2014). *OECD Environmental Performance Reviews: Colombia 2014*. Paris: OECD Publishing. doi:https://doi.org/10.1787/9789264208292-en

Oxford Learner's Dictionaries (n.d.). *Definition*. Retrieved December 5, 2022, from Oxford Learner's Dictionaries: https://www.oxfordlearnersdictionaries.com/definition/english/

Palanca-Tan, R. (2018-2019). Aquaculture, Poverty and Environment in the Philippines. *The Journal of Social, Political, and Economic Studies, 43*(3/4), 294-315. Retrieved from https://www.proquest.com/docview/2119862767?accountid=27871

Palazzoli, I., Montanari, A. and Ceola, S. (2022). Influence of Urban Areas on Surface Water Loss in the Contiguous United States. *AGU Advances, 3*(1). doi:https://doi.org/10.1029/2021AV000519

Papa, F., Cretaux, J.-F., Grippa, M., Robert, E., Trigg, M., Tshimanga, R., . . . Calmant, S. (2022). Water Resources in Africa under Global Change: Monitoring Surface Waters from Space. *Surveys in Geophysics*. doi:https://doi.org/10.1007/s10712-022-09700-9

Phosa, J. (2016). Improving Rural Livelihoods through Sustainable Integrated Fish: Crop Production in Limpopo Province, South Africa. In *Freshwater, fish and the future: proceedings of the global cross-sectoral conference* (pp. 233-238). Rome: Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org/3/i5711e/i5711e.pdf

Piet, G., Culhane, F., Jongbloed, R., Robinson, L., Rumes, B. and Tamis, J. (2019). An integrated risk-based assessment of the North Sea to guide ecosystem-based management. *Science of the Total Environment*, 654, 694-704.

Pimentel, J., Prada, C. and Walschburger, T. (2021). Hydrological Modeling for Multifunctional Landscape Planning in the Orinoquia Region of Colombia. *Frontiers in Environmental Science, 9*. doi:doi:10.3389/fenvs.2021.673215

Pitcher, G. C., Aguirre-Velarde, A., Breitburg, D., Cardich, J., Carstensen, J., Conley, D. J., . . . Huang, H. H. (2021). System controls of coastal and open ocean oxygen depletion. *Progress in Oceanography, 197*, 102613. doi:https://doi.org/10.1016/j.pocean.2021.102613

Popkin, B., Corvalan, C. and Grummer-Strwan, L. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. *The Lancet, 395*(10217), 65-74.doi:https://doi.org/10.1016/S0140-6736(19)32497-3

Potapov, P., Li, X., Hernandez-Serna, A., Tyukavina, A., Hansen, M. C., Kommareddy, A., . . . Hofton, M. (2021). Mapping global forest canopy height through integration of GEDI and Landsat data. *Remote Sensing of Environment, 253*, 112165. doi:https://doi.org/10.1016/j.rse.2020.112165

Potapov, P., Turubanova, S., Hansen, M. C., Tyukavina, A., Zalles, V., Khan, A., . . . Cortez, J. (2022). Global maps of cropland extent and change show accelerated cropland expansion in the twenty-first century. *Nature Food, 3*(1), 19-28. doi:https://doi.org/10.1038/s43016-021-00429-z

Rabalais, N., Turner, R., Díaz, R. and Justić, D. (2009). Global change and eutrophication of coastal waters. *ICES Journal of Marine Science, 66*(7), 1528-1537.

Raiten, D. and Combs, G. (2019). Nutritional ecology: Understanding the intersection of climate/environmental change, food systems and health. In *Agriculture for Improved Nutrition: Seizing the Momentum* (pp. 68-80). CAB International. Retrieved from https://books.google.co.ke/books?hl=en&lr=&id=EiqLDwAAQBAJ&oi=fnd&pg=PA68&dq=Raiten,+J.+D.,+Combs,+G.+F.+.+Nutritional+Ecology:+Understanding+The+Intersection+Of+ClimateEnvironmental+Change,+Food+Systems+And+Health.+In:+Fan,+S.,+Yosefk,+S.,+Pandya-Lorch,+

Reich, R. (2015, September 18). *Big Tech Has Become Way Too Powerful.* Retrieved September 30, 2022, from NYtimes: https://www.nytimes.com/2015/09/20/opinion/is-big-tech-too-powerful-ask-google.html

Renaud, F., Huang, S., Zhou, X., Barrett, B., Bosher, L., Hoey, T., . . . Zhao, J. (2020). *Lessons learnt from synergies and trade-offs between SDGs at the sub-national scale.* Luanhe. Retrieved from https://www.iges.or.jp/en/publication_documents/pub/issue/en/11599/tase-research-brief-final.pdf

Renjifo, L., Amaya-Villarreal, A. and Butchart, S. (2020). Tracking extinction risk trends and patterns in a mega-diverse country: A Red List Index for birds in Colombia. *PLOS ONE*. doi:https://doi.org/10.1371/journal.pone.0227381

Rodriguez, N., Armenteras, D. and Retana, J. (2015, January). National ecosystems services priorities for planning carbon and water resource management in Colombia. *Land Use Policy, 42,* 609-618. doi:https://doi.org/10.1016/j.landusepol.2014.09.013

Roe, D. and Geneletti, D. (2016). Addressing the interactions between biodiversity conservation and poverty alleviation in impact assessment. In D. Geneletti, *Handbook on biodiversity and ecosystem services in impact assessment* (pp. 347-363). Edward Elgar Publishing. Retrieved from https://www.researchgate.net/publication/317673193_Addressing_the_interactions_between_biodiversity_conservation_and_poverty_alleviation_in_impact_assessment

Rowbottom, J., Graversgaard, M., Wright, I., Dudman, K., Klages, S., Heidecke, C., . . . Wuijts, S. (2022). Water governance diversity across Europe: Does legacy generate sticking points in implementing multi-level governance? *Journal of environmental management,* 319, 115598. doi:https://doi.org/10.1016/j.jenvman.2022.115598

Ruiz Toro, J., Aguirre Ramirez, N., Serna Lopez, J., Hernández Atilano, E. and Vélez Macías, F. d. (2020). Caloric energy, biomass and structure of aquatic macroinvertebrates in la Nitrera reserve, Concordia, Antioquia, Colombia. *Acta Biologica Colombiana, 25*(1), 29-36. doi:https://doi.org/10.15446/abc.v25n1.76435

Saintilan, N., Kovalenko, K., Guntenspergen, G., Rogers, K., Lynch, J., Cahoon, D., . . . et al. (2022). Constraints on the adjustment of tidal marshes to accelerating sea level rise. *Science, 377*(6605), 523-527. doi:https://doi.org/10.1126/science.abo7872

Sarkodie, S. and Owusu, P. (2020). Bibliometric analysis of water-energy-food nexus: Sustainability assessment of renewable energy. *Current Opinion in Environmental Science and Health, 13,* 29-34. doi:https://doi.org/10.1016/j.coesh.2019.10.008

Sawicka, J. E. and Brüchert, V. (2017). Annual variability and regulation of methane and sulfate fluxes in Baltic Sea estuarine sediments. *Biogeosciences, 14*(2), 325-339. doi:https://doi.org/10.5194/bg-14-325-2017

Scanlon, B., Ruddell, B., Reed, P., Hook, R., Zheng, C., Tidwell, V. and Siebert, S. (2017). The food-energy-water nexus: Transforming science for society. *Water Resources Research, 53*(5), 3550-3556. doi:https://doi.org/10.1002/2017WR020889

Schiavina, M., Melchiorri, M., Corbane, C., Florczyk, A. J., Freire, S., Pesaresi, M. and Kemper, T. (2019). Multi-scale estimation of land use efficiency (SDG 11.3. 1) across 25 years using global open and free data. *Sustainability, 20*, 5674. doi:https://doi.org/10.3390/su11205674

Schindler, D. (2007). Fish extinctions and ecosystem functioning in tropical ecosystems. *PNAS, 104*(14), 5707-5708. doi:https://doi.org/10.1073/pnas.0700426104

Shaddick, G., Thomas, M. L., Mudu, P., Ruggeri, G. and Gumy, S. (2020). Half the world's population are exposed to increasing air pollution. *NPJ Climate and Atmospheric Science, 3*(1), 1-5. doi:https://doi.org/10.1038/s41612-020-0124-2

Shah, K., Dulal, H. and Awojobi, M. (2019). Food Security and Livelihood Vulnerability to Climate Change in Trinidad and Tobago. In *Food Seucirty in Small Island States* (pp. 219-237). Singapore: Springer. doi:https://doi.org/10.1007/978-981-13-8256-7_12

Shen, G., Fu, W., Guo, H. and Liao, J. (2022). Water Body Mapping Using Long Time Series Sentinel-1 SAR Data in Poyang Lake. *Water, 14.* doi:https://doi.org/10.3390/w14121902

Shi, T., Zhang, X., Du, H. and Shi, H. (2015). Urban water resource utilization efficiency in China. *Chinese Geographical Science, 25*, 684-697. doi:https://doi.org/10.1007/s11769-015-0773-y

Shinneman, A., Umbanhowar, C., Edlund, M. and Soninkhishig, N. (2010). Late-Holocene moisture balance inferred from diatom and lake sediment records in western Mongolia. *The Holocene, 20*(1), 123-138. doi:https://doi.org/10.1177/0959683609348861

Smith, V. (1998). Cultural eutrophication of inland, estuarine, and coastal waters. *In Successes, limitations, and frontiers in ecosystem science*, 7-49.

Smith, V., Joye, S. and Howarth, R. (2006). Eutrophication of freshwater and marine ecosystems. *Limnology and oceanography, 51*(1part2), 351-355. doi:https://doi.org/10.4319/lo.2006.51.1_part_2.0351

Sood, A. and Smakhtin, V. (2015). Global hydrological models: a review. *Hydrological Sciences Journal, 60*(4). doi:https://doi.org/10.1080/02626667.2014.950580

Springmann, D., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H., Gollin, D., . . . Scarborough, P. (2016). Global and regional health effects of future food production under climate change: a modelling study. *The Lancet, 387*(10031), 1937-1946. doi:https://doi.org/10.1016/S0140-6736(15)01156-3

Stark, T., Wurm, M., Zhu, X. X. and Taubenböck, H. (2020). Satellite-Based mapping of urban poverty with transfer-learned slum morphologies. I*EEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13,* 5251-5263. doi:https://doi.org/10.1109/JSTARS.2020.3018862

Stockholm Environment Institute (2019). *Piloting the SDG Synergies approach in Mongolia.* Stockholm: Stockholm Environment Institute.

Stockholm Environment Institute and United Nations Environment Programme (2020). P*romoviendo una implemetacion coherente de la dimension ambiental de los ODS en Colombia.* Panama: Stockholm Environment Institute.

Stockholm International Water Institute (2009). *Securing water for ecosystems and human well-being: The importance of environmental flows.* Swedish Water House Report 24. Retrieved from https://siwi.org/wp-content/uploads/2015/03/1250435228124report24_e-flows-low-res-3.pdf

Stramma, L. and Schmidtko, S. (2019). Global evidence of ocean deoxygenation. In D. Laffoley and J. Baxter, *Ocean deoxygenation: Everyone's problem* (pp. 25-36). IUCN. doi:https://doi.org/10.2305/IUCN.CH.2019.13.en

Struijs, P., Braaksma, B. and Daas, P. (2014). Official statistics and big data. *Big Data & Society*, 1(1), 2053951714538417. doi:https://doi.org/10.1177/2053951714538417

Sullivan, D. and Hickel, J. (2023). Capitalism and extreme poverty: A global analysis of real wages, human height, and mortality since the long 16th century. *World Development, 161*, 106026. doi:https://doi.org/10.1016/j.worlddev.2022.106026

Sun, A. Y. (2013). Predicting groundwater level changes using GRACE data. *Water resources research, 49*(9), 5900-5912. doi:https://doi.org/10.1002/wrcr.20421

Surówka, M., Popławski, Ł. and Fidlerová, H. (2021). Technical infrastructure as an element of sustainable development of rural regions in małopolskie voivodeship in poland and trnava region in Slovakia. *Agriculture, 11*(2), 141.doi:https://doi.org/10.3390/agriculture11020141

Tam, S. M. and Van Halderen, G. (2020). The five V's, seven virtues and ten rules of big data engagement for official statistics. *Statistical Journal of the IAOS, 36*(2), 423-433. doi:10.3233/SJI-190595

Tang, X., Xie, G., Shao, K., Tian, W., Gao, G. and Qin, B. (2021). Aquatic Bacterial Diversity, Community Composition and Assembly in the Semi-Arid Inner Mongolia Plateau: Combined Effects of Salinity and Nutrient Levels. *Macroorganisms, 9*(2). doi:https://doi.org/10.3390%2Fmicroorganisms9020208

Toesland, F. (2022, March 17). *Ocean Decade: Blue economy presents vast opportunities for Africa.* Retrieved September 30, 2022, from United Nations: https://www.un.org/africarenewal/magazine/april-2022/ocean-decade-blue-economy-presents-vast-opportunities-africa

Trisos, C., Adelekan, I., Totin, E., Ayanlade, A., Efitre, J., Gemeda, A., . . . Mgaya, Y. (2022). Africa. In *Climate Change 2022: Impacts, Adaptation and Vulnerability* (pp. 1285-1455). Cambridge and New York: Cambridge University Prgress. Retrieved from https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter09.pdf

Tuholske, C., Halpern, B. S., Blasco, G., Villasenor, J. C., Frazier, M. and Caylor, K. (2021). Mapping global inputs and impacts from of human sewage in coastal ecosystems. *PloS one, 16*(11). doi:https://doi.org/10.1371/journal.pone.0258898

Udall, B. and Overpeck, J. (2017). The twenty-first century Colorado River hot drought and implications for the future. *Water Resources Research, 53*(3), 2404-2418. doi:https://doi.org/10.1002/2016WR019638

Uliasz-Misiak, B., Winid, B., Lewandowska-Smierzchalska, J. and Matula, R. (2022, June 10). Impact of road transport on groundwater quality. *Science of The Total Environment, 824*. doi:https://doi.org/10.1016/j.scitotenv.2022.153804

United Nations (2015). A*ddis Ababa Action Agenda of the Third International Conference on Financing for Development.* New York: United Nations. Retrieved from https://www.un.org/esa/ffd/wp-content/uploads/2015/08/AAAA_Outcome.pdf

United Nations (2017). *Factsheet: People and Oceans.* New York: United Nations. Retrieved from https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf

United Nations (2021a). *The United Nations World Water Development Report 2021: Valuing Water.* Paris: United Nations Educational, Scientific and Cultural Organization.

United Nations (2021b). *The Second World Ocean Assessment.* New York: United Nations. doi:https://www.un.org/regularprocess/sites/www.un.org.regularprocess/files/2011859-e-woa-ii-vol-i.pdf

United Nations (2022a). *The United Nations World Water Development Report 2022: Groundwater: Making the invisible visible.* Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://www.unesco.org/reports/wwdr/2022/en

United Nations (2022b). *The Sustainable Development Goals Report 2022.* New York: United Nations. Retrieved from https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf

United Nations (n.d.a). *United Nations, Africa Renewal.* Retrieved from Taking charge of Africa's oceans and blue resources: https://www.un.org/africarenewal/magazine/june-2022/taking-charge-africa%E2%80%99s-oceans-and-blue-resources

United Nations (n.d.b). *SDG 6 snapshot in Mongolia.* Retrieved October 15, 2022, from United Nations UN Water: https://sdg6data.org/country-or-area/Mongolia#anchor_6.1.1

United Nations Department of Economic and Social Affairs (2018, May 16). *68% of the world population projected to live in urban areas by 2050, says UN.* Retrieved September 30, 2022, from UN Department of Economic and Social Affairs: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html#:~:text=Today%2C%2055%25%20of%20the%20world%27s,increase%20to%2068%25%20by%202050.

United Nations Department of Economic and Social Affairs (2022a). *World Population Prospects 2022: Summary of Results.* New York: United Nations Department of Economic and Social Affairs, Population Division. Retrieved from https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

United Nations Department of Economic and Social Affairs (2022b). *World Population Prospects 2022.* Retrieved December 14, 2022, from Department of Economic and Social Affairs, Population Division: https://population.un.org/dataportal/data/indicators/49/locations/947/start/2000/end/2020/line/linetimeplot

United Nations Economic and Social Commission for Asia and the Pacific (2017). *Gender, the Environment and Sustainable Development in Asia and the Pacific.* Retrieved from https://www.unescap.org/sites/default/files/publications/SDD-Gender-Environment-report.pdf

United Nations Economic and Social Commission for Asia and the Pacific (2020). *Changing Sails: Accelerating Regional Actions for Sustainable Oceans in Asia and the Pacific.* Bangkok: United Nations Economic and Social Commission for Asia and the Pacific. Retrieved from https://hdl.handle.net/20.500.12870/1595

United Nations Economic and Social Commission for Asia and the Pacific (2021a). *UN Ocean Decade.* Retrieved September 30, 2022, from UN Economic and Social Commission for Asia and the Pacific: https://www.unescap.org/speeches/un-ocean-decade

United Nations Economic and Social Commission for Asia and the Pacific (2021b). *Big Data for the SDGs: Country examples in compiling SDG indicators using non-traditional data sources.* Bangkok: United Nations Economic and Social Commission for Asia and the Pacific. Retrieved from https://unescap.org/sites/default/d8files/knowledge-products/SD_Working_Paper_no12_Jan2021_Big_data_for_SDG_indicators.pdf

United Nations Economic and Social Commission for Asia and the Pacific (2022). *Asia and the Pacific: SDG Progress Report 2022: Widening disparities amid COVID-19.* Bangkok: United Nations. Retrieved from https://www.unescap.org/sites/default/d8files/knowledge-products/ESCAP-2022-FG_SDG-Progress-Report.pdf

United Nations Economic Commission for Europe (2021, October 22). *Rapid response mechanism to protect environmental defenders established under the Aarhus Convention*. Retrieved September 30, 2022, from United Nations Economic Commission for Europe: https://unece.org/media/press/361413

United Nations Economic Commission for Europe (n.d.). *Climate change threatens access to water and sanitation, warn UNECE & WHO/ Europe, urging reinforced measures under Protocol to boost resilience.* Retrieved from https://unece.org/media/press/367685

United Nations Economic Commission for Latin America and the Caribbean (2020). *The outlook for oceans, seas and marine resources in Latin America and the Caribbean: conservation, sustainable development and climate change mitigation.* Santiago: UN Economic Commission for Latin America and the Caribbean. Retrieved from https://repositorio.cepal.org/bitstream/handle/11362/46509/4/S2000911_en.pdf

United Nations Economic Commission for Latin America and the Caribbean (2022). *ECLAC: Report on the Latin American and Caribbean regional process to accelerate the achievement of SDG 6.* UN Economic and Commission of Latin America and the Caribbean. Retrieved from https://www.cepal.org/sites/default/files/events/files/report_on_the_latin_american_and_caribbean_regional_process_to_accelerate_the_achievement_of_sdg_6.pdf

United Nations Economic and Social Council (2020). Resolution adopted by the Economic and Social Commission for Asia and the Pacific. ESCWA/RES/76/1. United Nations. Retrieved from https://www.unescap.org/sites/default/d8files/event-documents/RES_76_1_ENG.pdf

United Nations Educational, Scientific and Cultural Organization (2009). *Water Education for Sustainable Development.* Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000185302

United Nations Educational, Scientific and Cultural Organization (2012). *Youth and skills: putting education to work, EFA global monitoring report.* Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000218003?posInSet=1&queryId=04cb6b34-1408-444d-88a2-3ce8bc4bd62a

United Nations Educational, Scientific and Cultural Organization (2013). *Water and Sanitation in Municipalities in the Selenge River Basin of Mongolia.* Ulaanbaatar: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000231292

United Nations Educational, Scientific and Cultural Organization (2022). *Water quality from Space through satellite Earth Observation.* Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000383336

United Nations Educational, Scientific and Cultural Organization (n.d.). *Traditional craftsmanship of the Mongol Ger and its associated customs.* Retrieved December 10, 2022, from UNESCO Intangible Cultural Heritage: https://ich.unesco.org/en/RL/traditional-craftsmanship-of-the-mongol-ger-and-its-associated-customs-00872#:~:text=The%20Ger%20is%20a%20round,withstand%20Mongolia%27s%20fierce%20spring%20winds.

United Nations Educational, Scientific and Cultural Organization and UN-Water (2020). *United Nations World Water Development Report 2020: Water and Climate Change*. Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://en.unesco.org/themes/water-security/wwap/wwdr/2020

United Nations Entity for Gender Equality and the Empowerment of Women (2022b). *Women and the Environment - An Asia-Pacific Snapshot.* Retrieved from https://data.unwomen.org/sites/default/files/documents/Publications/APRO_Women-environment-snapshot.pdf

United Nations Environment Programme (2008a). *Freshwater under threat: North East Asia.* Nairobi: United Nations Environment Programme. Retrieved from https://wedocs.unep.org/handle/20.500.11822/7897

United Nations Environment Programme (2008b). *Freshwater under threat: South Asia.* Nairobi: United Nations Environment Programme. Retrieved from https://wedocs.unep.org/handle/20.500.11822/7715

United Nations Environment Programme (2009). *Freshwater under threat: South East Asia.* Nairobi: United Nations Environment Programme. Retrieved from https://wedocs.unep.org/handle/20.500.11822/8020

United Nations Environment Programme (2011). *Freshwater under Threat - Pacific Islands.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/pt-br/node/11661

United Nations Environment Programme (2016a). *GEO-6: Global Environment Outlook: Regional assessment for Asia and the Pacific.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/report/geo-6-global-environment-outlook-regional-assessment-asia-and-pacific

United Nations Environment Programme (2016b). *A Snapshot of the World's Water Quality: Towards a global assessment.*

United Nations Environment Programme (2016c). *Options for decoupling economic growth from water use and water pollution.* United Nations Environment Programme. Retrieved from https://www.resourcepanel.org/file/342/download?token=LmsRBoq4

United Nations Environment Programme (2017a). *GEO-6: Global Environment Outlook: Regional assessment for the Pan-European Region.* Nairobi: UNEP. Retrieved from https://www.unep.org/resources/report/geo-6-global-environment-outlook-regional-assessment-pan-european-region

United Nations Environment Programme (2017b). *GEO-6: Global Environment Outlook: Regional assessment for West Asia. Nairobi:* UNEP. Retrieved from https://www.unep.org/resources/report/geo-6-global-environment-outlook-regional-assessment-west-asia

United Nations Environment Programme (2019a). *Global Environment Outlook 6 For Industry in Asia-Pacific*. Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/report/global-environment-outlook-6-industry-asia-pacific

United Nations Environment Programme (2019b). *Species extinction not just a curiosity: our food security and health are at stake*. Retrieved October 25, 2022, from United Nations Environment Programme: https://www.unep.org/news-and-stories/story/species-extinction-not-just-curiosity-our-food-security-and-health-are-stake

United Nations Environment Programme (2019c). *Measuring Progress: Towards Achieving the Environmental Dimension of the SDGs.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/report/measuring-progress-towards-achieving-environmental-dimension-sdgs

United Nations Environment Programme (2019d). *Global Environment Outlook 6.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/global-environment-outlook-6

United Nations Environment Programme (2020). *Analysis Document - Gender and the Environment: A Preliminary Analysis of Gaps and Opportunities in Latin America and the Caribbean - Regional Group on Gender and Environment of the Forum of Ministers of Environment of Latin America and the Caribbean.* Retrieved from https://wedocs.unep.org/20.500.11822/34929

United Nations Environment Programme (2021a). *Progress on Integrated Water Resources Management. Tracking SDG 6 series: global indicator 6.5.1 updates and acceleration needs*. Nairobi: United Nations Environment Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/36690/PIWRS6.5.1.pdf

United Nations Environment Programme (2021b). *Measuring Progress: Environment and the SDGs*. Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/publication/measuring-progress-environment-and-sdgs

United Nations Environment Programme (2021c). *The use of natural resources in the economy: A Global Manual on Economy Wide Material Flow Accounting*. Nairobi: United Nations Environment Programme.

United Nations Environment Programme (2021d). *Report on Environmental and health impacts of pesticides and fertilizers and ways of minimizing them, Summary for Policy Makers*. United Nations Environment Programme. Retrieved from https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/34463/JSUNEPPF.pdf?sequence=13

United Nations Environment Programme (2022a). *Freshwater Strategic Priorities 2022-2025 to implement UNEP's Medium-Term Strategy*. Nairobi: United Nations Environment Programme. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/39607/Freshwater_Strategic_Priorities.pdf

United Nations Environment Programme (2022b). *Historic day in the campaign to beat plastic pollution: Nations commit to develop a legally binding agreement*. Retrieved September 30, 2022, from United Nations Environment Programme: https://www.unep.org/news-and-stories/press-release/historic-day-campaign-beat-plastic-pollution-nations-commit-develop

United Nations Environment Programme (n.d.a). *Asia and the Pacific, Our projects*. Retrieved from SEA circular Project: https://www.unep.org/regions/asia-and-pacific/our-projects/sea-circular-project

United Nations Environment Programme (n.d.b). *West Asia, Regional initiatives, Nature Action*. Retrieved from https://www.unep.org/regions/west-asia/regional-initiatives/nature-action

United Nations Environment Programme (n.d.c). *West Asia Regional Initiatives*. Retrieved from Building resilience disasters and conflicts: https://www.unep.org/regions/west-asia/regional-initiatives/building-resilience-disasters-and-conflicts

United Nations Environment Programme (n.d.d). *Regions West Asia*. Retrieved from Our work in West Asia: https://www.unep.org/regions/west-asia

United Nations Environment Programme (n.d.e). *Freshwater Ecosystems Explorer*. Retrieved 11 10, 2022, from United Nations Environment Programme: https://www.sdg661.app/

United Nations Environment Programme and Climate and Clean Air Coalition (2021). *Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unep.org/resources/report/global-methane-assessment-benefits-and-costs-mitigating-methane-emissions

United Nations Environment Programme and Food and Agriculture Organization of the United Nations (2020). *The UN Decade on Ecosystem Restoration 2021-2030*. United Nations Environment Programme and Food and Agriculture Organization of the United Nations. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/30919/UNDecade.pdf

United Nations Environment Programme and United Nations Human Settlement Programme (2010). *Sick Water? The Central Role of Wastewater Management in Sustainable Development - A Rapid Assessment.* United Nations Environment Programme and United Nations Human Settlements Programme. Retrieved from https://wedocs.unep.org/handle/20.500.11822/9156

United Nations General Assembly (2016). *A/RES/71/222 International Decade for Action, "Water for Sustainable Development"*, 2018-2028. New York: United Nations. Retrieved from https://digitallibrary.un.org/record/859143?ln=en

United Nations General Assembly (2017a). A/RES/71/222: Resolution adopted by the General Assembly on 21 December 2016. *General Assembly* (p. 5). New York: United Nations. Retrieved from https://documents-dds-ny.un.org/doc/UNDOC/GEN/N16/459/99/PDF/N1645999.pdf?OpenElement

United Nations General Assembly (2017b). *Work of the statistical commission pertaining to the 2030 agenda for sustainable development.* New York: United Nations General Assembly. Retrieved from https://ggim.un.org/documents/a_res_71_313.pdf

United Nations General Assembly (2018). A/RES/72/73: Resolution adopted by the General Assembly on 5 December 2017. (p. 55). New York: United Nations. Retrieved from https://documents-dds-ny.un.org/doc/UNDOC/GEN/N17/421/90/PDF/N1742190.pdf?OpenElement

United Nations Human Settlement Programme and World Health Organization (2021). Progress on wastewater treatment - *Global status and acceleration needs for SDG indicator 6.3.1.* Geneva: United Nations Human Settlements Programme (UN_Habitat) and World Health Organization (WHO). Retrieved from https://www.unwater.org/sites/default/files/app/uploads/2021/09/SDG6_Indicator_Report_631_Progress-on-Wastewater-Treatment_2021_EN.pdf

United Nations Office for Disaster Risk Reduction (2022). *Earth Observations into Action: Systemic Integration of Earth Observation Applications into National Risk Reduction Decision Structures Leveraging Geospatial Data Infrastructures.* Geneva: United Nations Office for Disaster Risk Reduction. Retrieved from https://reliefweb.int/attachments/e3a578f3-0474-40bf-9c74-bc7f2445e630/Earth%20observations%20into%20action%20-%20Systemic%20integration%20of%20Earth%20observation%20applications%20into%20national%20risk%20reduction%20decision%20structures%20leveraging%20

United Nations Office for the Coordination of Humanitarian Affairs (2022). *Horn of Africa Drought: Regional Humanitarian Overview & Call to Action*. Retrieved September 30, 2022, from ReliefWeb: https://reliefweb.int/report/ethiopia/horn-africa-drought-regional-humanitarian-overview-call-action-revised-24-august-2022

United Nations Statistics Department (2022a, October 4). *SDG Indicators Metadata* repository. Retrieved from United Nations Department of Economic and Social Affairs: https://unstats.un.org/sdgs/metadata/

United Nations Statistics Department (2022b, September). *SDG Indicators Database*. Retrieved from United Nations Department of Economic and Social Affairs: https://unstats.un.org/sdgs/dataportal/database

United Nations Statistics Department (2022c). *National Accounts Statistics: Main Aggregates and Detailed Tables, 2021, Part I*. New York: United Nations. Retrieved from https://unstats.un.org/unsd/nationalaccount/sdpubs/MADT-2021.pdf

United Nations Sustainable Development Solutions Network (2015). *Data for Development: A Needs Assessment for SDG Monitoring and Statistical Capacity Development*. United Nations Sustainable Development Solutions Network. Retrieved from https://sdgs.un.org/sites/default/files/publications/2017Data-for-Development-Full-Report.pdf

United Nations World Water Assessment Programme (2015). *The United Nations World Water Development Report 2015: Water for a Sustainable World.* Paris: United Nations Educational, Scientific and Cultural.

United Nations World Water Assessment Programme (2016). *The United Nations World Water Development Report 2016: Water and Jobs*. Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000243938

United Nations World Water Assessment Programme (2019). *The United Nations World Water Development Report 2019: Leaving No One Behind*. Paris: United Nations Educational, Scientific and Cultural Organization. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000367306

UN-Water (2016). *Water and Sanitation Interlinkages across the 2030 Agenda for Sustainable Development.* Geneva. Retrieved from https://unwater.org/sites/default/files/app/uploads/2016/08/Water-and-Sanitation-Interlinkages.pdf

UN-Water (2018a). *Progress on Ambient Water Quality, Piloting the monitoring methodology and initial findings for SDG indicator 6.3.2.* Nairobi: United Nations Environment Programme. Retrieved from https://www.unwater.org/sites/default/files/app/uploads/2018/12/SDG6_Indicator_Report_632_Progress-on-Ambient-Water-Quality_ENGLISH_2018-1.pdf

UN-Water (2018b). *United Nations Secretary-General's Plan: Water Action Decade 2018-2028.* Retrieved October 6, 2022, from https://wateractiondecade.org/wp-content/uploads/2018/03/UN-SG-Action-Plan_Water-Action-Decade-web.pdf

UN-Water (2021). *Summary Progress Update 2021 - SDG 6 - water and sanitation for all*. Geneva: UN-Water. Retrieved from https://www.unwater.org/sites/default/files/app/uploads/2021/12/SDG-6-Summary-Progress-Update-2021_Version-July-2021a.pdf

UN-Water (n.d.). *Country activities and commitments*. Retrieved October 6, 2022, from Water Action Decade: https://wateractiondecade.org/country-activities/

Usigbe, L. (2019, December 24). *Drying Lake Chad Basin gives rise to crisis*. Retrieved September 30, 2022, from United Nations: https://www.un.org/africarenewal/magazine/december-2019-march-2020/drying-lake-chad-basin-gives-rise-crisis#:~:text=The%20water%20body%20has%20diminished,areas%20in%20search%20of%20water.

Valenzuela, S. (2022, May 31). *Innovate to protect our ecosystems*. Retrieved September 30, 2022, from Atlantic Council: https://www.atlanticcouncil.org/in-depth-research-reports/books/allies-innovate-to-protect-our-ecosystems/

Van Brussel, S. and Huyse, H. (2019). Citizen science on speed? Realising the triple objective of scientific rigour, policy influence and deep citizen engagement in a large-scale citizen science project on ambient air quality in Antwerp. *Journal of Environmental Planning and Management, 62*(3), 534-551. doi:https://doi.org/10.1080/09640568.2018.1428183

Wang, J., Wang, Z.-C., Cui, Y.-H., Hao, S. and Yi, H.-Y. (2022). Comparison of phycocyanin concentrations in Chaohu Lake, China, retrieved using MODIS and OLCI images. *Frontiers in Environmental Science, 10*. doi:https://doi.org/10.3389/fenvs.2022.922505

Wang, R., van Rijswick, M. and Dai, L. (2022). Improving connectivity in water governance: the implementation of water cooperation mechanisms in disparate political and social contexts. *International Journal of Water Resources Development*, 38(4), 545. doi:https://doi.org/10.1080/07900627.2022.2071848

Wang, S., Tang, D., He, F., Fukuyo, Y. and Azanza, R. V. (2008). Occurrences of harmful algal blooms (HABs) associated with ocean environments in the South China Sea. *Hydrobiologia, 596*(1), 79-93. doi:https://doi.org/10.1007/s10750-007-9059-4

Weber, M., Rinke, K., Hipsey, M. and Boehrer, B. (2017). Optimizing withdrawal from drinking water reservoirs to reduce downstream temperature pollution and reservoir hypoxia. *Journal of Environmental Management, 197*, 96-105. doi:https://doi.org/10.1016/j.jenvman.2017.03.020

Weerasekara, S., Wilson, C., Lee, B., Hoang, V., Managi, S. and Rajapaksa, D. (2021). The impacts of climate induced disasters on the economy: Winners and losers in Sri Lanka. *Ecological Economics, 185,* 107043. doi:https://doi.org/10.1016/j.ecolecon.2021.107043

WeObserve (n.d.). *WeObserve Homepage*. Retrieved 11 10, 2022, from WeObserve: https://www.weobserve.eu/

Western Indian Ocean Marine Science Association and Intergovernmental Oceanographic Commission of UNESCO (2022). *United Nations Ocean Decade for Africa:* The Science we need for the ocean we want in Africa. Zanzibar: WIOMSA. Retrieved from http://wio-ecsn.wiomsa.org/wp-content/uploads/2022/10/UN-Ocean-decade-B5-pages-LR.pdf

Wiedmann, T., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J. and Kanemoto, K. (2013, September 3). The material footprint of nations. *PNAS, 112*(20), 6271-6276. doi:https://doi.org/10.1073/pnas.1220362110

Wildlife Science and Conservation Center of Mongolia (n.d.). *Key Biodiversity Areas*. Retrieved October 15, 2022, from Wildlife Science and Conservation Center of Mongolia: https://www.wscc.org.mn/p/41

Williams, B., Watson, J., Beyer, H., Klein, C., Montgomery, J., Runting, R., . . . Wenger, A. (2022). Global rarity of intact coastal regions. *Conservation Biology*, 36(4). doi:https://doi.org/10.1111/cobi.13874

Wilson, J. and Primack, R. (2019). *Conservation biology in sub-saharan Africa*. Open Book Publishers.

Withers, P., Neal, C., Jarvie, H. and Doody, D. (2014). Agriculture and eutrophication: where do we go from here? *Sustainability*, *6*(9), 5853-5875.

Woolway, R., Kraemer, B., Lenters, J., Merchant, C., O'Reilly, C. and Sharma, S. (2020). Global lake responses to climate change. *Nautre Reviews Earth & Environment*, 388-403. doi:https://doi.org/10.1038/s43017-020-0067-5

World Bank (2019). The Impact of Water Quality on GDP Growth : *Evidence from Around the World.* Washington D.C.

World Bank (2020a). *Colombia Turning the Tide: Water Security For Recovery and Sustainable Growth.* Washington, DC.: World Bank. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/34452/Colombia-Turning-the-Tide-Water-Security-for-Recovery-and-Sustainable-Growth-Policy-Brief.pdf?sequence=7&isAllowed=y

World Bank (2020b). *World Bank - Light Every Night*. Retrieved 11 10, 2022, from World Bank: https://worldbank.github.io/OpenNightLights/wb-light-every-night-readme.html

World Bank (2021a). *Annual Report 2021: Cooperation in International Waters in Africa.* Washington, DC.: World Bank. Retrieved from https://www.ciwaprogram.org/pdf/CIWA_AR2021_LOWRES.pdf

World Bank (2021b). *Priorities for Sustainably Managing Sri Lanka's Fisheries, Coastal Aquaculture, and the Ecosystems That Support Them*. Washington: The World Bank. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/36503/Priorities-for-Sustainably-Managing-Sri-Lanka-s-Marine-Fisheries-Coastal-Aquaculture-and-the-Ecosystems-that-Support-Them.pdf?sequence=5&isAllowed=y

World Bank (2022a). *From Source to Sea 2013-2021 South Asia Water Initiative Completion Report*. Washington, DC: World Bank Group. Retrieved from https://documents1.worldbank.org/curated/en/099312405272210424/pdf/IDU0274da53607b1704a6c0beba048461972fe3e.pdf

World Bank (2022b). *World Development Indicators*. Retrieved October 15, 2022, from The World Bank: https://databank.worldbank.org/reports.aspx?source=2&country=MNG

World Bank (n.d., October). *The World Bank, Who We Are, News.* Retrieved from Towards Improved Livelihoods and Higher Revenues From Sustainable Fisheries in Sri Lanka: https://www.worldbank.org/en/news/feature/2022/03/02/towards-improved-livelihoods-higher-revenues-from-sustainable-fisheries-srilanka#:~:text=STORY%20HIGHLIGHTS-,Fish%20make%20up%20about%2050%25%20of%20Sri%20Lankans'%20animal%20protein,degraded%2C%20and%2

World Health Organization (2021, June 9). *Malnutrition*. Retrieved October 25, 2022, from World Health Organization: https://www.who.int/news-room/fact-sheets/detail/malnutrition

World Health Organization (n.d.). *Water and sanitation*. Retrieved from https://www.who.int/europe/news-room/fact-sheets/item/water-and-sanitation

World Quality Portal (n.d.). *Water Quality Portal*. Retrieved 09 30, 2022, from Water Quality Portal: https://www.waterqualitydata.us/

World Resources Institute (2022, July 7). *Profiles of Adaptation: Colombia*. Retrieved November 15, 2022, from World Resources Institute: https://www.wri.org/update/profiles-adaptation-colombia#:~:text=Melting%20of%20glaciers%20due%20to,rising%20seas%20and%20storm%20surges.

World Wildlife Fund (2022). *Threats I Infrastructure*. Retrieved from Overview: https://www.worldwildlife.org/threats/infrastructure

World Wildlife Fund -Colombia (2017). *Colombia Viva: un país megadiverso de cara al futuro. Informe 2017*. Cali: WWF-Colombia. Retrieved from https://wwflac.awsassets.panda.org/downloads/colombia_viva___informe_2017__resumen_en_espanol.pdf

Wurm, M., Stark, T., Zhu, X. X., Weigand, M. and Taubenböck, H. (2019). Semantic segmentation of slums in satellite images using transfer learning on fully convolutional neural networks. *ISPRS journal of photogrammetry and remote sensing, 150*, 59-69. doi:https://doi.org/10.1016/j.isprsjprs.2019.02.006

Yadamsuren, O., Morse, J., Hayford, B., Gelhaus, J. and Adler, P. (2020). Macroinvertebrate community responses to land use: a trait-based approach for freshwater biomonitoring in Mongolia. *Environmental Science*, 1887-1902. Retrieved from https://www.semanticscholar.org/paper/Macroinvertebrate-community-responses-to-land-use%3A-Yadamsuren-Morse/d6c448096b8961127202722be578a4575afe2681

Zhang, X., Long, T., He, G., Guo, Y., Yin, R., Zhang, Z., . . . Cheng, B. (2020). Rapid generation of global forest cover map using Landsat based on the forest ecological zones. *Journal of Applied Remote Sensing, 14*(2). doi:https://doi.org/10.1117/1.JRS.14.022211

Zhang, Y., Guo, Y. and Nurdazym, A. (2022). How do female CEOs affect corporate environmental policies?. *Corporate Social Responsibility and Environmental Management*. doi:https://doi.org/10.1002/csr.2366

Zhao, Y., Wei, Y., Wu, B., Lu, Z. and Fu, L. (2018). A connectivity-based assessment framework for river basin ecosystem service management. *Current Opinion in Environmental Sustainability, 33*, 34-41. doi:https://doi.org/10.1016/j.cosust.2018.03.010

Zhou, X., Moinuddin, M. and Li, Y. (2019, July). *SDG Interlinkages Analysis and Visualisation Tool* (V3.0). Retrieved September 30, 2022, from Institute for Global Environmental Strategies: https://www.iges.or.jp/en/pub/sdg-interlinkages-web-tool-v3/en

Zhou, X., Moinuddin, M., Renaud, F., Barrett, B., Xu, J., Liang, Q., . . . Hoey, T. (2022). Development of an SDG interlinkages analysis model at the river basin scale: a case study in the Luanhe River Basin, China. *Sustainability Science, 17*, 1405-1433. doi:https://doi.org/10.1007/s11625-021-01065-z

Annex A. Environment-related SDG targets, indicators, and relevant sub-indicators in the SDG Global Indicator Framework

Table A.1 List of the 92 environment-related indicators in the SDG Global Indicator Framework

Note: Indicators for which UNEP is Custodian Agency are marked in blue font

Goal	Target	Indicator	Sub-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, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure	Proportion of people with secure tenure rights to land out of total adult population, by sex (%)
	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	Number of directly affected persons attributed to disasters per 100,000 population (number)
		1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)	Direct economic loss attributed to disasters relative to 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	Number of countries that reported having a National DRR Strategy which is aligned to the Sendai Framework
		1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies (%)

Goal	Target	Indicator	Sub-Indicator
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	Plant breeds for which sufficient genetic resources are stored (number)
		2.5.2 Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction	Proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk (%)
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	Age-standardized mortality rate attributed to household and ambient air pollution (deaths per 100,000 population)
		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)	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene from diarrhoea, intestinal nematode infections, malnutrition and acute respiratory infections (deaths per 100,000 population)
		3.9.3 Mortality rate attributed to unintentional poisoning	Mortality rate attributed to unintentional poisonings, by sex (deaths per 100,000 population)
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, 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	Extent to which global citizenship education and education for sustainable development are mainstreamed in national education policies

Goal	Target	Indicator	Sub-Indicator
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	Proportion of people with ownership or secure rights over agricultural land, both sexes (%)
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	Proportion of population using safely managed drinking water services, by urban/rural (%)
	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	Proportion of population using safely managed sanitation services, All areas (%)
	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 wastewater safely treated	Proportion of safely treated domestic wastewater flows (%)
		6.3.2 Proportion of bodies of water with good ambient water quality	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	Water Use Efficiency (United States dollars per cubic meter)
		6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	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 implementation (0-100)	Degree of integrated water resources management implementation (%)
		6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	Proportion of transboundary basins (river and lake basins and aquifers) 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	Lakes and Rivers permanent water area (% of total land area)

Goal	Target	Indicator	Sub-Indicator
	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	Total official development assistance (gross disbursement) for water supply and sanitation, by recipient countries (millions of constant 2020 United States dollars)
	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	Proportion of countries with clearly defined procedures in law or policy for participation by service users/ communities in planning program in water resources planning and management (%)
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	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	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	Energy intensity level of primary energy (megajoules per constant 2011 purchasing power parity 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	International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems (millions of constant 2016 United States dollars)
	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)	Installed renewable electricity-generating capacity (watts per capita)

Goal	Target	Indicator	Sub-Indicator
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	Material footprint per unit of GDP, by type of raw material (kilograms per constant 2015 United States dollar)
		8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	Domestic material consumption per capita, by type of raw material (tonnes)
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 CO_2 emission per unit of value added	Carbon dioxide emissions per unit of manufacturing value added (kilogrammes of CO_2 per constant 2010 United States dollars)
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	Proportion of population that has convenient access to public transport (%)
	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)	Total expenditure per capita spent on cultural and natural heritage, public and private (PPP, constant 2017 United States dollars)

Goal	Target	Indicator	Sub-Indicator
	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	Number of directly affected persons attributed to disasters per 100,000 population (number)
		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	Direct economic loss attributed to disasters relative to GDP (%)
	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 urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities	Municipal Solid Waste collection coverage, by cities (%)
		11.6.2 Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted)	Annual mean levels of fine particulate matter (population-weighted), by location (micrograms per cubic meter)
	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	Average share of the built-up area of cities that is open space for public use for all (%)
	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	Score of adoption and implementation of national DRR strategies in line with the Sendai Framework
		11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies (%)

Goal	Target	Indicator	Sub-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 with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies	Countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or target into national policies (1 = YES; 0 = NO)
	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	Material footprint per unit of GDP, by type of raw material (kilograms per constant 2010 United States dollar)
		12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	Domestic material consumption per capita, by type of raw material (tonnes)
	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	Food loss percentage (%) and Food Waste
	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	Parties meeting their commitments and obligations in transmitting information as required by MEA's on hazardous waste, and other chemicals
		12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment	Electronic waste generated, per capita (KG)
	12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled	Electronic waste recycling rate (%)
	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	Number of companies publishing sustainability reports with disclosure by dimension, by level of requirement (Number)

Goal	Target	Indicator	Sub-Indicator
	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	Number of countries implementing sustainable public procurement policies and action plans
	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 (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment	Extent to which global citizenship education and education for sustainable development are mainstreamed in national education policies
	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)	Installed renewable electricity-generating capacity (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	Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism (number of tables)
	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) and as a proportion of total national expenditure on fossil fuels	Fossil-fuel pre-tax subsidies (consumption and production) (billions of current United States dollars)

Goal	Target	Indicator	Sub-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	Number of directly affected persons attributed to disasters per 100,000 population (number)
		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	Score of adoption and implementation of national DRR strategies in line with the Sendai Framework
		13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	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	Number of countries with nationally determined contributions (Number)
		13.2.2 Total greenhouse gas emissions per year	Greenhouse gas emissions per year (SDG 13.2.2)
	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	Extent to which global citizenship education and education for sustainable development are mainstreamed in national education policies
	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 Mobilized amount of United States dollars per year between 2020 and 2025 accountable towards the $100 billion commitment	Total financial support provided (Billions of current United States dollars)

Goal	Target	Indicator	Sub-Indicator
	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 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	Number of least developed countries and small island developing States with nationally determined contributions (Number)
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	Chlorophyll-a deviations, remote sensing (%)
	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	Number of countries using ecosystem-based approaches to managing marine areas (1 = YES; 0 = NO)
	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	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	Proportion of fish stocks within biologically sustainable levels (not overexploited) (%)
	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	Average proportion of Marine Key Biodiversity Areas (KBAs) covered by protected areas (%)

Goal	Target	Indicator	Sub-Indicator
	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	Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing (level of implementation: 1 lowest to 5 highest)
	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	Sustainable fisheries as a proportion of GDP
	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	National ocean science expenditure as a share of total research and development funding (%)
	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	Score for the implementation of UNCLOS and its two implementing agreements (%)

Goal	Target	Indicator	Sub-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	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	Average proportion of Terrestrial Key Biodiversity Areas (KBAs) covered by protected areas (%)
	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	Proportion of forest area with a long-term management plan (%)
	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	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	Average proportion of Mountain Key Biodiversity Areas (KBAs) covered by protected areas (%)
		15.4.2 Mountain Green Cover Index	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	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	Countries that have legislative, administrative and policy framework or measures reported to the Access and Benefit-Sharing Clearing-House (1 = YES; 0 = NO)
	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	Legislation, Regulation, Act related to the prevention of introduction and management of Invasive Alien Species (1 = YES, 0 = NO)

Goal	Target	Indicator	Sub-Indicator
	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	Countries that established national targets in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020 in their National Biodiversity Strategy and Action Plans (1 = YES; 0 = NO)
	15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	**15.a.1** Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	Total official development assistance for biodiversity, by donor countries (millions of constant 2017 United States dollars)
	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** Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems	Total official development assistance for biodiversity, by recipient countries (millions of constant 2017 United States dollars)
	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	Sub-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 approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies	Total amount of approved 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	Total official development assistance (gross disbursement) for technical cooperation (millions of 2017 United States dollars)
	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	Mechanisms in place to enhance policy coherence for 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	Progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals (1 = YES; 0 = NO)
	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**	**92**

Annex B. The SDG Regional Groupings

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; Hong Kong, China; Macao, China; 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; 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; North 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, Sint Eustatius (Neth.); Saba (Neth.); 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; Sint Maarten (Neth.); 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

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

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; Türkiye; 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

Annex C. Socio-economic and environmental factors compilation

Annex C.1 Identified socio-economic and environmental factors for freshwater-related ecosystems

Goal	Target
Economic and social	Gross national income per capita, purchasing power parity (PPP)
	Urban population as a percentage of the total population
	2.a.1.3 Agriculture value added share of GDP (%)
	5.5.1 Proportion of seats held by women in (a) national parliaments and (b) local governments.
	5.5.2 Proportion of individuals who own a mobile telephone, by sex
	8.3.1 Proportion of informal employment in non-agriculture employment, by sex
	8.7.1 Proportion and number of children aged 5-17 years engaged in child labor, by sex and age
	9.2.1 Manufacturing value added as a proportion of GDP and per capita
	17.7.1 Total government revenue as a proportion of GDP, by source
Physical infrastructure	7.1.1 Proportion of population with access to electricity
	7.3.1 Energy intensity measured in terms of primary energy and GDP
	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
	11.7.1 Average share of the bult-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
	12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
	17.8.1 Proportion of individuals using the internet
Human infrastructure	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.
	4.1.2 Completion rate of upper secondary education
	4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill
	12.6.1 Number of companies publishing sustainability reports
	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 assessments
	16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official or were asked for a bribe by those public officials during the previous 12 months

Goal	Target
Environment conditions	9.4.1 CO_2 emission per unit of value added
	11.6.2 Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted)
	13.2.2 Total greenhouse gas emissions per year
	15.4.2 Mountain Green Cover Index
	15.5.1 Red List Index
Natural resources	15.1.1 Forest area as a proportion of total land area
	15.3.1 Proportion of land that is degraded over total land area

Annex C.2 Identified socio-economic and environmental factors for marine-related ecosystems

Goal	Target
Economic and social	Gross national income per capita, purchasing power parity (PPP)
	Urban population as percentage of total population
	2.1.1 Prevalence of undernourishment
	5.5.1 Proportion of seats held by women in (a) national parliaments and (b) local governments.
	8.3.1 Proportion of informal employment in non-agriculture employment, by sex
	8.7.1 Proportion and number of children aged 5-17 years engaged in child labour, by sex and age
	17.7.1 Total government revenue as a proportion of GDP, by source
Physical infrastructure	1.4.1 Proportion of population living in households with access to basic services
	4.a.1 Proportion of schools with access to (a) electricity; (b) the internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapter infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions).
	6.1.1 Proportion of population using safely managed drinking water services
	6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
	7.1.1 Proportion of population with access to electricity
	7.3.1 Energy intensity measured in terms of primary energy and GDP
	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
	11.7.1 Average share of the bult-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.
	17.8.1 Proportion of individuals using the internet

Goal	Target
Human infrastructure	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.
	4.1.2 Completion rate of education (upper secondary education)
	4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill
	11.3.2 Number of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
	12.6.1 Number of companies publishing sustainability reports
	16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months
Environment conditions	11.6.2 Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted)
	13.2.2 Total greenhouse gas emissions per year
	15.2.1 Progress towards sustainable forest management
	15.5.1 Red List Index
Natural resources	6.3.2 Proportion of bodies of water with good ambient water quality
	15.1.1 Forest area as a proportion of total land area
	15.3.1 Proportion of land that is degraded over total land area

Annex D. Indicators considered for the statistical analyses

Note: Annex D provides an overview of the indicators that were considered for the statistical analyses of the report (Table D.1 and Table D.3), and an overview of indicators that were eventually used because of sufficient data for the statistical analyses for global and national level (Table D.2 and Table D.4).

Annex D.1 Indicators considered for freshwater-related ecosystems

State of freshwater-related ecosystem indicators
6.3.2 Proportion of bodies of water with good ambient water quality
6.6.1 Change in the extent of water-related ecosystems over time

Drivers of change indicators for freshwater-related ecosystems
1.4.1 Proportion of population living in households with access to basic services
2.4.1 Proportion of agricultural area under productive and sustainable agriculture
6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
6.3.1 Proportion of domestic and industrial wastewater flows safely treated
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
6.5.1 Degree of integrated water resources management
6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
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
7.2.1 Renewable energy share in the total final energy consumption
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
9.1.2 Passenger and freight volumes, by mode of transport
11.1.1 Proportion of urban population living in slums, informal settlements, or inadequate housing
11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.5.3 (a) Damage to critical infrastructure and (b) number of disruptors to basic services, attributed to disasters

11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
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 (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
12.7.1 Degree of sustainable public procurement policies and action plan implementation
15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15.2.1 Forest area certified under an independently verified certification scheme (thousands of hectares)
15.4.1 Coverage by protected areas of important sites for mountain biodiversity

State of human well-being indicators related to freshwater-related ecosystems
1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)
1.2.1 Proportion of population living below the national poverty line, by sex and age.
1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
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)
2.1.1 Prevalence of undernourishment (%)
2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type
2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
2.3.2 Average income of small-scale food producers
3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene
4.a.1 Proportion of schools with access to (a) electricity; (b) the internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapted infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions).
6.1.1 Proportion of population using safely managed drinking water services
8.5.2 Unemployment rate, by sex, age and persons with disabilities
10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population
10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities
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 attributed to disasters in relation to global gross domestic product (GDP)
13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population

Annex D.2 Indicators with available data for freshwater-related ecosystems for Global, Mongolia and Colombia

Freshwater-related ecosystems indicators with available data, global level
1.1.1 Employed population below international poverty line (%)
2.1.1 Prevalence of undernourishment (%)
2.1.2 Proportion of children moderately or severely stunted (%)
2.2.2 Proportion of children moderately or severely overweight (%)
6.1.1 Proportion of population using safely managed drinking water services (%)
6.2.1 Proportion of population using basic sanitation water services (%)
6.6.1 Lakes and rivers permanent water area (% of total land area)
6.6.1 Lakes and rivers seasonal water area (% of total land area)
6.6.1 Reservoir minimum water area (% of total land area)
6.6.1 Reservoir maximum water area (% of total land area)
7.1.1 Proportion of population with access to electricity (%)
7.2.1 Renewable energy share in the total final energy consumption (%)
7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 PPP)
8.4.1 Material footprint per unit of GDP (kilograms per constant 2015 USD)
8.4.2 Domestic material consumption per unit of GDP (kilograms per constant 2015 USD)
8.5.2 Unemployment rate (%)
9.2.1 Manufacturing value added (current United States dollars) as a proportion of GDP (%)
9.4.1 Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2017 USD)
12.a.1 Installed renewable electricity-generating capacity (watts per capita)
12.4.2 Electronic waste generated, per capita (KG)
15.1.2 Average proportion of terrestrial Key Biodiversity Areas (KBAS) covered (%)
15.1.2 Average proportion of freshwater Key Biodiversity Areas (KBAs) covered (%)
15.4.1 Average proportion of mountain Key Biodiversity Areas (KBAS) covered (%)
15.5.1 Red List Index
Urban population as a percentage of total population
GNI per capita, Atlas method (current USD)
Completion rate of upper secondary education (%)

Freshwater-related ecosystems indicators with available data, Colombia
6.1.1 Proportion of population using safely managed drinking water services (%)
6.2.1 Proportion of population using basic sanitation water services (%)
6.4.1 Water-use efficiency (USD per cubic meter)
6.4.2 Levels of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)
6.6.1 Lakes and rivers permanent water area (% of total land area)
6.6.1 Lakes and rivers seasonal water area (% of total land area)
6.6.1 Reservoir minimum water area (% of total land area)
6.6.1 Reservoir maximum water area (% of total land area)
7.2.1 Renewable energy share in the total final energy consumption (%)
7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 PPP)
8.4.2 Domestic material consumption per unit of GDP (kilograms per constant 2015 USD)
9.2.1 Manufacturing value added (current United States dollars) as a proportion of GDP (%)
9.4.1 Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2017 USD)
15.1.2 Average proportion of freshwater Key Biodiversity Areas (KBAs) covered (%)
15.1.2 Average proportion of terrestrial Key Biodiversity Areas (KBAS) covered (%)
15.4.1 Average proportion of mountain Key Biodiversity Areas (KBAS) covered (%)
15.5.1 Red List Index
Urban population as a percentage of total population
GNI per capita, Atlas method (current USD)

Freshwater-related ecosystems indicators with available data, Mongolia
6.1.1 Proportion of population using safely managed drinking water services (%)
6.2.1 Proportion of population using basic sanitation water services (%)
6.4.1 Water-use efficiency (USD per cubic meter)
6.4.2 Levels of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)
6.6.1 Lakes and rivers permanent water area (% of total land area)
6.6.1 Lakes and rivers seasonal water area (% of total land area)
6.6.1 Reservoir minimum water area (% of total land area)
6.6.1 Reservoir maximum water area (% of total land area)
7.2.1 Renewable energy share in the total final energy consumption (%)
7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 PPP)

8.4.2 Domestic material consumption per unit of GDP (kilograms per constant 2015 USD)
9.2.1 Manufacturing value added (current United States dollars) as a proportion of GDP (%)
9.4.1 Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2017 USD)
15.1.2 Average proportion of freshwater KBAs covered (%)
15.1.2 Average proportion of terrestrial KBAs covered (%)
15.4.1 Average proportion of mountain KBAs covered (%)
15.5.1 Red List Index
Urban population as a percentage of total population
GNI per capita, Atlas method (current USD)

Annex D.3 Indicators considered for marine-related ecosystems

State of marine-related ecosystems indicators
14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density
14.3.1 Average marine acidity (pH) measured at the agreed suite of representative sampling stations
14.4.1 Proportion of fish stocks within biologically sustainable levels

Drivers of change indicators for marine-related ecosystems
6.3.1 Proportion of domestic and industrial wastewater flows safely treated
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.6.1 Change in the extent of water-related ecosystems over time
6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
7.2.1 Renewable energy share in the total final energy consumption
8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
9.1.2 Passenger and freight volumes, by mode of transport
9.4.1 CO_2 emission per unit of value added
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 (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
12.7.1 Degree of sustainable public procurement policies and action plan implementation
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.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
12.c.1 Amount of fossil-fuel subsidies (production and consumption) per unit of GDP
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-terms strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change.
14.2.1 Number of countries using ecosystem-based approaches to managing marine areas
14.5.1 Coverage of protected areas in relation to marine areas
14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregular fishing
14.a.1 Proportion of total research budget allocated to research in the field of marine technology
14.c.1 Number of countries making progress in ratifying UN Convention of the law of the sea

State of human well-being indicators related to marine-related ecosystems
1.1.1 Proportion of population below the international poverty line, by sex, age, employment status, and geographical location (urban/rural)
1.2.1 Proportion of population living below the national poverty line, by sex and age.
1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
2.3.2 Average income of small-scale food producers
8.5.2 Unemployment rate, by sex, age and persons with disabilities
8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training
10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population.
10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities
14.7.1 Sustainable fisheries as a proportion of GDP

Annex D.4 Indicators with available data for marine-related ecosystems for Global and Sri Lanka

Marine-related ecosystems indicators with available data, global level
1.1.1 Employed population below international poverty line (%)
2.1.1 Prevalence of undernourishment (%)
6.1.1 Proportion of population using safely managed drinking water services (%)
6.1.1 Proportion of population using basic drinking water services (%)
6.2.1 Proportion of population using basic sanitation services (%)
6.2.1 Proportion of population practicing open defecation (%)
6.2.1 Proportion of population using safely managed sanitation services (%)
6.6.1 Lakes and rivers permanent water area (% of total land area)
6.6.1 Lakes and rivers seasonal water area (% of total land area)
6.6.1 Reservoir minimum water area (% of total land area)
6.6.1 Reservoir maximum water area (% of total land area)
7.1.1 Proportion of population with access to electricity (%)
7.2.1 Renewable energy share in the total final energy consumption (%)
7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 PPP)
8.4.2 Domestic material consumption per unit of GDP (kilograms per constant 2015 USD)
8.5.2 Unemployment rate (%)
9.4.1 Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2017 USD)
12.a.1 Installed renewable electricity-generating capacity (watts per capita)
12.4.2 Electronic waste generated, per capita (KG)
14.1.1 Chlorophyll-a deviations, remote sensing (%)
14.5.1 Coverage protected areas in relation to marine areas
14.5.1 Protected marine areas (square kilometers)
15.1.2 Average proportion of marine KBAs covered (%)
15.5.1 Red List Index
Urban population as a percentage of total population
GNI per capita, Atlas method (current USD)
Completion rate of upper secondary education (%)

Marine-related ecosystems indicators with available data, Sri Lanka
1.1.1 Employed population below international poverty line (%)
6.1.1 Proportion of population using basic drinking water services (%)
6.2.1 Proportion of population using basic sanitation services (%)
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.6.1 Lakes and rivers permanent water area (% of total land area)
6.6.1 Lakes and rivers seasonal water area (% of total land area)
6.6.1 Reservoir minimum water area (% of total land area)
6.6.1 Reservoir maximum water area (% of total land area)
7.1.1 Proportion of population with access to electricity (%)
7.2.1 Renewable energy share in the total final energy consumption (%)
7.3.1 Energy intensity level of primary energy (megajoules per constant 2017 PPP)
8.4.2 Domestic material consumption per unit of GDP (kilograms per constant 2015 USD)
9.4.1 Carbon dioxide emissions per unit of GDP PPP (kilograms of CO_2 per constant 2017 USD)
9.4.1 Carbon dioxide emissions from fuel consumption (millions of tonnes)
14.1.1 Chlorophyll-a deviations, remote sensing (%)
15.1.2 Average proportion of marine KBAs covered (%)
15.5.1 Red List Index
Urban population as a percentage of total population
GNI per capita, Atlas method (current USD)

Annex E. Potential synergies identified as part of the statistical analysis

Annex E.1 Identified synergies between the drivers of change and the state of freshwater-related ecosystems and identified synergies between the state of freshwater-related ecosystems and the state of the human well-being

Note: Potential synergies are highlighted in blue.

Synergies Freshwater-related Ecosystems		State of Freshwater-related Ecosystems	
		6.3.2 Proportion of bodies of water with good ambient water quality	6.6.1 Change in the extent of water-related ecosystems over time
Drivers of change	1.4.1 Proportion of the population living in households with access to basic services		
	2.4.1 Proportion of agricultural area under productive and sustainable agriculture		
	6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water		
	6.3.1 Proportion of domestic and industrial wastewater flows safely treated		
	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		
	6.5.1 Degree of integrated water resources management		
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation		
	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan		
	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		
	7.2.1 Renewable energy share in the total final energy consumption		
	8.4.1 Material footprint, material footprint per capita, and material footprint per GDP		

Synergies Freshwater-related Ecosystems		State of Freshwater-related Ecosystems	
		6.3.2 Proportion of bodies of water with good ambient water quality	6.6.1 Change in the extent of water-related ecosystems over time
Drivers of change	8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP		
	9.1.2 Passenger and freight volumes, by mode of transport		
	11.1.1 Proportion of urban population living in slums, informal settlements, or inadequate housing		
	11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically		
	11.5.3 (a) Damage to critical infrastructure and (b) number of disruptors to basic services, attributed to disasters		
	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities		
	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 (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		
	12.7.1 Degree of sustainable public procurement policies and action plan implementation		
	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type		
	15.2.1 Forest area certified under an independently verified certification scheme (thousands of hectares)		
	15.4.1 Coverage by protected areas of important sites for mountain biodiversity		

Synergies Freshwater-related Ecosystems		State of Freshwater-related Ecosystems	
		6.3.2 Proportion of bodies of water with good ambient water quality	6.6.1 Change in the extent of water-related ecosystems over time
State of human well-being	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)		
	1.2.1 Proportion of population living below the national poverty line, by sex and age.		
	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions		
	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)		
	2.1.1 Prevalence of undernourishment (%)		
	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)		
	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type		
	2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)		
	2.3.2 Average income of small-scale food producers		
	3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene		
	4.a.1 Proportion of schools with access to (a) electricity; (b) the internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapted infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions).		
	6.1.1 Proportion of population using safely managed drinking water services		
	8.5.2 Unemployment rate, by sex, age and persons with disabilities		
	10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population		
	10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities		
	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 attributed to disasters in relation to global gross domestic product (GDP)		
	13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population		

Annex E.2 Identified synergies between the drivers of change and the state of marine-related ecosystems, and identified synergies between the state of marine-related ecosystems and the state of the human well-being

Synergies Marine-related Ecosystems		State of Marine-related Ecosystems		
		14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density	14.2.1 Average marine acidity (pH) measured at the agreed suite of representative sampling stations	14.3.1 Proportion of fish stocks within biologically sustainable levels
Drivers of change	6.3.1 Proportion of domestic and industrial wastewater flows safely treated	■		
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources		■	■
	6.6.1 Change in the extent of water-related ecosystems over time	■		
	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	■		
	7.2.1 Renewable energy share in the total final energy consumption	■		
	8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP	■		
	9.1.2 Passenger and freight volumes, by mode of transport	■	■	■
	9.4.1 CO_2 emission per unit of value added		■	
	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 (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	■		
	12.7.1 Degree of sustainable public procurement policies and action plan implementation	■	■	■
	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.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)		■	
	12.c.1 Amount of fossil-fuel subsidies (production and consumption) per unit of GDP		■	

Synergies Marine-related Ecosystems		State of Marine-related Ecosystems		
		14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density	14.2.1 Average marine acidity (pH) measured at the agreed suite of representative sampling stations	14.3.1 Proportion of fish stocks within biologically sustainable levels
Drivers of change	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-terms strategies, national adaptation plans and adaptation communications, as reported to the secretariat of the United Nations Framework Convention on Climate Change			
	14.2.1 Number of countries using ecosystem-based approaches to managing marine areas			
	14.5.1 Coverage protected areas in relation to marine areas			
	14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregular fishing			
	14.a.1 Proportion of total research budget allocated to research in the field of marine technology			
	14.c.1 Number of countries making progress in ratifying UN Convention of the law of the sea			

Synergies Marine-related Ecosystems		State of Marine-related Ecosystems		
		14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density	14.2.1 Average marine acidity (pH) measured at the agreed suite of representative sampling stations	14.3.1 Proportion of fish stocks within biologically sustainable levels
State of human well-being	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status, and geographical location (urban/rural)			
	1.2.1 Proportion of population living below the national poverty line, by sex and age.			
	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions			
	2.3.2 Average income of small-scale food producers			
	8.5.2 Unemployment rate, by sex, age and persons with disabilities			
	8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training			
	10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population.			
	10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities			
	14.7.1 Sustainable fisheries as a proportion of GDP			

Annex F. Instrumental models

Annex F.1 Instrumental statistical models for the state of freshwater-related ecosystems at global level

		LAKES AND RIVERS SEASONAL WATER AREA									
Type	Description	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10
Divers of change	Proportion of population using basic drinking water services	0.72	0.67								0.68
	Electronic waste generated, per capita			-2.32	-2.97	-3.71	-1.6	-3.96	-4.47	-4.92	
	Average proportion of freshwater KBAs covered			0.9				0.62			1.69
	Average proportion of terrestrial KBAs covered				1.28				0.85		
	Average proportion of mountain KBAs covered					1.79	1.65			1.14	
	Renewable energy share in the total final energy consumption										
	Material footprint per unit of GDP	-0.27									
	Domestic material consumption per unit of GDP		-0.28								
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP	-0.22	-0.24								
	Red List Index			-2.26	-2.54	-2.78					
	Carbon dioxide emissions per unit of GDP PPP						-0.83				
	GNI per capita, Atlas method										-1.59
	Completion rate of upper secondary education										
	Installed renewable electricity-generating capacity										
	Proportion of population with access to electricity										
	Energy intensity level of primary energy										
	Urban population as percentage of total population							4.18	4.46	4.62	

		LAKES AND RIVERS SEASONAL WATER AREA												
Type	Description	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23
Divers of change	Proportion of population using basic drinking water services													
	Electronic waste generated, per capita						-1.8	-4.23						
	Average proportion of freshwater KBAs covered	2.19							1.59	1.68	1.86	1.88	1.57	1.72
	Average proportion of terrestrial KBAs covered		1.9	1.87										
	Average proportion of mountain KBAs covered				1.82	1.78								
	Renewable energy share in the total final energy consumption	0.27												
	Material footprint per unit of GDP		-0.19		-0.2									
	Domestic material consumption per unit of GDP			-0.2		-0.2								
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP						-0.31	-0.26						
	Red List Index						-2.45		-0.74					
	Carbon dioxide emissions per unit of GDP PPP									-0.44				
	GNI per capita, Atlas method	-1.51	-1.11	-1.1	-1.02	-1.01			-1.55	-1.3	-1.74	-1.83	-1.34	-1.46
	Completion rate of upper secondary education										0.65			
	Installed renewable electricity-generating capacity											0.7		
	Proportion of population with access to electricity												0.57	
	Energy intensity level of primary energy													-0.53
	Urban population as percentage of total population							4.93						

		LAKES AND RIVERS SEASONAL WATER AREA											
Type	**Description**	**M24**	**M25**	**M26**	**M27**	**M28**	**M29**	**M30**	**M31**	**M32**	**M33**	**M34**	**M35**
Divers of change	Proportion of population using basic drinking water services												
	Electronic waste generated, per capita												
	Average proportion of freshwater KBAs covered	1.52											
	Average proportion of terrestrial KBAs covered		1.97	2.09	1.99	2.13	1.89						
	Average proportion of mountain KBAs covered												
	Renewable energy share in the total final energy consumption												
	Material footprint per unit of GDP							-0.24	-0.3	-0.3	-0.17	-0.19	-0.27
	Domestic material consumption per unit of GDP												
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP							-0.23	-0.27	-0.27	-0.26	-0.29	-0.2
	Red List Index		-0.47					-0.71					
	Carbon dioxide emissions per unit of GDP PPP			-0.27									
	GNI per capita, Atlas method	-1.65	-1.68	-1.58	-1.6	-1.67	-1.72						
	Completion rate of upper secondary education								0.69				
	Installed renewable electricity-generating capacity									0.68			
	Proportion of population with access to electricity				0.39						0.69		
	Energy intensity level of primary energy					-0.3						-0.67	
	Urban population as percentage of total population	0.9					0.57						0.73

		LAKES AND RIVERS SEASONAL WATER AREA										
Type	**Description**	**M36**	**M37**	**M38**	**M39**	**M40**	**M41**	**M42**	**M43**	**M44**	**M45**	**M46**
Divers of change	Proportion of population using basic drinking water services								0.83	0.79		
	Electronic waste generated, per capita											
	Average proportion of freshwater KBAs covered										0.84	0.81
	Average proportion of terrestrial KBAs covered											
	Average proportion of mountain KBAs covered											
	Renewable energy share in the total final energy consumption											
	Material footprint per unit of GDP								-0.21		-0.29	
	Domestic material consumption per unit of GDP	-0.25	-0.3	-0.31	-0.18	-0.2	-0.27	-0.41		-0.2		-0.3
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP	-0.25	-0.29	-0.28	-0.27	-0.3	-0.22	-0.2				
	Red List Index	-0.67										
	Carbon dioxide emissions per unit of GDP PPP											
	GNI per capita, Atlas method							0.69				
	Completion rate of upper secondary education		0.64									
	Installed renewable electricity-generating capacity			0.63								
	Proportion of population with access to electricity				0.66							
	Energy intensity level of primary energy					-0.63						
	Urban population as percentage of total population						0.69					

		LAKES AND RIVERS SEASONAL WATER AREA									
Type	**Description**	**M47**	**M48**	**M49**	**M50**	**M51**	**M52**	**M53**	**M54**	**M55**	**M56**
Divers of change	Proportion of population using basic drinking water services										
	Electronic waste generated, per capita						-2.84				
	Average proportion of freshwater KBAs covered							0.45	1.84		
	Average proportion of terrestrial KBAs covered	0.84	0.81							0.45	2.47
	Average proportion of mountain KBAs covered			0.85	0.81						
	Renewable energy share in the total final energy consumption										
	Material footprint per unit of GDP	-0.3		-0.3		3.55					
	Domestic material consumption per unit of GDP		-0.3		-0.3	-3.71					
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP										
	Red List Index										
	Carbon dioxide emissions per unit of GDP PPP							-0.38		-0.37	
	GNI per capita, Atlas method								-1.13		-1.76
	Completion rate of upper secondary education										
	Installed renewable electricity-generating capacity										
	Proportion of population with access to electricity										
	Energy intensity level of primary energy										
	Urban population as percentage of total population						3.66				

LAKES AND RIVERS SEASONAL WATER AREA													
Type	Description	M57	M58	M59	M60	M61	M62	M63	M64	M65	M66	M67	Average Impact
Divers of change	Proportion of population using basic drinking water services												0.74
	Electronic waste generated, per capita												-3.28
	Average proportion of freshwater KBAs covered												1.41
	Average proportion of terrestrial KBAs covered												1.58
	Average proportion of mountain KBAs covered	2.36											1.52
	Renewable energy share in the total final energy consumption		0.43										0.35
	Material footprint per unit of GDP			-0.17	-0.22	-0.23	-0.21	-0.37					-0.05
	Domestic material consumption per unit of GDP								-0.2	-0.22	-0.2	-0.37	-0.44
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		-0.57										-0.27
	Red List Index			-0.82									-1.49
	Carbon dioxide emissions per unit of GDP PPP												-0.46
	GNI per capita, Atlas method	-1.64						0.85				0.8	-1.19
	Completion rate of upper secondary education				0.81				0.77				0.71
	Installed renewable electricity-generating capacity					0.8				0.76			0.71
	Proportion of population with access to electricity												0.58
	Energy intensity level of primary energy												-0.53
	Urban population as percentage of total population						0.83				0.8		2.4

		LAKES AND RIVERS PERMANENT WATER AREA				
Type	Description	M01	M02	M03	M04	Average Impact
Divers of change	Proportion of population using basic drinking water services					
	Electronic waste generated, per capita					
	Average proportion of freshwater KBAs covered	2.93	2.39			2.66
	Average proportion of terrestrial KBAs covered			2.56		2.56
	Average proportion of mountain KBAs covered				2.1	2.1
	Renewable energy share in the total final energy consumption					
	Material footprint per unit of GDP	0.24				0.24
	Domestic material consumption per unit of GDP					
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP					
	Red List Index					
	Carbon dioxide emissions per unit of GDP PPP					
	GNI per capita, Atlas method	-2.64	-2.01	-2.18	-1.72	-2.14
	Completion rate of upper secondary education					
	Installed renewable electricity-generating capacity					
	Proportion of population with access to electricity					
	Energy intensity level of primary energy					
	Urban population as percentage of total population					

Type	Description	RESERVOIR MAXIMUM WATER AREA									
		M01	M02	M03	M04	M05	M06	M07	M08	M09	M10
Divers of change	Proportion of population using basic drinking water services	-0.88	-1.33							-0.63	-0.82
	Electronic waste generated, per capita			-1.07	-1.86						
	Average proportion of freshwater KBAs covered					2.89				1.17	
	Average proportion of terrestrial KBAs covered	3.26		3.23			1.74	3.34			1.34
	Average proportion of mountain KBAs covered		3.57		3.84				3.79		
	Renewable energy share in the total final energy consumption										
	Material footprint per unit of GDP					0.24					
	Domestic material consumption per unit of GDP										
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP						-0.26				
	Red List Index										
	Carbon dioxide emissions per unit of GDP PPP										
	GNI per capita, Atlas method	-1.89	-1.77	-1.64	-1.46	-2.41	-1.35	-1.87	-1.75		
	Completion rate of upper secondary education										
	Installed renewable electricity-generating capacity										
	Proportion of population with access to electricity										
	Energy intensity level of primary energy										
	Urban population as percentage of total population							-0.96	-1.55		

RESERVOIR MAXIMUM WATER AREA													
Type	Description	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	Average Impact
Divers of change	Proportion of population using basic drinking water services	-1.01											-0.93
	Electronic waste generated, per capita		-0.83	-1.19	-1.68								-1.33
	Average proportion of freshwater KBAs covered		1.4			0.39	1.27	2.36					1.58
	Average proportion of terrestrial KBAs covered			1.73					0.35	2.36			2.17
	Average proportion of mountain KBAs covered	1.52			2.22						0.34	1.68	2.42
	Renewable energy share in the total final energy consumption												
	Material footprint per unit of GDP												0.24
	Domestic material consumption per unit of GDP												
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP					-0.32			-0.35		-0.36		-0.32
	Red List Index												
	Carbon dioxide emissions per unit of GDP PPP												
	GNI per capita, Atlas method							-1.79		-1.8			-1.77
	Completion rate of upper secondary education												
	Installed renewable electricity-generating capacity												
	Proportion of population with access to electricity												
	Energy intensity level of primary energy												
	Urban population as percentage of total population						-0.72					-1.16	-1.1

		RESERVOIR MINIMUM WATER AREA												
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**	**M11**	**M12**	**Average Impact**
Divers of change	Proportion of population using basic drinking water services	-0.81	-1.24											-1.02
	Electronic waste generated, per capita			-1.6				-1.42						-1.51
	Average proportion of freshwater KBAs covered				2.95				0.37	2.34				1.89
	Average proportion of terrestrial KBAs covered	3.16				3.2					0.33	2.33		2.26
	Average proportion of mountain KBAs covered		3.47	3.56			3.56	1.95					0.32	2.57
	Renewable energy share in the total final energy consumption													
	Material footprint per unit of GDP				0.28	0.29								0.29
	Domestic material consumption per unit of GDP													
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP								-0.32		-0.35		-0.36	-0.34
	Red List Index													
	Carbon dioxide emissions per unit of GDP PPP													
	GNI per capita, Atlas method	-1.88	-1.77	-1.46	-2.5	-2.77	-1.72			-1.78		-1.79		-1.96
	Completion rate of upper secondary education													
	Installed renewable electricity-generating capacity													
	Proportion of population with access to electricity													
	Energy intensity level of primary energy													
	Urban population as percentage of total population						-1.37							-1.37

Annex F.2 Instrumental statistical models for the state of the freshwater-related ecosystems' impact on the state of human well-being at global level

		EMPLOYED POPULATION BELOW INTERNATIONAL POVERTY LINE					
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**Average Impact**
State of ecosystem	Lakes and rivers permanent water area		-0.05				-0.05
	Lakes and rivers seasonal water area					-0.27	-0.27
	Reservoir minimum water area	-0.05		-0.21			-0.13
	Reservoir maximum water area				-0.21		-0.21
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP						
	Red List Index	-0.46	-0.45				
	Carbon dioxide emissions per unit of GDP PPP			0.87	0.87	0.78	0.84
	GNI per capita, Atlas method						
	Completion rate of upper secondary education	-1.41	-1.42				-1.42
	Installed renewable electricity-generating capacity						
	Proportion of population with access to electricity						
	Energy intensity level of primary energy						
	Urban population as percentage of total population						

		UNEMPLOYMENT RATE			
Type	**Description**	**M01**	**M02**	**M03**	**Average Impact**
State of ecosystem	Lakes and rivers permanent water area				
	Lakes and rivers seasonal water area			-1.08	-1.08
	Reservoir minimum water area	-1.01			-1.01
	Reservoir maximum water area		-1.03		-1.03
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP	-0.56	-0.6	-0.52	-0.56
	Red List Index				
	Carbon dioxide emissions per unit of GDP PPP				
	GNI per capita, Atlas method				
	Completion rate of upper secondary education				
	Installed renewable electricity-generating capacity				
	Proportion of population with access to electricity				
	Energy intensity level of primary energy				
	Urban population as percentage of total population				

		PROPORTION OF CHILDREN MODERATELY OR SEVERELY OVERWEIGHT					
Type	Description	M01	M02	M03	M04	M05	Average Impact
State of ecosystem	Lakes and rivers permanent water area			0.82			0.82
	Lakes and rivers seasonal water area				1.37	0.97	1.17
	Reservoir minimum water area	0.86					0.86
	Reservoir maximum water area		0.82				0.82
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP						
	Red List Index	2.56	2.43	2.28	2.6	0.77	2.13
	Carbon dioxide emissions per unit of GDP PPP	-2.15	-2.04	-1.98	-1.61		-1.95
	GNI per capita, Atlas method						
	Completion rate of upper secondary education						
	Installed renewable electricity-generating capacity						
	Proportion of population with access to electricity						
	Energy intensity level of primary energy						
	Urban population as percentage of total population						

		PROPORTION OF CHILDREN MODERATELY OR SEVERELY STUNTED			
Type	Description	M01	M02	M03	Average Impact
State of ecosystem	Lakes and rivers permanent water area				
	Lakes and rivers seasonal water area			-0.23	-0.23
	Reservoir minimum water area	-0.16			-0.16
	Reservoir maximum water area		-0.16		-0.16
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP				
	Red List Index				
	Carbon dioxide emissions per unit of GDP PPP	0.93	0.93	0.84	0.9
	GNI per capita, Atlas method				
	Completion rate of upper secondary education				
	Installed renewable electricity-generating capacity				
	Proportion of population with access to electricity				
	Energy intensity level of primary energy				
	Urban population as percentage of total population				

		PREVALENCE OF UNDERNOURISHMENT									
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**Average Impact**
State of ecosystem	Lakes and rivers permanent water area			-0.18							-0.18
	Lakes and rivers seasonal water area				-0.42					-0.47	-0.44
	Reservoir minimum water area	-0.22				-0.35	-0.25				-0.27
	Reservoir maximum water area		-0.23					-0.37	-0.26		-0.29
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP										
	Red List Index	-1.79	-1.79	-1.91	-2.54						-2.01
	Carbon dioxide emissions per unit of GDP PPP					0.7		0.69		0.54	0.64
	GNI per capita, Atlas method										
	Completion rate of upper secondary education										
	Installed renewable electricity-generating capacity	-2.55	-2.54	-2.71	-3.1						-2.72
	Proportion of population with access to electricity										
	Energy intensity level of primary energy						0.79		0.77		0.78
	Urban population as percentage of total population										

Annex F.3 Instrumental statistical models for the state of freshwater-related ecosystems, Colombia

		LAKES AND RIVERS PERMANENT WATER AREA				
Type	Description	M01	M02	M03	M04	Average Impact
State of ecosystem	Proportion of population using basic drinking water services					
	Average proportion of freshwater KBAs covered					
	Average proportion of terrestrial KBAs covered	1.5				1.5
	Average proportion of mountain KBAs covered		1.5			1.5
	Water-use efficiency			1.15		1.15
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources				-1.73	-1.73
	Renewable energy share in the total final energy consumption					
	Domestic material consumption per unit of GDP					
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP	1.5	1.49			1.5
	Red List Index					
	Carbon dioxide emissions per unit of GDP PPP					
	GNI per capita, Atlas method			1.31	1.88	1.59
	Energy intensity level of primary energy					
	Urban population as percentage of total population					

		LAKES AND RIVERS SEASONAL WATER AREA				
Type	Description	M01	M02	M03	M04	Average Impact
State of ecosystem	Proportion of population using basic drinking water services	-0.4	-0.72	-0.68	-1.16	-0.74
	Average proportion of freshwater KBAs covered	1.24				1.24
	Average proportion of terrestrial KBAs covered		1.51			1.51
	Average proportion of mountain KBAs covered			1.48		1.48
	Water-use efficiency					
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources					
	Renewable energy share in the total final energy consumption					
	Domestic material consumption per unit of GDP					
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP					
	Red List Index				-1.95	-1.95
	Carbon dioxide emissions per unit of GDP PPP					
	GNI per capita, Atlas method					
	Energy intensity level of primary energy					
	Urban population as percentage of total population					

		RESERVOIR MAXIMUM WATER AREA	
Type	Description	M01	Average Impact
State of ecosystem	Proportion of population using basic drinking water services		
	Average proportion of freshwater KBAs covered		
	Average proportion of terrestrial KBAs covered		
	Average proportion of mountain KBAs covered		
	Water-use efficiency		
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources		
	Renewable energy share in the total final energy consumption	0.4	0.4
	Domestic material consumption per unit of GDP		
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		
	Red List Index		
	Carbon dioxide emissions per unit of GDP PPP		
	GNI per capita, Atlas method		
	Energy intensity level of primary energy	-0.32	-0.32
	Urban population as percentage of total population		

		RESERVOIR MINIMUM WATER AREA																
Type	Description	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10	M11	M12	M13	M14	M15	M16	M17	Average Impact
Divers of change	Proportion of population using basic drinking water services	0.7	0.39	0.6	0.81			0.92	0.48										0.65
	Average proportion of freshwater KBAs covered					0.22				0.22	0.36								0.27
	Average proportion of terrestrial KBAs covered																		
	Average proportion of mountain KBAs covered						0.24					0.22	0.4						0.29
	Water-use efficiency													0.38					0.38
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.47		-0.85	-0.34			-0.36							-1.06	-0.78			-0.64
	Renewable energy share in the total final energy consumption					0.18	0.17										0.28		0.21
	Domestic material consumption per unit of GDP	-0.34	-0.45															-0.83	-0.54
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		0.29															0.3	0.3
	Red List Index			-0.83										-0.95	-1.65				-1.14
	Carbon dioxide emissions per unit of GDP PPP									-0.38		-0.36							-0.37
	GNI per capita, Atlas method																		
	Energy intensity level of primary energy				-0.13	-0.26	-0.24		-0.14		-0.23		-0.19				-0.36		-0.22
	Urban population as percentage of total population															1.35			1.35

Annex F.4 Instrumental statistical models for the state of the freshwater-related ecosystems' impact on the state of human well-being, Colombia

		PROPORTION OF POPULATION USING SAFELY MANAGED DRINKING WATER SERVICES										
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**	**Average Impact**
State of ecosystem	Lakes and rivers permanent water area											
	Lakes and rivers seasonal water area	0.43							0.44	0.6	0.36	0.46
	Reservoir minimum water area	0.48	0.25	0.2	0.43							0.34
	Reservoir maximum water area					0.28	0.54	0.56				0.46
	Manufacturing value added as a proportion of GDP											
	Red List Index		-0.73			-0.7						-0.72
	Carbon dioxide emissions per unit of GDP PPP						-0.39		-0.54			-0.47
	GNI per capita, Atlas method				0.5			0.44			0.52	0.49
Socioeconomic and environmental factors	Energy intensity level of primary energy									-0.34		-0.34
	Urban population as percentage of total population			0.76								0.76
	Carbon dioxide emissions per unit of GDP PPP											
	GNI per capita, Atlas method	-1.88	-1.77	-1.46	-2.5	-2.77	-1.72			-1.78		-1.96
	Completion rate of upper secondary education											
	Installed renewable electricity-generating capacity											
	Proportion of population with access to electricity											
	Energy intensity level of primary energy											
	Urban population as percentage of total population						-1.37					-1.37

Annex F.5 Instrumental statistical models for the state of freshwater-related ecosystems, Mongolia

		LAKES AND RIVERS PERMANENT WATER AREA							
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**Average Impact**
Drivers of change	Proportion of population using basic drinking water services	0.57			0.95				0.76
	Average proportion of freshwater KBAs covered								
	Average proportion of terrestrial KBAs covered								
	Average proportion of mountain KBAs covered								
	Water-use efficiency		0.55						0.55
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources								
	Renewable energy share in the total final energy consumption	0.76	0.87	0.8	0.66	0.36	0.61	0.95	0.72
	Domestic material consumption per unit of GDP	-0.54	-0.69	-0.56		-0.68			-0.62
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP								
	Red List Index			-0.6					-0.6
	Carbon dioxide emissions per unit of GDP PPP								
	GNI per capita, Atlas method							1.19	1.19
	Energy intensity level of primary energy								
	Urban population as percentage of total population						0.89		0.89

		LAKES AND RIVERS SEASONAL WATER AREA								
Type	Description	M01	M02	M03	M04	M05	M06	M07	M08	Average Impact
Drivers of change	Proportion of population using basic drinking water services	1.04					1.3			1.17
	Average proportion of freshwater KBAs covered									
	Average proportion of terrestrial KBAs covered									
	Average proportion of mountain KBAs covered									
	Water-use efficiency		0.9							0.9
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources									
	Renewable energy share in the total final energy consumption	0.88	0.98	0.94	0.6	0.57	0.81	0.84	0.5	0.76
Socioeconomic and environmental factors	Domestic material consumption per unit of GDP	-0.38	-0.65	-0.41	-0.64	-0.66				-0.55
	Manufacturing value added as a proportion of GDP									
	Red List Index			-1.08				-1.33		-1.21
	Carbon dioxide emissions per unit of GDP PPP				-0.52					
	GNI per capita, Atlas method									
	Energy intensity level of primary energy					-0.47				-0.47
	Urban population as percentage of total population								0.96	0.96

		RESERVOIR MAXIMUM WATER AREA										
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**	**M11**
Drivers of change	Proportion of population using basic drinking water services	0.51			0.43							
	Average proportion of freshwater KBAs covered					0.52				0.33		
	Average proportion of terrestrial KBAs covered										0.56	0.64
	Average proportion of mountain KBAs covered						0.57					
	Water-use efficiency		0.99					0.67				
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.21		-0.18					-0.4			
	Renewable energy share in the total final energy consumption		0.41									
	Domestic material consumption per unit of GDP	-0.31	-0.36	-0.3	-0.21	-0.5	-0.41	-0.27	-0.69			
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP											
	Red List Index			-0.53								
	Carbon dioxide emissions per unit of GDP PPP										-0.41	
	GNI per capita, Atlas method											
	Energy intensity level of primary energy				-0.28							-0.32
	Urban population as percentage of total population									0.64		

		RESERVOIR MAXIMUM WATER AREA										
Type	**Description**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**Average Impact**
Drivers of change	Proportion of population using basic drinking water services											0.47
	Average proportion of freshwater KBAs covered											0.43
	Average proportion of terrestrial KBAs covered	0.53	0.49									0.56
	Average proportion of mountain KBAs covered			0.35	0.42	0.36						0.42
	Water-use efficiency						0.58					0.75
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources							-0.26				-0.26
	Renewable energy share in the total final energy consumption											0.41
	Domestic material consumption per unit of GDP								-0.68	-0.36	-0.4	-0.41
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP								0.29			0.29
	Red List Index											-0.53
	Carbon dioxide emissions per unit of GDP PPP			-0.58						-0.58		-0.52
	GNI per capita, Atlas method		0.46									0.46
	Energy intensity level of primary energy				-0.51						-0.54	-0.41
	Urban population as percentage of total population	0.42				0.58	0.32	0.74				0.54

		RESERVOIR MINIMUM WATER AREA									
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**
Drivers of change	Proportion of population using basic drinking water services	0.7	0.6						0.44		
	Average proportion of freshwater KBAs covered									0.28	
	Average proportion of terrestrial KBAs covered			0.44							
	Average proportion of mountain KBAs covered	0.23			0.21		0.25		0.36		0.4
	Water-use efficiency				0.73	0.69					
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.15	-0.3	-0.36		-0.14	-0.12	-0.28			
	Renewable energy share in the total final energy consumption										
	Domestic material consumption per unit of GDP		-0.22	-0.4	-0.1	-0.24		-0.22		-0.24	-0.17
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP										
	Red List Index						-0.71	-0.62			
	Carbon dioxide emissions per unit of GDP PPP								-0.26	-0.56	-0.5
	GNI per capita, Atlas method										
	Energy intensity level of primary energy										
	Urban population as percentage of total population										

		RESERVOIR MINIMUM WATER AREA									
Type	**Description**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**
Drivers of change	Proportion of population using basic drinking water services		0.48								
	Average proportion of freshwater KBAs covered					0.25			0.29	0.27	0.26
	Average proportion of terrestrial KBAs covered						0.38				
	Average proportion of mountain KBAs covered		0.36	0.43							
	Water-use efficiency										
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.27			-0.3	-0.15	-0.17	-0.32			
	Renewable energy share in the total final energy consumption										
	Domestic material consumption per unit of GDP	-0.44		-0.19	-0.48			-0.24			
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP										
	Red List Index										
	Carbon dioxide emissions per unit of GDP PPP	-0.41							-0.42	-0.3	
	GNI per capita, Atlas method					0.69	0.54	0.54		0.49	
	Energy intensity level of primary energy		-0.22	-0.46	-0.35						-0.37
	Urban population as percentage of total population								0.36		0.42

		RESERVOIR MINIMUM WATER AREA									
Type	**Description**	**M21**	**M22**	**M23**	**M24**	**M25**	**M26**	**M27**	**M28**	**M29**	**M30**
Drivers of change	Proportion of population using basic drinking water services										
	Average proportion of freshwater KBAs covered	0.24									
	Average proportion of terrestrial KBAs covered		0.5	0.36	0.38	0.33					
	Average proportion of mountain KBAs covered						0.44	0.35	0.34	0.4	0.35
	Water-use efficiency										
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources										
	Renewable energy share in the total final energy consumption										
	Domestic material consumption per unit of GDP										
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		0.18				0.16				
	Red List Index							-0.5	-0.53		
	Carbon dioxide emissions per unit of GDP PPP			-0.31				-0.21		-0.4	-0.35
	GNI per capita, Atlas method	0.54		0.36		0.42					0.35
	Energy intensity level of primary energy	-0.26			-0.37	-0.28			-0.18		
	Urban population as percentage of total population		0.42		0.29		0.51			0.26	

		RESERVOIR MINIMUM WATER AREA									
Type	**Description**	**M31**	**M32**	**M33**	**M34**	**M35**	**M36**	**M37**	**M38**	**M39**	**M40**
Drivers of change	Proportion of population using basic drinking water services					0.65	0.84				
	Average proportion of freshwater KBAs covered							0.71			
	Average proportion of terrestrial KBAs covered										
	Average proportion of mountain KBAs covered	0.39	0.32			0.4			0.25	0.82	
	Water-use efficiency								0.78		0.87
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources						-0.22				
	Renewable energy share in the total final energy consumption										
	Domestic material consumption per unit of GDP			-0.32	-0.35			-0.41		-0.25	-0.13
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP			0.18	0.19						
	Red List Index										
	Carbon dioxide emissions per unit of GDP PPP			-0.59							
	GNI per capita, Atlas method		0.4								
	Energy intensity level of primary energy	-0.37	-0.31		-0.55						
	Urban population as percentage of total population	0.31									

		RESERVOIR MINIMUM WATER AREA									
Type	**Description**	**M41**	**M42**	**M43**	**M44**	**M45**	**M46**	**M47**	**M48**	**M49**	**M50**
Drivers of change	Proportion of population using basic drinking water services		0.88	0.63	0.67						
	Average proportion of freshwater KBAs covered					0.35	0.5	0.37			
	Average proportion of terrestrial KBAs covered								0.58	0.64	0.72
	Average proportion of mountain KBAs covered										
	Water-use efficiency										
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	-0.53									
	Renewable energy share in the total final energy consumption										
	Domestic material consumption per unit of GDP	-0.67									
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		0.14								
	Red List Index										
	Carbon dioxide emissions per unit of GDP PPP			-0.34		-0.68			-0.46		
	GNI per capita, Atlas method							0.69			
	Energy intensity level of primary energy				-0.3					-0.4	
	Urban population as percentage of total population						0.59				0.33

RESERVOIR MINIMUM WATER AREA														
Type	**Description**	**M51**	**M52**	**M53**	**M54**	**M55**	**M56**	**M57**	**M58**	**M59**	**M60**	**M61**	**M62**	**Average Impact**
Drivers of change	Proportion of population using basic drinking water services													0.65
	Average proportion of freshwater KBAs covered													0.35
	Average proportion of terrestrial KBAs covered	0.51												0.48
	Average proportion of mountain KBAs covered		0.37	0.51	0.55	0.6	0.43							0.4
	Water-use efficiency													0.77
	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources							-0.18	-0.38	-0.23				-0.26
	Renewable energy share in the total final energy consumption													
	Domestic material consumption per unit of GDP										-0.65	-0.28	-0.31	-0.32
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP										0.44			0.22
	Red List Index		-0.69					-0.86						-0.65
	Carbon dioxide emissions per unit of GDP PPP			-0.55								-0.71		-0.44
	GNI per capita, Atlas method	0.52					0.6			0.8				0.53
	Energy intensity level of primary energy				-0.5								-0.67	-0.37
	Urban population as percentage of total population					0.46			0.74					0.43

Annex F.6 Instrumental statistical models for the state of the freshwater-related ecosystems' impact on the state of human well-being, Mongolia

PROPORTION OF POPULATION USING SAFELY MANAGED DRINKING WATER SERVICES																							
Type	Description	M01	M02	M03	M04	M05	M06	M07	M08	M09	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	Average Impact
State of ecosystem	Lakes and rivers permanent water area	-0.38		0.15		0.2		-1.21					0.67	0.09	0.25	0.29	0.14						0.02
	Lakes and rivers seasonal water area	0.62			0.21		0.27	1.94										0.74	0.11	0.33	0.37	0.2	0.53
	Reservoir minimum water area					0.79	0.73		-0.38	0.33													0.37
	Reservoir maximum water area		0.3								0.34	0.39											0.34
Socioeconomic and environmental factors	Manufacturing value added as a proportion of GDP		0.09										0.54					0.47					0.37
	Red List Index								-1.33					-0.9					-0.88				-1.04
	Carbon dioxide emissions per unit of GDP PPP														-0.72					-0.65			-0.69
	GNI per capita, Atlas method	0.72		0.65	0.61							0.55					0.83					0.78	0.69
	Energy intensity level of primary energy			-0.19	-0.19											-0.68					-0.61		-0.42
	Urban population as percentage of total population		0.61							0.62	0.6												0.61

Annex F.7 Instrumental statistical models for the state of freshwater-related ecosystems, Poyang river, China

		EMPLOYED POPULATION BELOW INTERNATIONAL POVERTY LINE			
Type	Description	M01	M02	M03	Average Impact
Drivers of change	Freight volume				
	Passenger traffic				
	Rail freight volume				
	Railway passenger traffic				
	Road freight volume				
	Road passenger traffic	-0.18			-0.18
	Water freight volume				
	Waterway passenger traffic	-0.45	-0.31		
	Agricultural water consumption				
	Groundwater supply				
	Harmless treatment rate of domestic waste			0.23	0.23
	Hazardous waste disposal volume				
	Hazardous waste generation				
	Hazardous waste storage				
	General industrial solid waste disposal volume				
	General industrial solid waste storage				
	Industrial water consumption				
	General industrial solid waste dumping amount				
	General industrial solid waste generation				
	Industrial wastewater discharge	-0.25	-0.26	-0.16	-0.22
	Surface water supply				
	Comprehensive utilization of hazardous waste				
	Comprehensive utilization of general industrial solid waste				

Type	Description	EMPLOYED POPULATION BELOW INTERNATIONAL POVERTY LINE			
		M01	M02	M03	Average Impact
Socioeconomic and environmental factors	Total CO_2 emissions				
	Average level of PM				
	GDP per capita				
	Industrial sulfur dioxide emissions				
	Industrial soot emissions				
	Industrial waste gas treatment facilities				
	Forest cover rate				
	Operating cost of industrial waste gas treatment facilities				
	Urban population as percentage of total population				
	Comprehensive utilization rate of industrial solid waste				
	Freight volume				

Annex F.8 Instrumental statistical models for the state of marine-related ecosystems at global level

		CHLOROPHYLL-A DEVIATIONS, REMOTE SENSING									
Type	**Description**	**M01**	**M02**	**M03**	**M04**	**M05**	**M06**	**M07**	**M08**	**M09**	**M10**
Drivers of change	Electronic waste generated, per capita	5.13	7.69	7.45	1.84	10.89	7.22	11.47	7.34	7.9	9.97
	Installed renewable electricity-generating capacity	-5.68	-8.43	-7.33		-8.74	-5.27	-8.43	-6.85	-6.99	-6.98
	Coverage of protected areas in relation to marine areas										
	Protected marine area										
	Average proportion of marine KBAs covered										
	Lakes and rivers permanent water area										
	Lakes and rivers seasonal water area										
	Reservoir minimum water area										
	Reservoir maximum water area										
	Renewable energy share in the total final energy consumption	-0.41									
	Domestic material consumption per unit of GDP		0.32								
	Carbon dioxide emissions from fuel combustion										
	Carbon dioxide emissions per unit of GDP PPP			0.94	1.08						
Socioeconomic and environmental factors	Prevalence of undernourishment				1.61						
	Red List Index					2.92					
	GNI per capita, Atlas method										
	Completion rate of upper secondary education						-2.69				
	Proportion of population using basic drinking water services										
	Proportion of population using basic sanitation services							-3.78			
	Proportion of population using safely managed drinking water services								-1.32		
	Proportion of population practicing open defecation									1.76	
	Proportion of population using safely managed sanitation services										-3.76
	Proportion of population with access to electricity										
	Energy intensity level of primary energy										
	Urban population as percentage of total population										

		CHLOROPHYLL-A DEVIATIONS, REMOTE SENSING												
Type	**Description**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**M22**	**M23**
Drivers of change	Electronic waste generated, per capita	10.03	14.44		4.99	3.9	2.48	2.72	4.7	7.86				
	Installed renewable electricity-generating capacity	-9.51	-9.79	-3.54							-3.37	-2.74	-2.69	
	Coverage of protected areas in relation to marine areas													
	Protected marine area													
	Average proportion of marine KBAs covered													
	Lakes and rivers permanent water area													
	Lakes and rivers seasonal water area													
	Reservoir minimum water area													
	Reservoir maximum water area													
	Renewable energy share in the total final energy consumption													
	Domestic material consumption per unit of GDP													
	Carbon dioxide emissions from fuel combustion													
	Carbon dioxide emissions per unit of GDP PPP			1.6										4.8
Socioeconomic and environmental factors	Prevalence of undernourishment				2.22	1.34	1.75	1.58	1.41	2.38				1.77
	Red List Index				3.57						6.64			
	GNI per capita, Atlas method													
	Completion rate of upper secondary education					-3.32								
	Proportion of population using basic drinking water services													
	Proportion of population using basic sanitation services													
	Proportion of population using safely managed drinking water services						-1.6					-1.94		
	Proportion of population practicing open defecation							2.02					2.86	
	Proportion of population using safely managed sanitation services								-4.07					
	Proportion of population with access to electricity	-1.29												
	Energy intensity level of primary energy													-5.57
	Urban population as percentage of total population		-5.43	4.3						-6.29	9.27	3.85	4.67	

		CHLOROPHYLL-A DEVIATIONS, REMOTE SENSING										
Type	**Description**	**M24**	**M25**	**M26**	**M27**	**M28**	**M29**	**M30**	**M31**	**M32**	**M33**	**M34**
Drivers of change	Electronic waste generated, per capita		6.46									
	Installed renewable electricity-generating capacity		-7.15	-0.56	-2.35							
	Coverage of protected areas in relation to marine areas					-0.55						
	Protected marine area						-0.55					
	Average proportion of marine KBAs covered							-0.52				
	Lakes and rivers permanent water area											
	Lakes and rivers seasonal water area								-0.4			
	Reservoir minimum water area									-0.35		
	Reservoir maximum water area										-0.36	
	Renewable energy share in the total final energy consumption			-0.47		-0.47	-0.47	-0.54	-0.66	-0.79	-0.8	-0.58
	Domestic material consumption per unit of GDP											
	Carbon dioxide emissions from fuel combustion				1.65							-0.52
	Carbon dioxide emissions per unit of GDP PPP	1.31										
Socioeconomic and environmental factors	Prevalence of undernourishment	1.29										
	Red List Index											
	GNI per capita, Atlas method											
	Completion rate of upper secondary education											
	Proportion of population using basic drinking water services											
	Proportion of population using basic sanitation services											
	Proportion of population using safely managed drinking water services											
	Proportion of population practicing open defecation											
	Proportion of population using safely managed sanitation services											
	Proportion of population with access to electricity											
	Energy intensity level of primary energy											
	Urban population as percentage of total population	1.75										

		CHLOROPHYLL-A DEVIATIONS, REMOTE SENSING												
Type	Description	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	Average Impact
Drivers of change	Electronic waste generated, per capita	2.45	3.05											6.67
	Installed renewable electricity-generating capacity			-1.93										-5.7
	Coverage of protected areas in relation to marine areas													-0.55
	Protected marine area													-0.55
	Average proportion of marine KBAs covered													-0.52
	Lakes and rivers permanent water area													
	Lakes and rivers seasonal water area													-0.4
	Reservoir minimum water area													-0.35
	Reservoir maximum water area													-0.36
	Renewable energy share in the total final energy consumption				-0.48	-0.42	-0.4	-0.45	-0.45	-0.42	-0.46	-0.61		-0.52
	Domestic material consumption per unit of GDP													0.32
	Carbon dioxide emissions from fuel combustion												1.21	0.78
	Carbon dioxide emissions per unit of GDP PPP													1.95
Socioeconomic and environmental factors	Prevalence of undernourishment				0.57									1.59
	Red List Index					0.58								3.43
	GNI per capita, Atlas method			1.25								-0.51		0.37
	Completion rate of upper secondary education	-3.22					-0.59							-2.46
	Proportion of population using basic drinking water services							-0.57						-0.57
	Proportion of population using basic sanitation services								-0.56					-2.17
	Proportion of population using safely managed drinking water services													-1.62
	Proportion of population practicing open defecation													2.21
	Proportion of population using safely managed sanitation services		-3.84							-0.58			-1.96	-2.84
	Proportion of population with access to electricity													-1.29
	Energy intensity level of primary energy													-5.57
	Urban population as percentage of total population										-0.56			1.44

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