Progress on Freshwater Ecosystems

GLOBAL INDICATOR 6.6.1 UPDATES AND ACCELERATION NEEDS

2021

United Nations | UN WATER | UN environment programme 50 1972-2022

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Progress on Freshwater Ecosystems

Global indicator 6.6.1 updates and acceleration needs

2021

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Presenting the UN-Water Integrated Monitoring Initiative for SDG 6

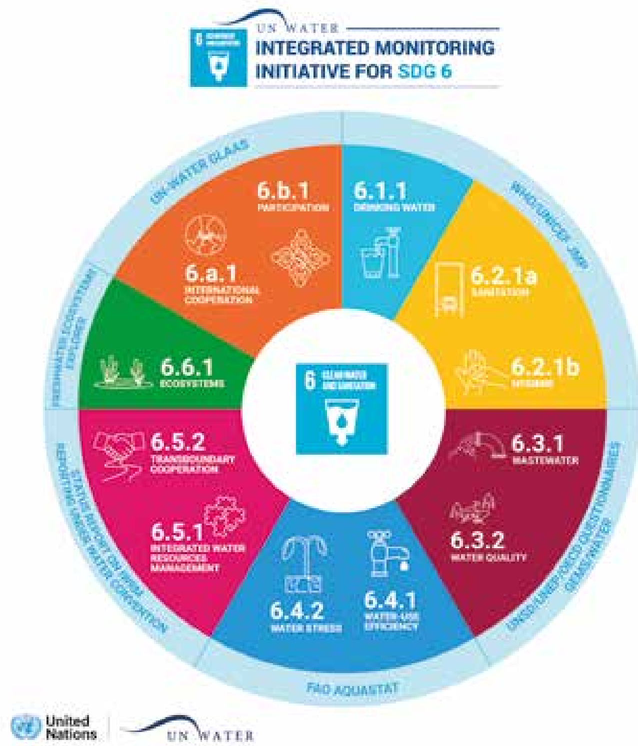
Through the UN-Water Integrated Monitoring Initiative for SDG 6 (IMI-SDG6), the United Nations seeks to support countries in monitoring water- and sanitation-related issues within the framework of the 2030 Agenda for Sustainable Development, and in compiling country data to report on global progress towards SDG 6.

IMI-SDG6 brings together the United Nations organizations that are formally mandated to compile country data on the SDG 6 global indicators, and builds on ongoing efforts such as the World Health Organization (WHO)/United Nations Children's Fund (UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), the Global Environment Monitoring System for Freshwater (GEMS/Water), the Food and Agriculture Organization of the United Nations (FAO) Global Information System on Water and Agriculture (AQUASTAT) and the UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS).

This joint effort enables synergies to be created across United Nations organizations and methodologies and requests for data to be harmonized, leading to more efficient outreach and a reduced reporting burden. At the national level, IMI-SDG6 also promotes intersectoral collaboration and consolidation of existing capacities and data across organizations.

The overarching goal of IMI-SDG6 is to accelerate the achievement of SDG 6 by increasing the availability of high-quality data for evidence-based policymaking, regulations, planning and investments at all levels. More specifically, IMI-SDG6 aims to support countries to collect, analyse and report SDG 6 data, and to support policymakers and decision makers at all levels to use these data.

- Learn more about SDG 6 monitoring and reporting and the support available: www.sdg6monitoring.org
- Read the latest SDG 6 progress reports, for the whole goal and by indicator: https://www.unwater.org/publication_categories/sdg6-progress-reports/
- Explore the latest SDG 6 data at the global, regional and national levels: www.sdg6data.org



INDICATORS	CUSTODIANS
6.1.1 Proportion of population using safely managed drinking water services	WHO, UNICEF
6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	WHO, UNICEF
6.3.1 Proportion of domestic and industrial wastewater flows safely treated	WHO, UN-Habitat, UNSD
6.3.2 Proportion of bodies of water with good ambient water quality	UNEP
6.4.1 Change in water-use efficiency over time	FAO
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	FAO
6.5.1 Degree of integrated water resources management	UNEP
6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	UNECE, UNESCO
6.6.1 Change in the extent of water-related ecosystems over time	UNEP, Ramsar
6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	WHO, OECD
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	WHO, OECD

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Foreword

The COVID-19 crisis has caused enormous disruption to sustainable development. However, even before the pandemic, the world was seriously off track to meet Sustainable Development Goal 6 (SDG 6) – to ensure water and sanitation for all by 2030.

No matter how significant the challenges we face, achieving SDG 6 is critical to the overarching aim of the 2030 Agenda, which is to eradicate extreme poverty and create a better and more sustainable world. Making sure that there is water and sanitation for all people, for all purposes, by 2030 will help protect global society against many and varied looming threats.

Our immediate, shared task is to establish safe water and sanitation services in all homes, schools, workplaces and health care facilities. We must increase investment in water use efficiency, wastewater treatment and reuse, while protecting water-related ecosystems. And we must integrate our approaches, with improved governance and coordination across sectors and geographical borders.

In short, we need to do much more, and do it much more quickly. In the SDG 6 Summary Progress Update 2021 that preceded this series of reports, UN-Water showed that the current rate of progress needs to double - and in some cases quadruple - to reach many of the targets under SDG 6.

At the March 2021 high-level meeting on the "Implementation of the Water-related Goals and Targets of the 2030 Agenda", UN Member States noted that to achieve SDG 6 by 2030 will require mobilizing an additional US$ 1.7 trillion, three times more than the current level of investment in water-related infrastructure. To make this happen, Member States are calling for new partnerships between governments and a diverse group of stakeholders, including the private sector and philanthropic organizations, as well as the wide dissemination of innovative technology and methods.

We know where we need to go, and data will help light the way. As we ramp up our efforts and target them at areas of greatest need, information and evidence will be of critical importance.

Published by the UN-Water Integrated Monitoring Initiative for SDG 6 (IMI-SDG6), this series of indicator reports is based on the latest available country data, compiled and verified by the custodian United Nations agencies, and sometimes complemented by data from other sources.

The data were collected in 2020, a year in which the pandemic forced country focal points and UN agencies to collaborate in new ways. Together we learned valuable lessons on how to build monitoring capacity and how to involve more people, in more countries, in these activities.

The output of IMI-SDG6 makes an important contribution to improving data and information, one of the five accelerators in the SDG 6 Global Acceleration Framework launched last year.

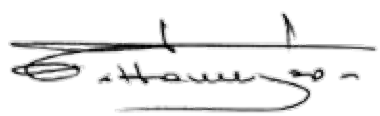
With these reports, our intention is to provide decision-makers with reliable and up-to-date evidence on where acceleration is most needed, so as to ensure the greatest possible gains. This evidence is also vital to ensure accountability and build public, political and private sector support for investment.

Thank you for reading this document and for joining this critical effort. Everyone has a role to play. When governments, civil society, business, academia and development aid agencies pull together dramatic gains are possible in water and sanitation. To deliver them, it will be essential to scale up this cooperation across countries and regions.

The COVID-19 pandemic reminds us of our shared vulnerability and common destiny. Let us “build back better” by ensuring water and sanitation for all by 2030.

Gilbert F. Houngbo

UN-Water Chair and President of the International Fund for Agricultural Development



UNEP foreword

In 2017, with the ambitions of the 2030 Agenda for Sustainable Development firmly under way, the United Nations Environment Programme (UNEP) reached out to Member States to request – for the first time – national data on freshwater ecosystems (Sustainable Development Goal (SDG) indicator 6.6.1). The aim was to obtain global data on the extent of freshwater ecosystems, and a baseline from which countries could monitor progress on their protection and restoration (target 6.6). However, it was very clear that monitoring dynamic ecosystem changes was in practice an enormous and complex undertaking, and an entirely new task to many countries.

As part of efforts to reduce the global data gap on freshwater ecosystems, UNEP deployed the use of global Earth observations to generate accurate and statistically robust information. Countries were able to approve the national and river basin-level data collected, which are freely available on the Freshwater Ecosystems Explorer thanks to the support of many public and private partners. Tapping into the digital revolution has enabled long-term, global environmental trends to be observed with accuracy and confidence.

With only nine years left before 2030, it is crucial to accelerate efforts to protect and restore freshwater ecosystems. Eighty-five per cent of wetlands have disappeared in the last 300 years and one fifth of the world's river basins (including lakes, reservoirs and rivers on which humankind depends to develop sustainably) are experiencing dramatic, above-normal changes in available surface water.

This is a cause for concern for all countries and signals the need to rapidly increase and enforce the protection of critical freshwater ecosystems.

While humans may be responsible for driving ecosystem changes, they are also able to find solutions using available data to make informed decisions. At no other point in human history have people had to face such climate, pollution and biodiversity crises. Keeping ecosystems healthy will help address these crises and allow the world to “make peace with nature”. Now is the time for action.

Inger Andersen

Executive Director of the United Nations Environment Programme

Target 6.6: Ecosystems

By 2030, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes[1]

Freshwater ecosystems have enormous biological, environmental, social, educational and economic value and provide a range of goods and services upon which people, and all life, depend. Ecosystems purify fresh water, regulate flows, supply water and food to billions of people, drive water, carbon and nutrient cycles, harbour exceptional freshwater biodiversity (Reid and others, 2018) and enable the productive use of water for drinking, agriculture, energy generation, navigation, employment and tourism (UN-Water, 2019). In the context of the Sustainable Development Goal (SDG) framework, freshwater ecosystems are foundational natural resources of the biosphere. Numerous development actions depend on them and either succeed or fail depending on the functional capacity or integrity of the ecosystem. Any adverse changes in the quantity and quality of fresh water ultimately reduce capacities to develop sustainably.

SDG target 6.6 seeks to halt the degradation and destruction of freshwater ecosystems and to assist the recovery of those that are already degraded. The target includes ecosystems such as inland and coastal wetlands, rivers, lakes, reservoirs and groundwater. Actions taken to protect and restore freshwater ecosystems readily contribute to the achievement of other SDG targets including on climate (target 13.1 on strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all countries), land (target 15.3 to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world) and oceans (target 14.1 to prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution). Progress towards target 6.6 is monitored through indicator 6.6.1.

1 While the official wording of target 6.6 states 2020, it is assumed the date will be updated to 2030.

Indicator 6.6.1: Change in the extent of water-related ecosystems over time

To inform decisions and actions that protect and restore freshwater ecosystems requires monitoring their particular properties (area, quantity and quality) to generate information that can be used to determine the extent of any changes over time. This includes, for example, changes to the surface area of lakes, reservoirs and wetlands, changes in the water quality of lakes, reservoirs and rivers, and changes in the quantity of river flow and water held underground in aquifers.

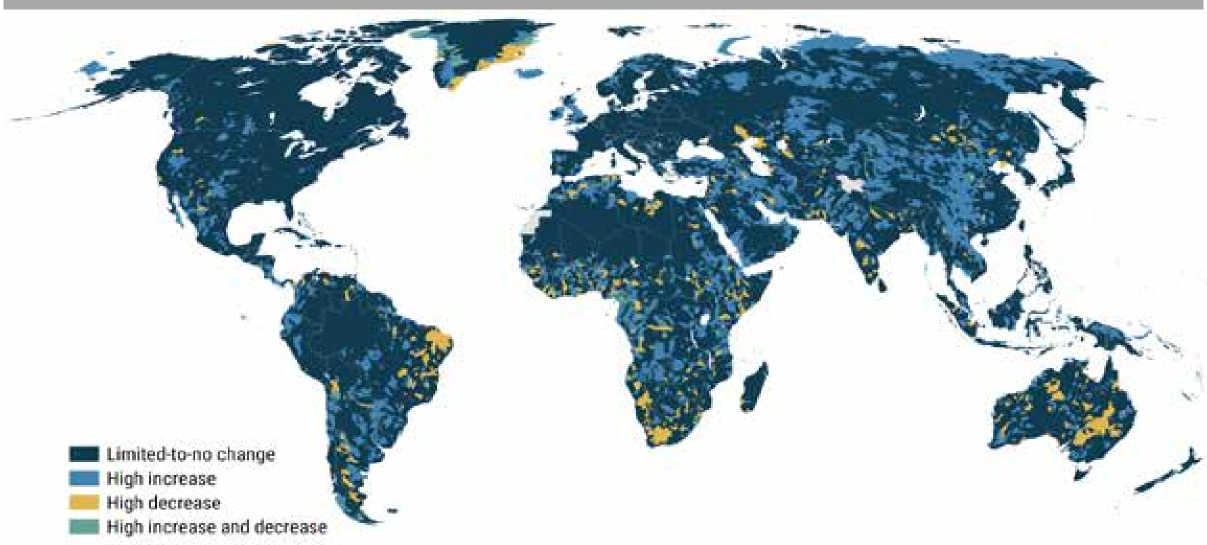
Denali National Park and Preserve, Arkansas, USA by Sterling Lanier on Unsplash

Executive summary

Human activities are causing globally observable changes to freshwater ecosystems and hydrological regimes. Demand for water from the world's increasing population has redefined natural landscapes into agricultural and urban land. Global precipitation and temperature changes are exacerbating the problem, impacting the quantity and quality of fresh water.

Rapid changes are being observed in surface-water area. The extent of surface water available in one fifth of the world's rivers basins[2] has changed significantly in the last five years. These impacted river basins are experiencing both rapid increases (light blue on map) in their surface-water area due to flooding, a growth in reservoirs and newly inundated land, and rapid declines (yellow on map) due to the drying up of lakes, reservoirs, wetlands, floodplains and seasonal water bodies.

Figure 0.1. Global surface-water changes



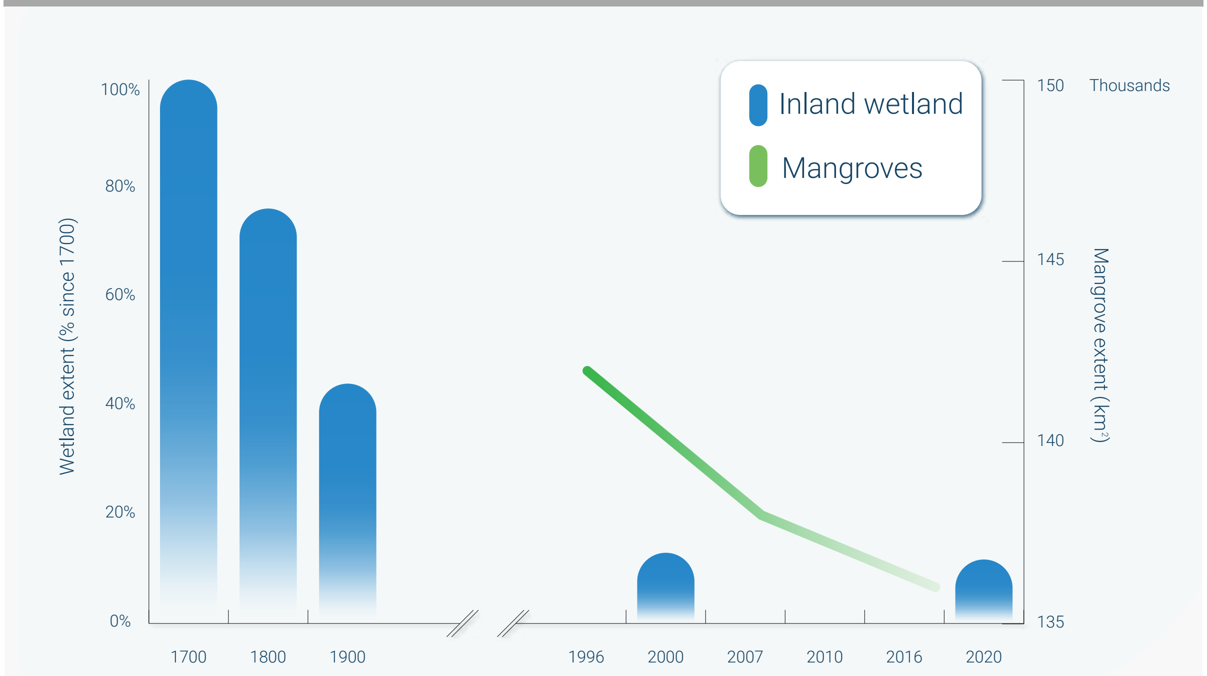
Source: DHI GRAS / UNEP

2 4,111 out of a total of 19,426 basins. The indicator compares changes during the last five years with changes during the last 20 years.

Coastal and inland wetlands are experiencing ongoing loss, with more than 80 per cent of wetlands estimated to have been lost since the pre-industrial era. At present, only 10–12 million km^2 are estimated to remain.

The area covered by coastal mangroves has also declined globally, by 4.2 per cent since 1996. Wetlands are needed to mitigate climate change, reduce the impacts of floods and droughts, and protect freshwater biodiversity loss.

Figure 0.2. Extent of wetlands and mangroves



It is crucial that the quality of lake water be improved. From a sample of 2,300 large lakes, almost a quarter recorded high to extreme turbidity readings in 2019. Approximately 21 million people, including 5 million children, live within a 5 km radius of the high-turbidity lakes, and likely rely on their water for various purposes. High turbidity can indicate water pollution, as the large volume of suspended particles act as hosts for pollutants such as metals and bacteria. Lakes with high turbidity can therefore adversely impact human and ecosystem health and must be improved to prevent this.

Recommendations to accelerate action to protect freshwater ecosystems

Implement and enforce national and river basin-level policies, laws and practices to effectively protect the integrity of freshwater ecosystems and undertake large-scale restoration of degraded freshwater ecosystems. Governments are urged to act to develop and implement action plans, road maps, investment portfolios, legislative frameworks and governing mechanisms that are able to identify, protect and/or restore countries' priority freshwater ecosystems.

Protection and restoration interventions should account for interdependent hydrological processes occurring within the entire river basin or watershed area. The provision of fresh water of sufficient quantity and quality to sustainably meet the socioeconomic and environmental demands of a dependent population should be the minimum benchmark of success.

Increase the uptake of freshwater data into water-dependent sectoral processes. Promote, share and disseminate available data across sectors and institutions and to companies that depend on fresh water.

The SDG 6 and indicator 6.6.1 national focal points are well positioned to promote planning across sectors and to process data and trends (particularly at the basin level) using data on the Freshwater Ecosystems Explorer.

Cross-sectoral planning should be in line with the framework of integrated water resources management (IWRM; indicator 6.5.1), with its implementation supporting the achievement of SDG 6.

Improve coordination across institutions working on freshwater security in order to achieve SDG 6. Recognizing the central role of healthy ecosystems in achieving water security, each of the above recommendations requires effective coordination among the institutions working on various aspects of social, economic and environmental water-related objectives, covered by each of the SDG 6 targets. Implementation of indicator 6.5.1 on IWRM supports cross-sectoral coordination and planning.

Denali National Park and Preserve, Arkansas, USA by Sterling Lanier on Unsplash

1. Freshwater ecosystems in the context of the 2030 Agenda for Sustainable Development

While freshwater ecosystems are recognized within a number of international development frameworks (including the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change (UNFCCC), the Ramsar Convention on Wetlands and the Sendai Framework for Disaster Risk Reduction), this report presents information on global and regional freshwater ecosystem trends in the context of the 2030 Agenda for Sustainable Development using country-approved indicator 6.6.1 data. These data, captured through the global Sustainable Development Goals (SDGs) reporting process, assess changes to surface water, wetlands and the water quality of large lakes. Global data remain sparse on streamflow and groundwater, and are therefore not presented in this report. The information in this document and online[3] is intended to inform stakeholders, governments and regional and global organizations about the state and trends of freshwater ecosystems. Specifically, the report intends to highlight long-term freshwater trends, connect these with other related global trends, such as climate and population trends, and provide evidence on changes in ecosystems locally, nationally and regionally. Although this report addresses physical environmental changes, it is important to stress that environmental changes are increasingly linked to issues of social inequality, including gender inequality, and can exacerbate unequal access to natural resources, uneven distribution of the impacts of environmental degradation, and uneven distribution of responsibilities with respect to addressing environmental challenges (United Nations Environment Programme [UNEP], 2019).

Given the huge volume of dynamic freshwater data available per country, this report does not detail each national situation. Instead, national freshwater data can be viewed online on the Freshwater Ecosystems Explorer. The full time series of reported national indicator 6.6.1 data is also available online on the United Nations Statistics Division SDG indicators database and downloadable from the United Nations Environment Programme's (UNEP) environmental database. Online story maps and analyses on freshwater ecosystems can be accessed on the dedicated case studies website.[4]

3 See https://www.sdg661.app/.
4 See https://mango-river-0ac1c3d03.azurestaticapps.net/.

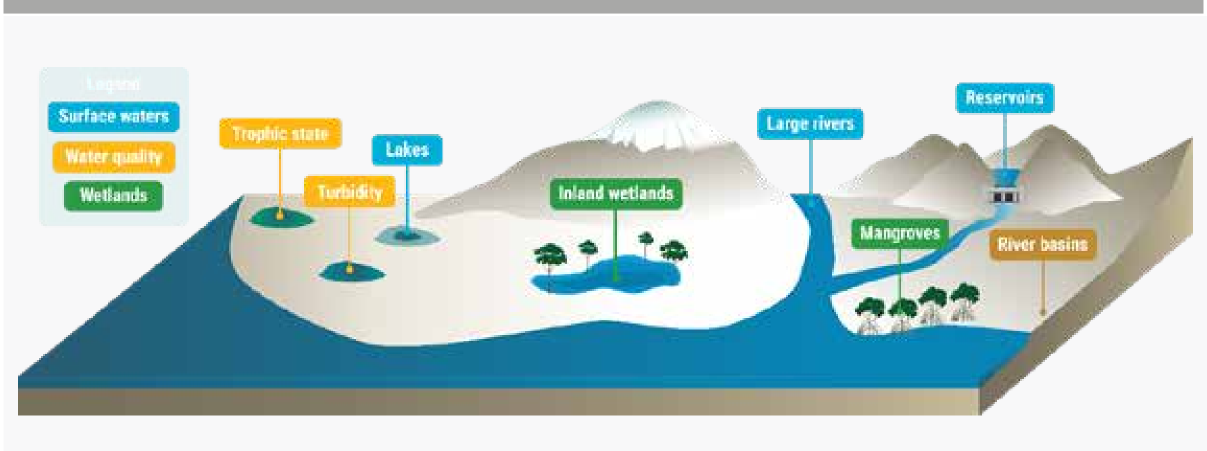
2. Approach to globally monitoring freshwater ecosystems

2.1. Types of freshwater ecosystems and the properties used to monitor changes

SDG indicator 6.6.1 includes the following different types of freshwater ecosystems: lakes, rivers, wetlands, mangroves, groundwater and reservoirs, all of which purely contain fresh water, except for mangroves, which contain brackish water. Despite not being natural freshwater ecosystems, reservoirs are included as they hold significant amounts of water.

Understanding changes in available reservoir water relative to changes in the surface area of natural freshwater ecosystems is useful for freshwater ecosystem protection. Although mentioned in target 6.6, forests are not included in indicator 6.6.1 monitoring, with data instead captured under SDG 15. At present, the indicator does not capture data on the biological health or connectivity of freshwater ecosystems, even though the importance of such data is widely recognized.

Figure 1. Landscape containing various types of freshwater ecosystems



Source: DHI GRAS.

To obtain the fullest understanding of the extent to which ecosystems are changing over time requires information on the ecosystem properties used to measure changes. For indicator 6.6.1 these properties include spatial area (surface area of lakes or wetlands), water quantity (change in water volumes within a lake or aquifer) and water quality (water cloudiness or nutrient load within a lake). Frequent data collection is required to accumulate trend information per ecosystem type. This enables any increases or decreases per ecosystem property and ecosystem type to be tracked against a historical benchmark. Through this monitoring approach, decision makers can observe ecosystem-specific changes, determine the significance of the change (and also possibly any causality) and make informed decisions on interventions to control or mitigate particular freshwater ecosystems.

Satellite imagery captured between 2006 and 2010 was also used and compared with data from the three most recent years to assess the water quality of large lakes and reservoirs.

The satellite data used to monitor indicator 6.6.1 has been disaggregated into ecosystem types, thereby enabling ecosystem-level decisions to be taken. Indicator 6.6.1 data are available for lakes and large rivers (permanent and seasonal), reservoirs, inland wetlands (peatlands, bogs, marshes, paddies and fens) and coastal wetlands (mangroves). Information on the quality of freshwater lakes is available for large lakes with respect to turbidity and trophic state. Satellite data on river and groundwater volume changes, however, are not available. Water-quantity data for these two ecosystem types should therefore continue to be provided from modelling or ground-based measurements.

2.2. Use of Earth observations to monitor and report data on indicator 6.6.1

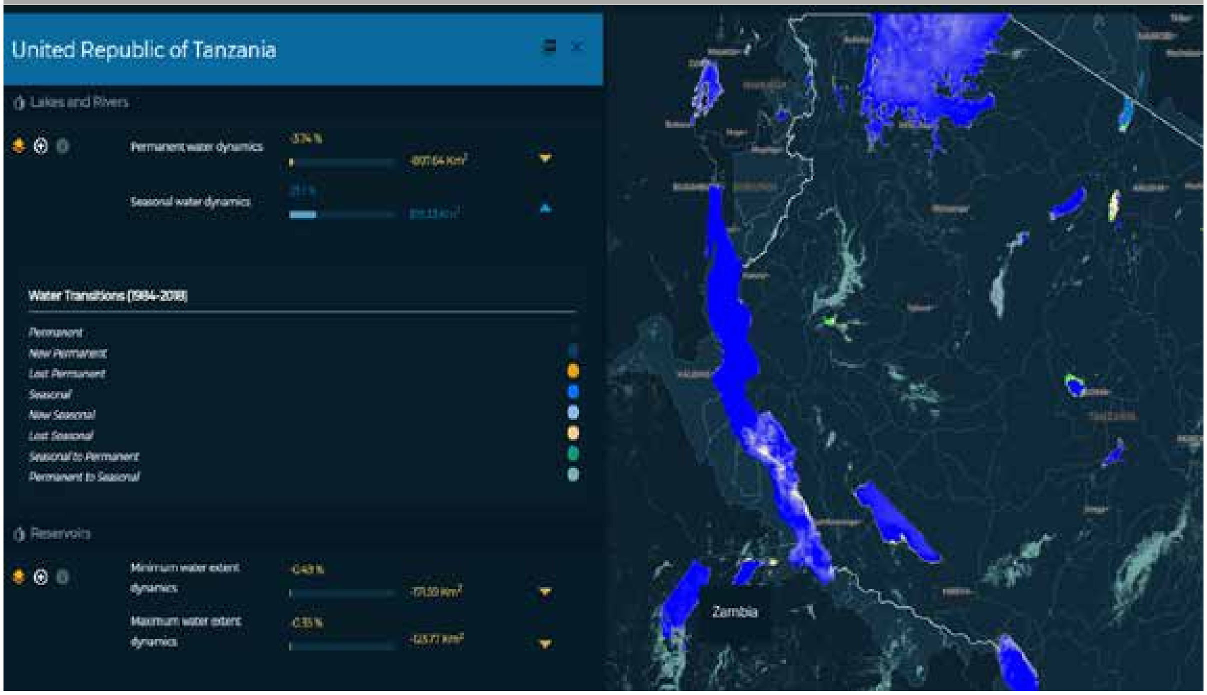
The task of monitoring numerous different types of freshwater ecosystems and consistently capturing dynamic data is enormous. To support countries in monitoring indicator 6.6.1, spatial and temporal freshwater data are taken from satellite-based Earth observations. Satellites map the entire surface of the Earth every few days in high resolution (30x30 metres). The last 20 years' worth of satellite data have been used to generate statistically robust and accurate information on the spatial area changes of surface waters (lakes, rivers, mangroves, reservoirs), thereby determining these ecosystems' long-term trends.

2.3. Freshwater Ecosystems Explorer – an innovative platform to access indicator 6.6.1 data

In March 2020, UNEP launched the Freshwater Ecosystems Explorer – a free and easy-to-use data platform.[5] It provides accurate, up-to-date, high-resolution, geospatial data used to monitor indicator 6.6.1 and depicts the extent to which freshwater ecosystems change over time in every country worldwide. The platform was developed to help decision makers readily access and understand ecosystem changes within their country.

5 The development of UNEP's Freshwater Ecosystems Explorer was made possible thanks to the contribution of several partners, including the European Commission's Joint Research Centre (JRC), Google and the Global Mangrove Watch consortium. The Freshwater Ecosystems Explorer is available at https://www.sdg661.app/.

Figure 2. Freshwater Ecosystems Explorer displaying indicator 6.6.1 data



Source: UNEP Freshwater Ecosystem Explorer (www.sdg661.app)

The data presented on the platform are intended to drive action to protect and restore freshwater ecosystems and enable countries to track progress towards the achievement of SDG target 6.6. Data are available for permanent and seasonal surface waters, reservoirs, wetlands, mangroves and lake water quality. National data on these ecosystems – where they exist – are also accessible on the platform.

Data can be visualized using geospatial maps with additional informational graphics and are downloadable at the national, subnational and river basin scales, including transboundary basins. The data available vary per ecosystem type, with surface-water data available since 1984, mangroves since 1996, lake water quality since 2006 and inland wetlands since 2017.

Data are updated annually, thus providing up-to-date observations per ecosystem that depict long-term trends and annual and monthly records.

The Freshwater Ecosystems Explorer supports countries with monitoring and reporting on SDG indicator 6.6.1 data. All interested practitioners and managers are encouraged to access the platform and use the data.

2.4. Satellite data sources and data providers for monitoring indicator 6.6.1

The data used to support monitoring and reporting on freshwater ecosystems come from several different data providers (Table 1), who use various satellite-derived imagery. The satellite data differ in their temporal coverage, and not all indicator 6.6.1 data therefore use the same reference period.

National Aeronautics and Space Administration (NASA) Landsat satellites (United States of America) have been orbiting Earth since the early 1970s and provide high-quality global coverage of surface water extent from 2000. Both the European sentinel and Japanese Synthetic Aperture Radar (SAR) satellites are more recent and, thanks to advances in technology, allow image and data capture for mangroves, wetlands and water quality monitoring.

Table 1. Satellite data sources currently used for status reporting on indicator 6.6.1

Ecosystem type	Satellite data source	Website
Permanent, seasonal, reservoir	NASA Landsat (1984–present)	United States Geological Survey (USGS) Earth Explorer (https://earthexplorer.usgs.gov/)
Inland vegetated wetlands	European Sentinel-1 (2014–present) European Sentinel-2 (2016–present)	Copernicus.eu (https://www.copernicus.eu/en/access-data)
Water quality	European Sentinel-3 (2017–present) European Envisat Medium Resolution Imaging Spectrometer (MERIS) (2002–2012)	Copernicus.eu (https://www.copernicus.eu/en/access-data)
Mangroves	Japanese L-Band SAR satellites: JERS-1 SAR (1992–1998) Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR) (2006–2011) ALOS-2 PALSAR-2 (2014–present)	Jaxa.jp(https://www.eorc.jaxa.jp/ALOS/en/dataset/dataset_index.htm)

Source: UNEP Freshwater Ecosystem Explorer (www.sdg661.app)

The European Commission's Joint Research Centre (JRC) uses the historical Landsat archive of more than 3 million satellite images to analyse and quantify global surface waters, which are disaggregated into permanent, seasonal and reservoir data sets (Pekel and others, 2016). The JRC also provides information on the water quality of the world's largest or most strategically important inland water bodies, including reservoirs. It assesses three recent years (2017–2019) and compares them with five historic years (2006–2010). The Global Mangrove Watch consortium provides global geospatial information on the extent of mangrove changes since 1996 (Bunting and others, 2018). Recently, DHI GRAS globally mapped vegetated wetlands in high resolution using a combination of optical, radar and thermal imagery (Tottrup and others, 2020).

2.5. National approval process of indicator 6.6.1 data

In March 2020, UNEP directly engaged with each of its Member States to obtain national approval of indicator 6.6.1 data. National statistics per ecosystem type were sent to confirmed focal persons for SDG 6 and indicator 6.6.1, as well as national statistics offices. At present, 160 countries have confirmed national focal persons for indicators. In the 33 countries where there were no such focal persons, communications were directed either to the national focal persons for SDG 6 or the SDG national statistics office.

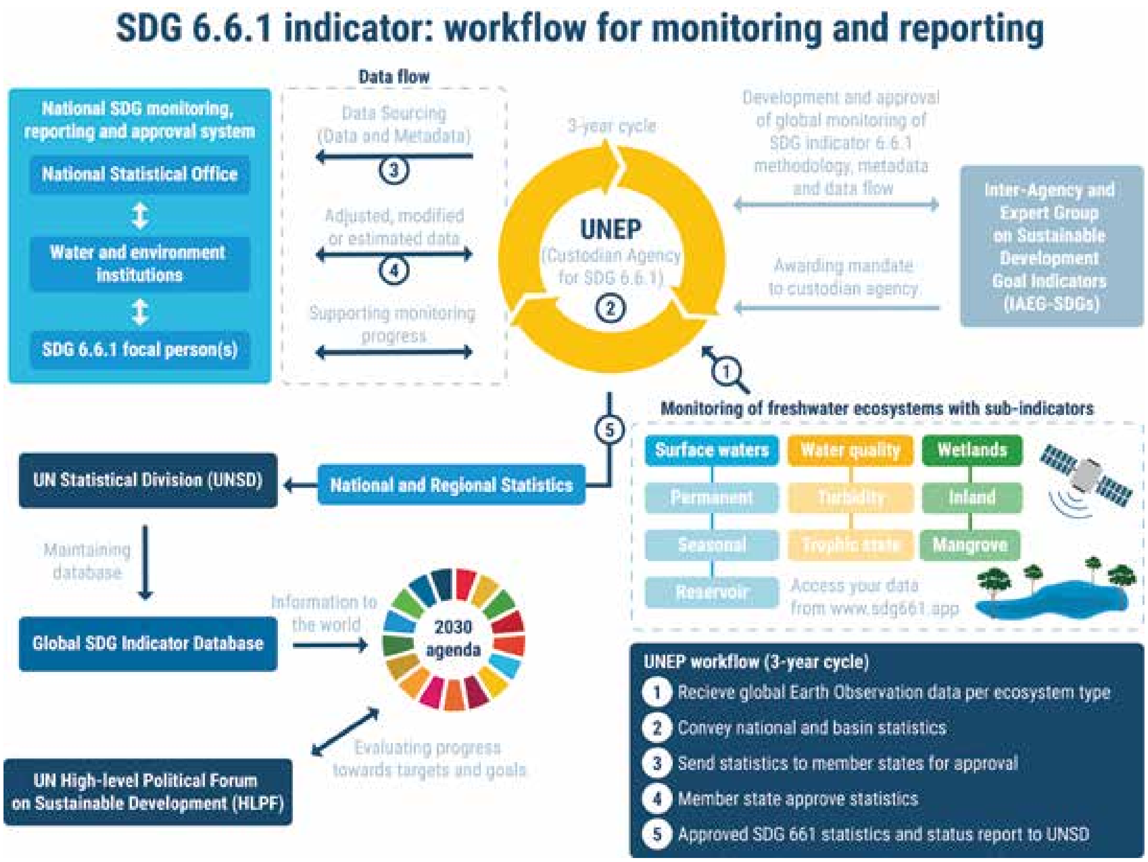
A UNEP help desk for indicator 6.6.1, which has a dedicated United Nations email address, was set up to manage the national data approval process and respond to technical questions and queries from countries about indicator data.

The indicator help desk team comprises staff within UNEP's Freshwater Unit (Ecosystems Division), technical specialists from data-providing organizations (including the JRC and its partners Plymouth Marine Laboratory and Brockmann Consult), the Global Mangrove Watch consortium and DHI GRAS. A no-objection approach was adopted for the national data validation.

More than 60 countries raised questions on specific ecosystem data, with most technical clarifications resolved. However, some technical queries could not be resolved, such as the lack of alignment of lake water turbidity data with Finland's national data (due to the shallow nature of the country's numerous lakes, which influenced the accuracy of turbidity measurements captured by satellite imagery) and the inaccurate national data set for surface-water extent in the Netherlands (where saline seawater, which is used in the canal and inland waterway system, were captured as part of national freshwater surface-area data).
In these cases, the specific ecosystem data were reported with explanatory notes and were not included in the national data series.

In February 2021, nationally approved data for 190 countries were submitted to the United Nations Statistics Division. Data were not available for three small island developing States.

Figure 3. Workflow for monitoring and reporting SDG indicator 6.6.1



Source: DHI GRAS / UNEP

Saksun, Faroe Islands by Marc Zimmer on Unsplash

3. Global and regional freshwater ecosystem trends derived from indicator 6.6.1 data

Understanding the state of the world's freshwater ecosystems is an essential first step in their protection and restoration. This section of the report and its associated online story maps[6] present the extent of freshwater changes, linking these to known pressures and drivers.

Recognizing how multiple pressures interact to cause changes in freshwater ecosystems is complex. For example, growing populations drive ecosystem changes through increased demand to generate locally stored fresh water, which alters hydrological systems, or by deforesting and urbanizing areas, which increases run-off, flooding rates and nutrient and sediment loss, thereby degrading water bodies. Draining inland wetlands and removing costal mangroves lowers these ecosystems' capacity to moderate the effects of extreme weather events and also reduces freshwater habitats and biodiversity. Climate change-induced rainfall variations are altering the geographical distribution of permanent surface water. At the same time, increased temperatures may result in drought and less surface water, while also contributing to increased glacial melting and permafrost thawing, thus leading to increased surface water.

The analysis presented in the following subsections uses evidence from global and regional single-pressure statistical correlations to confirm co-variability with respect to time and locations. The statistics are then supported using published scientific literature, with causality established. All results have been validated with domain experts. The analysis uses river basins to assess freshwater ecosystem trends, mapping the basin-level analysis at the global and regional levels. River basins are naturally connected hydrological systems where local freshwater changes (related to abstraction, drought, flooding, degradation and pollution) may affect larger connected freshwater ecosystems within the catchment, including across national borders. Although river basins experience a degree of natural variation in water quantity and quality, they are increasingly exposed to climate change, population growth and land-cover change from deforestation, urbanization and dam and reservoir construction.

6 See https://mango-river-0ac1c3d03.azurestaticapps.net/.

The impacts of changes in freshwater ecosystems are presented in a series of downloadable case studies and online story maps. These case studies and story maps observe changes in different freshwater ecosystems (as reported under indicator 6.6.1) and link them to impacts on the ground. The story maps also highlight the wide array of freshwater ecosystem pressures, the complex interaction between natural and anthropogenic stressors, and how different pressures act over large areas and across long timescales. These complex and hierarchically-linked interactions must be considered when designing approaches and taking action to protect and restore affected freshwater ecosystems, and ultimately make them more resilient to future changes.

It is hoped that the findings of the analysis will accelerate action towards improved management and protection of freshwater ecosystems.

Each case study includes data on the degree of integrated water resources management (IWRM) implementation in the country, as reported by the countries under indicator 6.5.1.[7] The importance of implementing IWRM for ecosystem protection is discussed in chapter 4 of this report on accelerating actions towards target 6.6.

The ecosystem trends analysis maps freshwater changes, aggregated at the regional level, using the SDG regional delineation shown in Figure 4.

Figure 4. Map of SDG regions

Source: DHI GRAS / UNEP

7 For more information on indicator 6.5.1 on IWRM implementation, see http://iwrmdataportal.unepdhi.org/.

3.1 Surface-water trends

Changes in the extent of surface water are measured at five-year intervals relative to a 20-year baseline period (2000–2019) and based on the annual aggregation of monthly water occurrence maps. Permanent, seasonal and reservoir data have been merged into a single surface-water trends map (though they are also presented separately) to depict river basins with the highest changes in surface-water area in the last five years (2015–2019).

Analysis of surface-water extent over the last 20 years reveals that one fifth of the world's river basins experienced either a high increase or decrease in surface water in the past five years (Figure 5). River basins with increased surface-water area tended to correspond to locations with a growth in reservoirs, newly inundated land (i.e. land intentionally flooded for agriculture) and areas with increased flooding, with decreased surface-water areas linked to locations that experienced drought, increased demand and excessive water usage. The surface-water changes presented in Figure 5 are also indicative of climate change, the impacts of which have contributed to the drying out of lakes in arid regions and expansion of lakes due to glacial melt and permafrost thawing.

The map shown in Figure 5 presents the overall changes to all open inland surface waters, including natural waters (rivers and lakes) and artificial reservoirs, both permanent and seasonal.

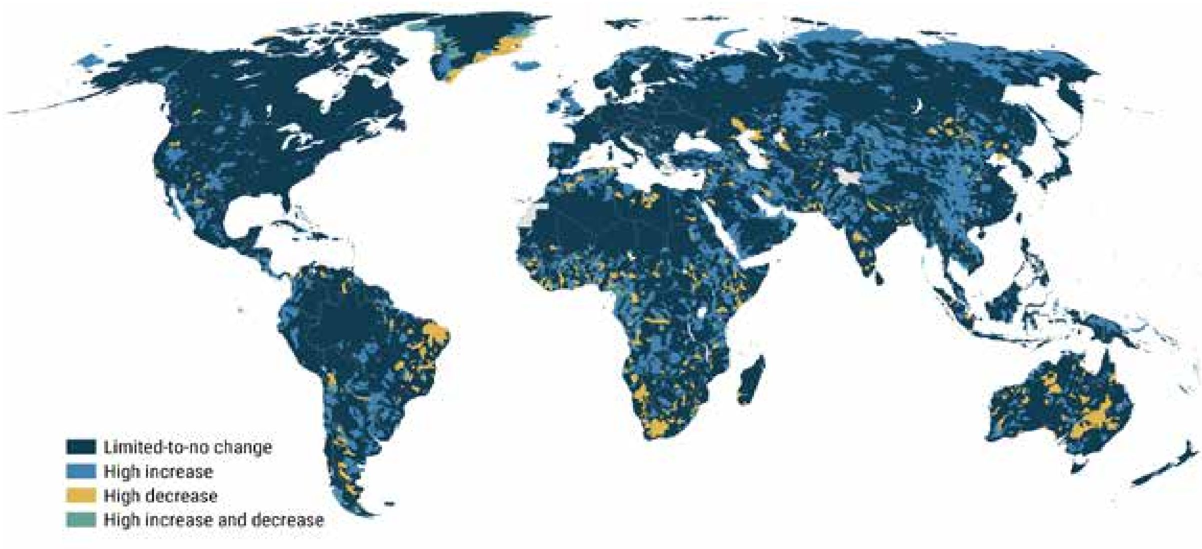
Individually, these types of surface water provide very different environmental, social and economic benefits, but together – and when adequately protected and well managed – they secure vital services for people and help maintain the health and integrity of ecosystems. It is therefore crucial to examine these water bodies together to gain an overall understanding of the situation, while also respecting their individual importance, exposure to different pressures and threats, and specific management needs. In the following sections, this report presents the mapping and analysis of changes in permanent water, seasonal water and reservoirs.

Online story maps can be accessed on the dedicated case studies website.

National data of combined surface-water changes (i.e. permanent + seasonal + reservoir changes) per country are available for download from the indicator 6.6.1 report website.[8] The table provides country information on changes in surface-water area observed in 2015 and 2020, which are compared against a 20-year reference period. Countries can use this tabulated data to observe the extent to which surface waters are increasing or decreasing.

8 See https://stories.sdg661.app/#/pdfs/report-annexes.

Figure 5. Basins with an observed high increase and/or decrease in surface-water area during 2015–2019 compared with 2000–2019



Note: The map summarizes changes to all open inland surface waters, both natural and artificial (for more information about the data analysis methodology, please refer to annex II of this report).
Source: DHI GRAS / UNEP

3.2 Permanent water trends

In the context of indicator 6.6.1, permanent water is defined as water that is observable year-round. Historically, people have chosen to live close to permanent water such as lakes and rivers because they support domestic and agricultural water needs, as well as trade and transport. However, since the industrial era, people have been able to decrease their reliance on living nearby permanent water bodies through the use of canals, pipelines, groundwater pumping and desalination, and due to the development of more effective land and air transportation (Fang and Jawitz, 2019). However, human settlement patterns are still influenced by access to permanent water resources, which enable irrigation, hydropower, navigation and domestic usage (Kummu and others, 2011).

Changes in permanent water can be an indicator of climate change, but they also stem from land-use changes and hydrological manipulations that may impact river flows and the extent and storage of lake water. A better understanding of the dynamics and influencing factors of permanent water will help improve the management and regulation of water resources. In many locations, both surface water and groundwater are used to meet water demand, which underscores the importance of a systems-based approach to water resources management.

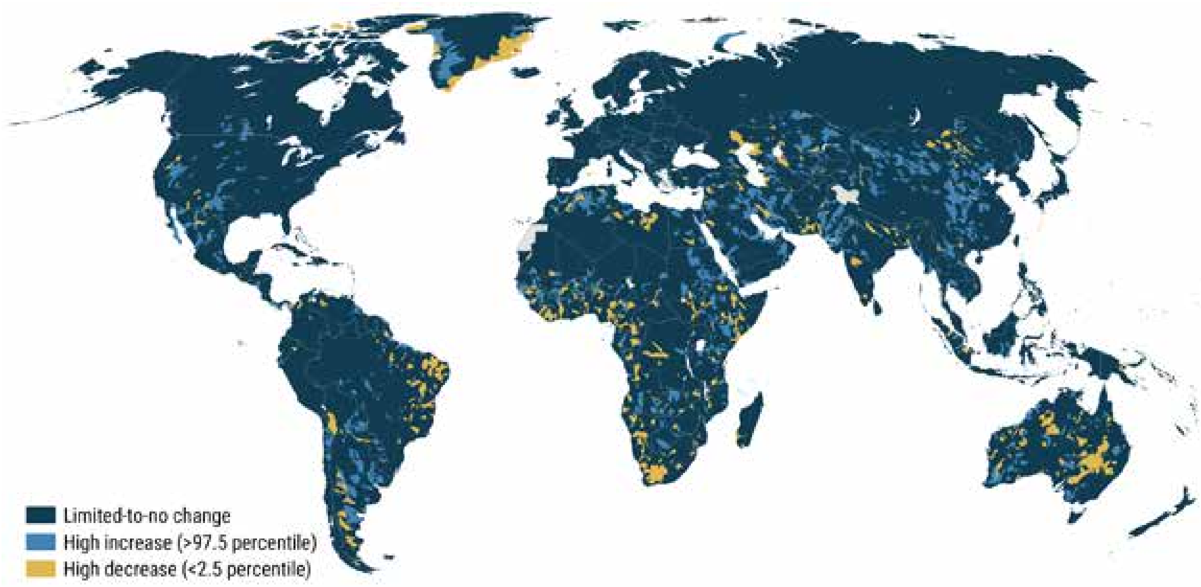
Figure 6 shows the changes in permanent water globally. Since water has a natural variability, the identification of high-change basins is based on annual fluctuations over a 20-year baseline period.

The global map and summary statistics for the SDG regions suggest there is no dominant global trend for permanent water (Figure 6 and Figure 7). Instead, significant changes are occurring at the subregional level, with high increases and decreases in permanent water depicted in Figure 6. Decreasing permanent water trends are most observable in Australia and sub-Saharan Africa, with increasing trends primarily found in Central, Eastern and Southern Asia and Northern Africa. Europe and North America (excluding Greenland and the United States of America) have the fewest basins with significant changes.

The most interesting pattern of the permanent surface-water changes over the full 20-year reference period (2000–2019) is the higher variability observed in the Australia and Western Asia and Northern Africa SDG regions (Figure 8), which indicates that drier regions have a higher sensitivity to climate variability.

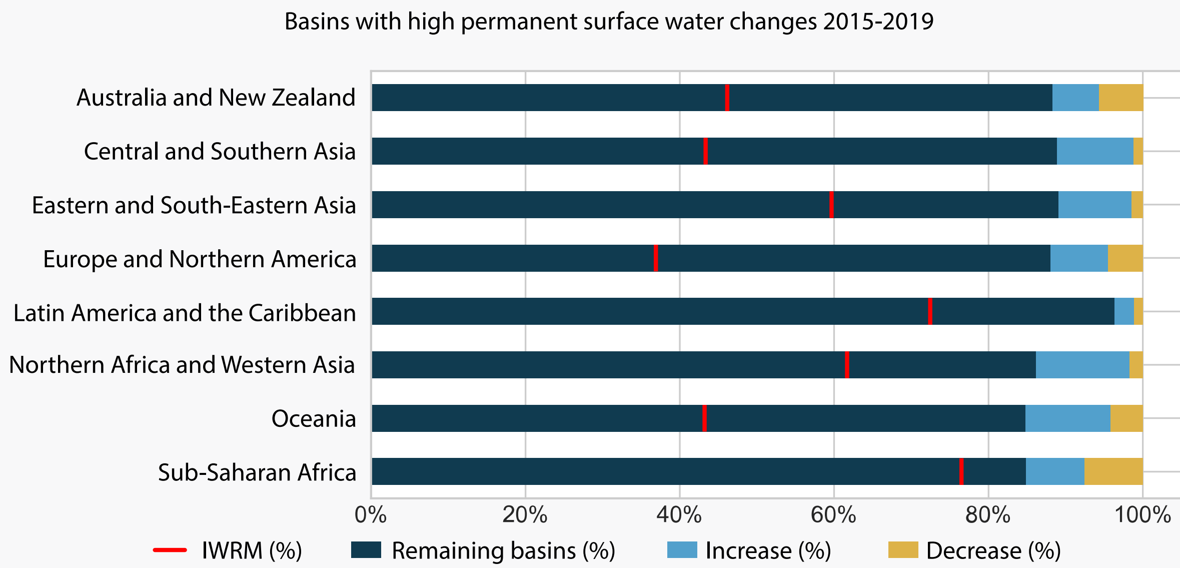
National data of permanent surface-water changes per country are available for download from the indicator 6.6.1 report website. The table provides country information on changes in permanent surface-water area observed in 2015 and 2020, which are compared against a 20-year reference period. Countries can use this tabulated data to observe the extent to which permanent water bodies are increasing or decreasing.

Figure 6. Basins with a high increase or decrease in permanent water during 2015–2019 compared with 2000–2019



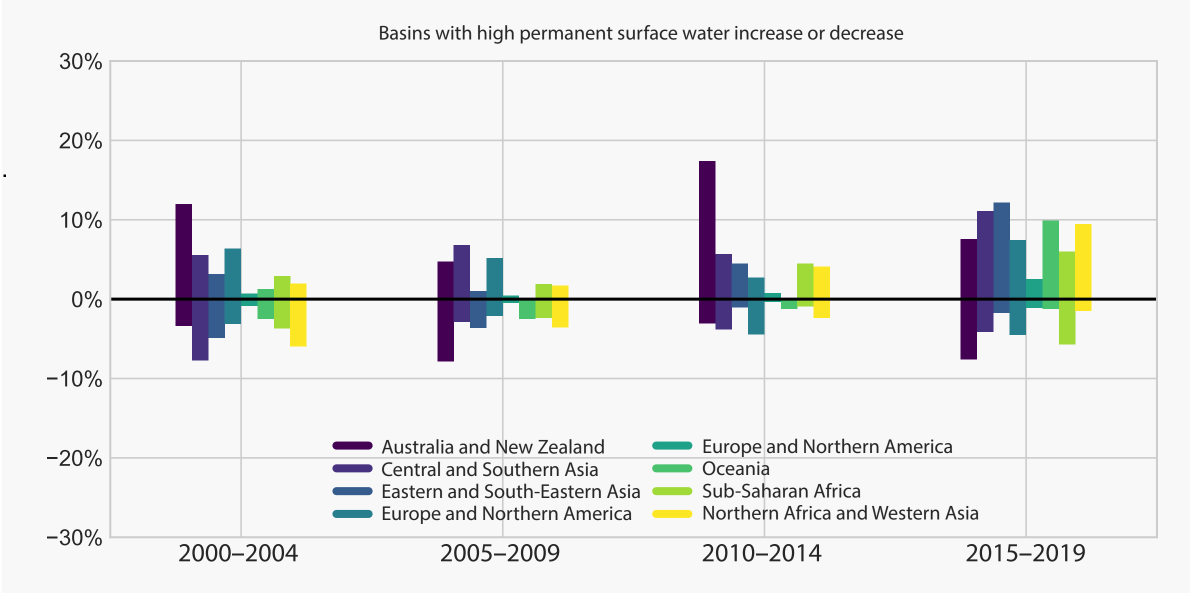
Note: For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

Figure 7. Share of basins per SDG region with a high increase or decrease in permanent surface water during 2005–2019 relative to the total number of basins and compared with the 2000–2019 baseline



Notes: Red lines indicate the average degree of IWRM implementation in the respective SDG regions (refer to indicator 6.5.1). For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

Figure 8. Change in the relative share of basins per SDG region with high changes in permanent surface water for each five-year period since 2000 and compared with the 2000–2019 baseline



Source: DHI GRAS / UNEP

Although fluctuating rates of permanent surface water tend to exceed those that have unidirectional trends (Pickens and others, 2020), case studies from Australia, Brazil and India[9] indicate that observed decreases in permanent water are part of a concerning trend driven by climate change and further impacted by local anthropogenic factors. In the case of the Texas High Plains in the United States of America, the opposite has occurred, with increases in permanent surface water observed in a complex geography, where surface-water changes are the result of complex interactions between climate change, recent conservation practices and excessive groundwater usage.

The case studies illustrate the value of the SDG indicator 6.6.1 app as a first-line assessment tool for evaluating the status and integrity of the world's freshwater resources. Countries are encouraged to use the SDG indicator 6.6.1 app and based on the observed changes, consider whether action is needed to protect and/or restore freshwater ecosystems.

9 See Australia; Brazil; India.

Big Basswood Lake, Huron Shores, Canada by James Thomas on Unsplash

CASE STUDY: PERMANENT WATER

IWRM [88%]

Drought-hit Australia

The online story map can be accessed on the dedicated case studies website.[10]

Some of the worst droughts in Australia have occurred this century. From 2003 to 2012 and 2017 to 2019, severe drought impacted freshwater ecosystems across much of eastern and inland Australia. Many of Australia's regions are still experiencing significant periods of drought, with the recent drying trend (i.e. higher temperatures and reduced cool-season rainfall) expected to continue according to current projections. The decrease in rainfall and increase in temperatures will increase potential evapotranspiration, decrease soil moisture and significantly reduce run-off and streamflow (Australian Government, Murray–Darling Basin Authority, 2019), hydrological changes that will affect freshwater ecosystems. The importance of protecting these ecosystems in the face of climate change is particularly evident in Australia's Murray–Darling Basin (MDB).

The MDB is the country's largest and most complex river system, covering 1 million km^2 (14 per cent of Australia's land area) of interconnected rivers and lakes in south-eastern Australia as it traverses Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. The MDB's landscape, water resources, plants and animals form some of Australia's most unique habitats and ecosystems, hosting 120 waterbird species and more than 50 native fish species across 16 internationally significant wetlands spanning 12 ecoregions within the basin. About 40 per cent of Australia's agricultural produce comes from the MDB, which also has significant economic, cultural and environmental value to the country. More than 2.2 million people live within the MDB, including 40 First Nations to whom water plays a key role in their well-being and identity, along with other aspects of Aboriginal culture (Australian Government, Murray–Darling Basin Authority, n.d.).

Rainfall deficiencies in the MDB hit a record level from 2017 to 2019. In July 2019, a climatologist from the Australian Bureau of Meteorology stated that the drought in the MDB was officially the worst on record, exceeding the Federation, World War II and Millennium droughts (Grain Central, 2019).

Land-use changes and water extraction practices that did not fully consider the MDB's long-term health have also affected the basin. Since the European settlement in the MDB during

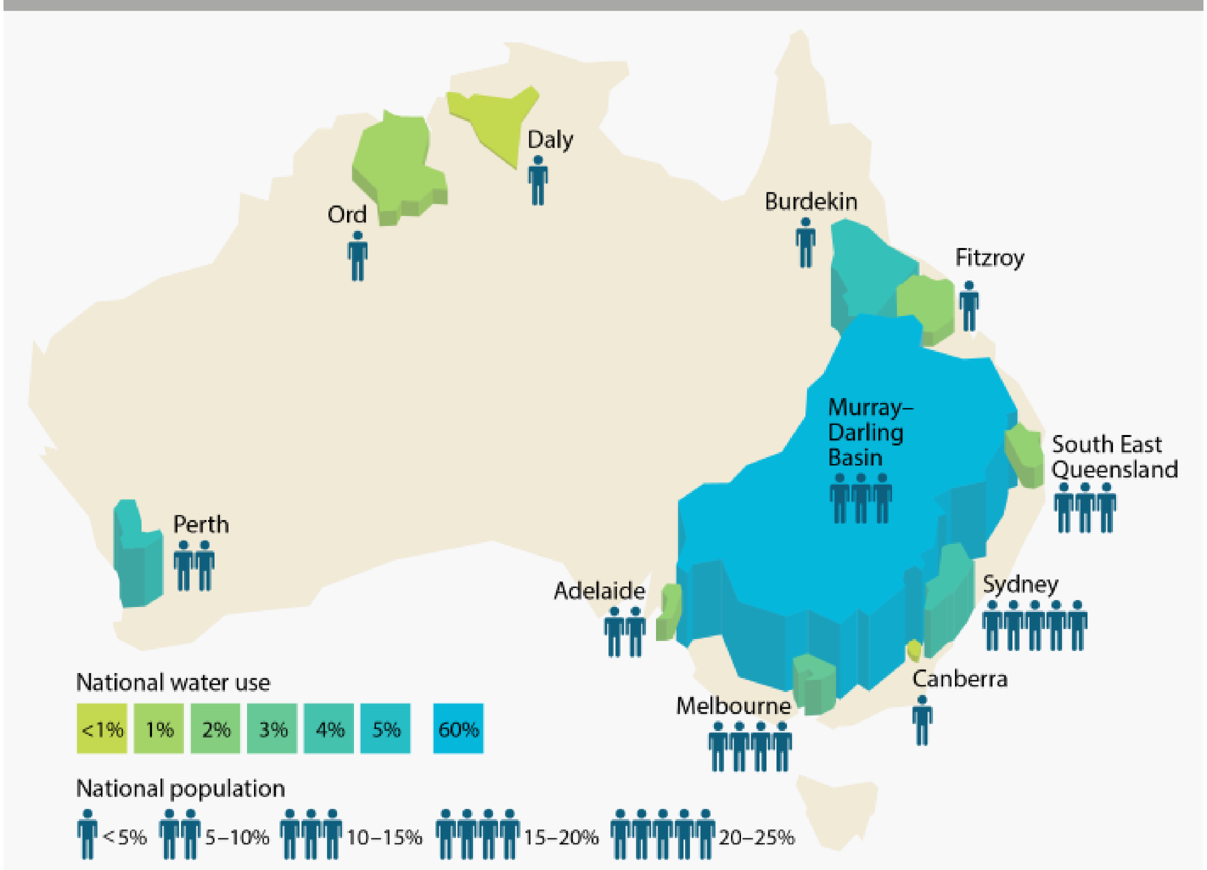
10 See https://mango-river-0ac1c3d03.azurestaticapps.net/#/story/0/0/0.

the early nineteenth century, there has been an increased demand for water to support population growth, industry and irrigated agriculture, thereby leaving less water for the environment. The need for consistent water access during wet and dry periods for consumption and transportation led to greater regulation of the MDB (through the construction of dams, locks and weirs), which changed the basin's natural flow and hydrology.

The 2012 Murray–Darling Basin Plan was developed to restore the basin's health and sustainability, leaving enough water for the rivers, lakes, wetlands and the plants and animals that depend on them, while continuing to support farming and other industries.

The Murray–Darling Basin Authority (MDBA) monitors and enforces compliance with the plan, including the development and implementation of methods to improve the accuracy of water measurement and water use (including through remote sensing and emerging technologies) (Australian Government, Murray–Darling Basin Authority, 2020).

Figure 9. Australia's National Water Account



Sources: Australian Government, Bureau of Meteorology (2021), DHI GRAS / UNEP.

CASE STUDY: PERMANENT WATER

IWRM [77%]

The Texas High Plains: a story of two parts

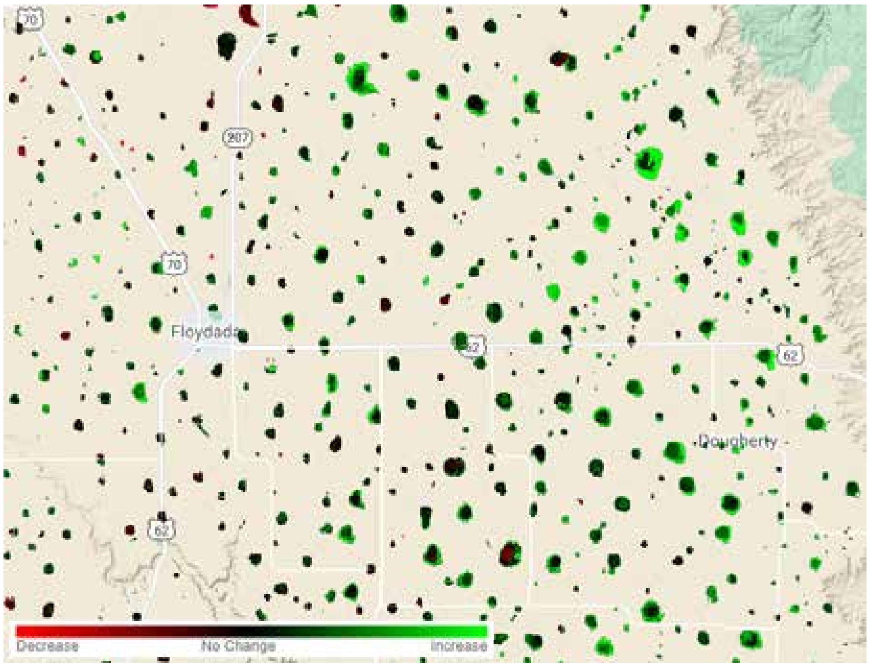
Fertile soils, favourable growing conditions and irrigation from the Ogallala aquifer have made the Texas High Plains one of the most productive agricultural regions in the world (Weinheimer and others, 2014). Although groundwater is the main source of irrigation, the plains' playa lakes are its most important hydrological feature. Playas are shallow, circular-shaped, rainwater-filled wetlands, though in cropland settings some receive water from irrigation run-off (Texas Parks & Wildlife, n.d.).

La Niña has long been associated with drought in the plains, as the phenomenon intensifies precipitation and temperature extremes. Climate change is adding to these extremes by raising average temperatures and increasing evaporation and surface drying which, in turn, drive demand for more irrigation.

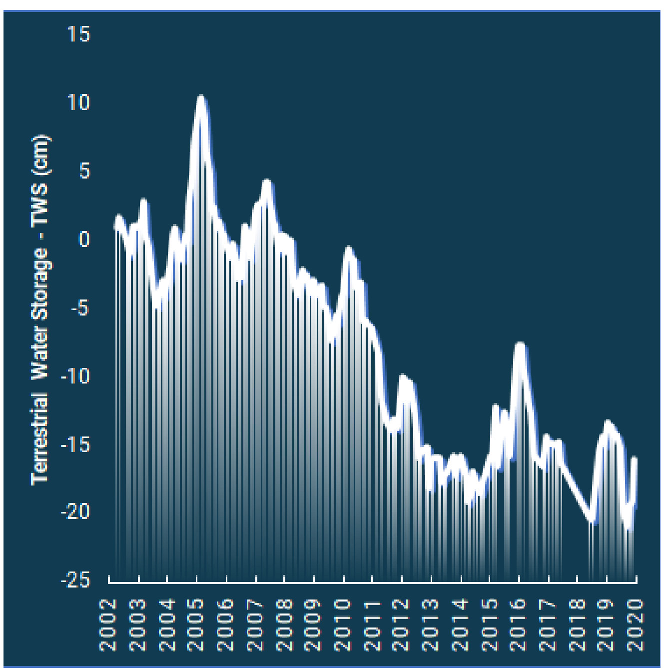
Water changes in the Texas High Plains are therefore a story of two parts: first, the area's capacity for irrigation despite its warm, dry climate, thanks to the Ogallala aquifer, which has also led to increases in surface water from irrigation-related spill-overs; and second, the recent focus on water conservation efforts to reduce groundwater dependence and to help preserve the rapidly depleting Ogallala aquifer.

Joel Dunn on Unsplash

Figure 10. Intensity map of water changes in playa lakes near Floydada on the Texas High Plains (left) and changes in terrestrial water storage (right)



Sources: European Commission (n.d.); Strassberg, Scanlon and Chambers (2009); Gravity Recovery and Climate Experiment (GRACE) (n.d.).



Note: While terrestrial water storage (TWS) represents both the water stored on and below the land surface, studies have documented the close correlation with TWS and groundwater storage changes on the High Plains' aquifer.

3.3 Seasonal water trends

In the context of indicator 6.6.1, seasonal water is defined as water observed for less than 12 months of the year. Worldwide, temporary bodies of fresh water are formed from rain, snow and glacial melt. Although the volume of these seasonal waters is only a fraction of that in permanent freshwater bodies, they are important for recharging groundwaters and restocking water sources such as ponds, reservoirs, dams and irrigation channels, and thereby help to meet year-round demand. Seasonal waters are also vital for sustaining ecosystem integrity, providing variable flows to natural river systems and wetlands. If a long-term seasonal water regime undergoes significant changes, wetlands' capacity to moderate the effects of extreme drought and rainfall is likely to diminish, leading to an increased risk of floods and droughts. Changes in water regimes may also lead to habitat and biodiversity loss.

Figure 11 shows the global changes in seasonal water (with seasonal water defined as water occurring in places which during the course of a year are land for at least one month and water for at least one month).

Since surface waters, especially seasonal surface waters, have a natural variability, the identification of significant changes to such waters requires analysis over a 20-year baseline period.

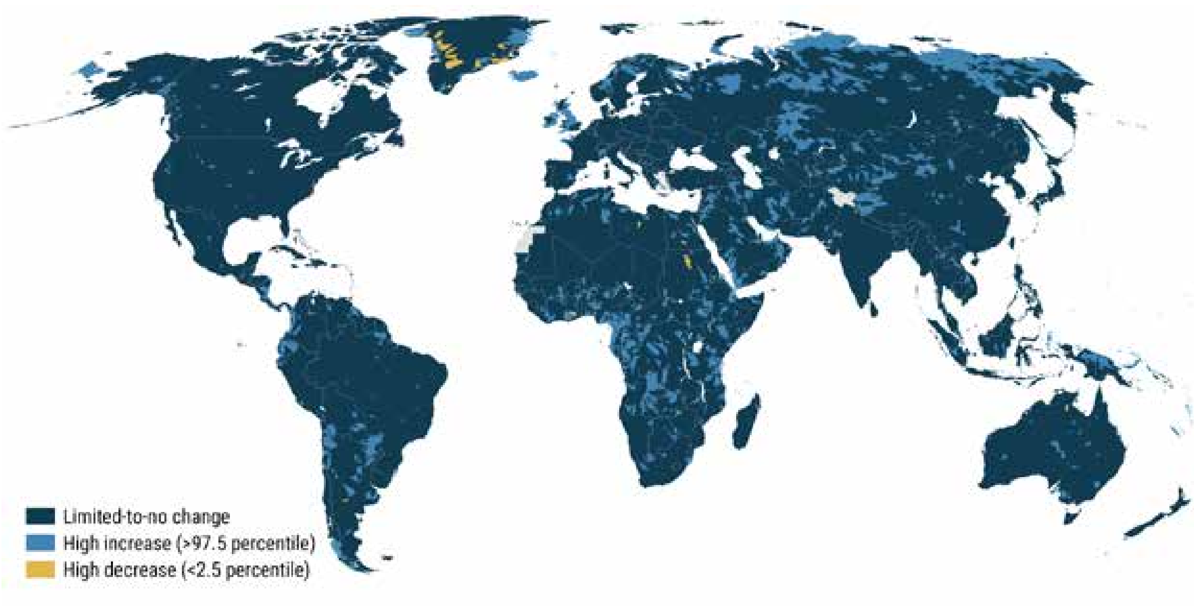
The global map (Figure 11) indicates that there is an increasing trend in seasonal surface water. Regions with the strongest increases are Europe (especially Siberia in Russia), Central, Eastern and Southern Asia, sub-Saharan Africa and parts of Latin America and the Caribbean. The only notable exception is the west coast of Greenland, where a seasonal decline in seasonal waters has been observed (Figure 12 and Figure 13).

Online story maps can be accessed on the dedicated case studies website.

National data of seasonal surface-water changes per country are available for download from the indicator 6.6.1 report website. The table provides country information on changes in seasonal surface-water area observed in 2015 and 2020, which are compared against a 20-year reference period. Countries can use this tabulated data to observe the extent to which seasonal water bodies are increasing or decreasing.

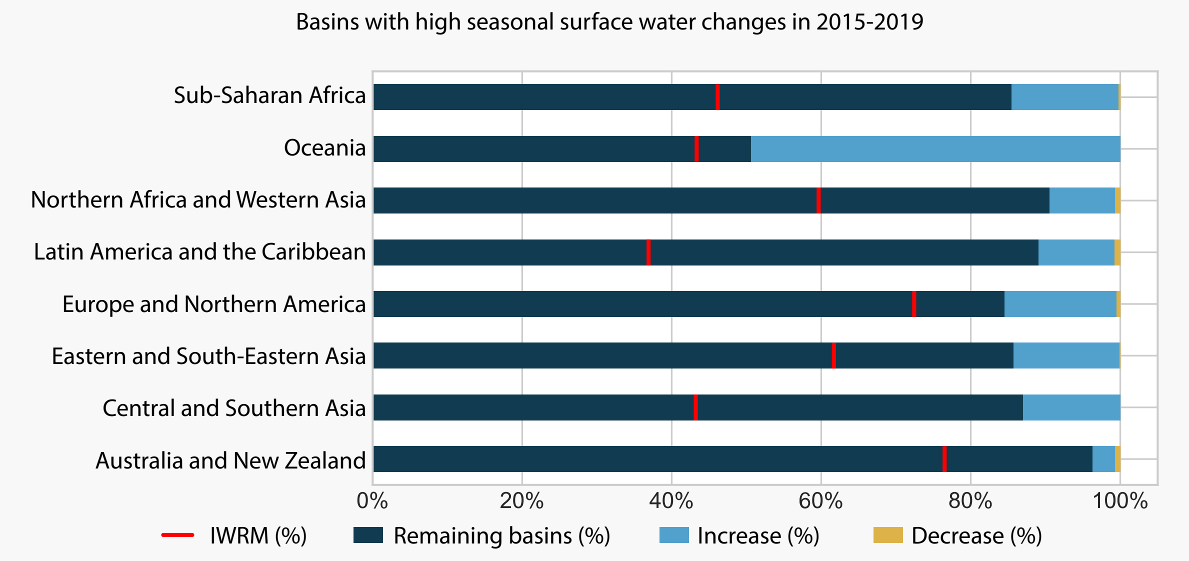
Tim Foster on Unsplash

Figure 11. Basins with a high increase or decrease in seasonal water during 2015–2019 compared with 2000–2019



Note: For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

Figure 12. Share of basins per SDG region with a high increase or decrease in permanent surface water during 2005–2019 relative to the total number of basins and compared with the 2000–2019 baseline

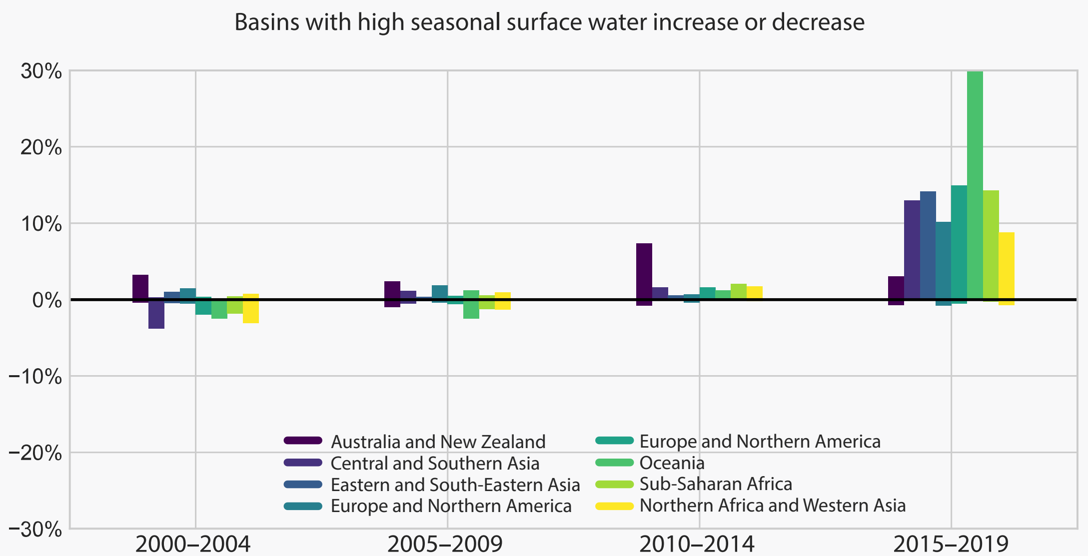


Notes: Red lines indicate the average degree of IWRM implementation in the respective SDG regions (refer to indicator 6.5.1). For more information about the data analysis methodology please refer to annex II of this report.
Source: DHI GRAS / UNEP

There is currently no clear understanding of this general increase in seasonal waters, though certain patterns seem to fit well with existing studies and narratives. Global warming and associated changes in precipitation are certainly factors. For example, the increase in seasonal surface waters on the Tibetan Plateau (China) has already been studied and attributed to higher temperatures and precipitation, which have accelerated stream run-off and glacial melt. Climate models also show a shift towards stronger total precipitation during extreme events, with recent studies suggesting that total precipitation from intense rainfall almost doubles for every degree of warming. The past five years have been the hottest on record. When combined with extensive land-use changes due to deforestation and urbanization (both known to increase run-off rates), this precipitation is resulting in seasonal surface waters and flooding on an unprecedented scale. This impact is evident in a series of in-depth case studies, which show how climate change is a primary driver of the increase in seasonal waters in some places (such as Siberia),[11] with land-use changes having amplified the effect of climate change on seasonal waters in other places (such as the United Kingdom and Central Africa).[12]

11 Siberia.
12 See Central Africa; United Kingdom.

Figure 13. Evolution of the relative share of basins per SDG region with high changes in permanent surface water in each five-year period since 2000 and compared with the 2000–2019 baseline



Source: DHI GRAS / UNEP

The case studies illustrate the value of the SDG indicator 6.6.1 app as a first-line assessment tool for evaluating the status and integrity of the world's freshwater resources. Countries are encouraged to use the SDG indicator 6.6.1 app and based on the observed changes, consider whether action is needed to protect and/or restore seasonal water flows to ensure that reservoirs are restocked, groundwater is recharged and variable river flows to natural river systems and wetlands are maintained.

CASE STUDY: SEASONAL WATER

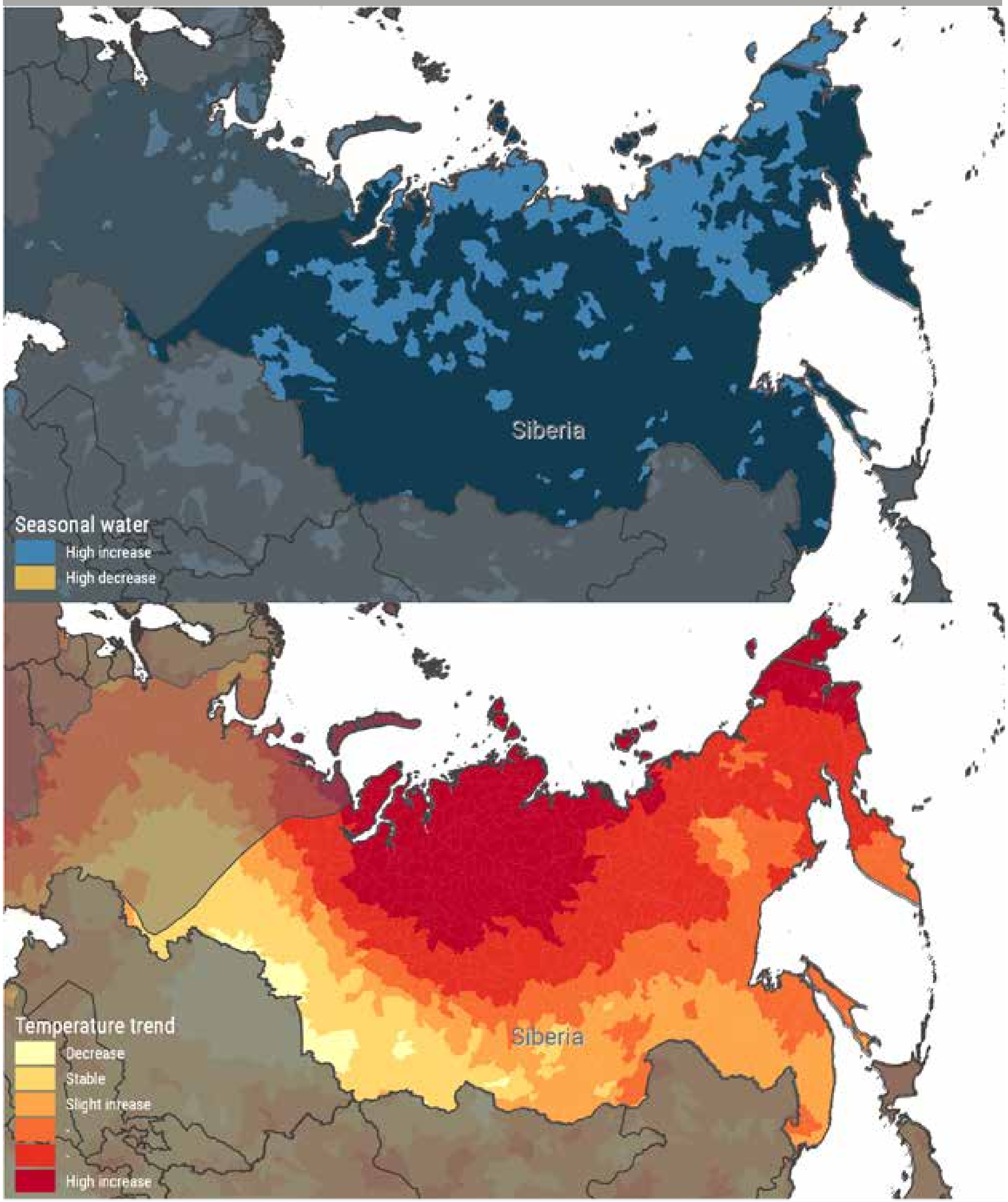
IWRM [88%]

Siberia's thawing permafrost

Above-average rates of warming in the Arctic (Anisimov and others, 2007) have led to changes in the lake-rich ecosystems of the continuous permafrost zone. Many of the lakes in permafrost regions are likely of thermokarst origin (Grosse, Jones and Arp, 2013), meaning they are formed in a depression left by thawing permafrost (Bryksina and Polishschuk, 2015). Patterns of general lake expansion are a common feature of continuous permafrost zones (Smith and others, 2005). In western Siberia, thermokarst lakes have been increasing at a faster rate in the continuous permafrost zone than in the discontinuous permafrost zone (Chetan and others, 2020; Vonk and others, 2015). Typically, thermokarst lakes are shallow, though their depths vary significantly depending on the season, with some parts even drying out in summer (Manasypov and others, 2020), as their main source of water comes from atmospheric precipitation and spring snowmelt. Western Siberian lakes tend to be shallower than Alaskan and Canadian thermokarst lakes of similar size.

Changes in thermokarst lakes have been associated with changes in temperatures, precipitation and snow cover, with climatic effects, surface geology and very flat terrain (which is impacted by seawater flooding) also responsible (Nitze and others, 2017). These changes affect around 2 million people – mainly indigenous – living in north-central and north-eastern Siberia, whose livelihoods depend heavily on fishing, hunting and reindeer husbandry, all of which are impacted by climate conditions. More frequent thawing, earlier melting and later river-ice formation are affecting animals' migration patterns, which is testing the resilience of these communities. More frequent and severe seasonal floods are also destroying vital infrastructure and threatening entire villages with permanent flooding (Stambler, 2020). Climate change is accelerating permafrost thawing, which in turn is generating further climate change. Furthermore, Arctic thermokarst lakes are both methane point sources and potential carbon dioxide sinks, which means their expansion can lead to large-scale increases or decreases in greenhouse gas emissions, thus indicating an urgent need for them to be better constrained (in 't Zandt, Liebner and Welte, 2020).

Figure 14. Seasonal water changes in Siberia (top) and corresponding temperature trends (bottom) from 2000 to 2019



Sources: UNEP (n.d.); Climate Data Store (n.d.).

CASE STUDY: SEASONAL WATER

IWRM [79%]

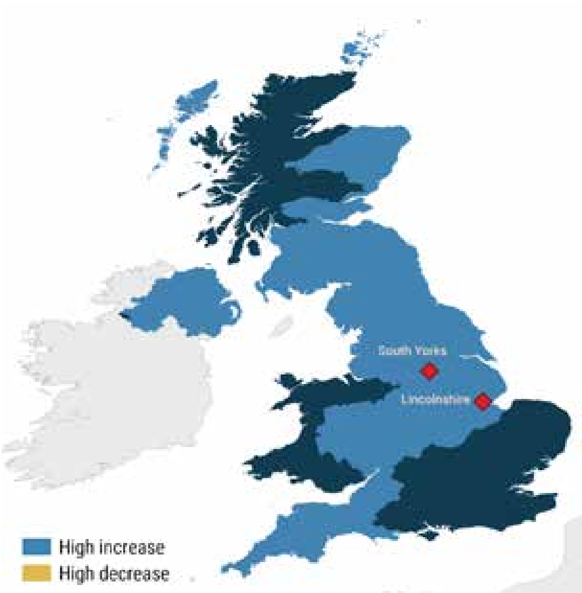
Flood-hit United Kingdom

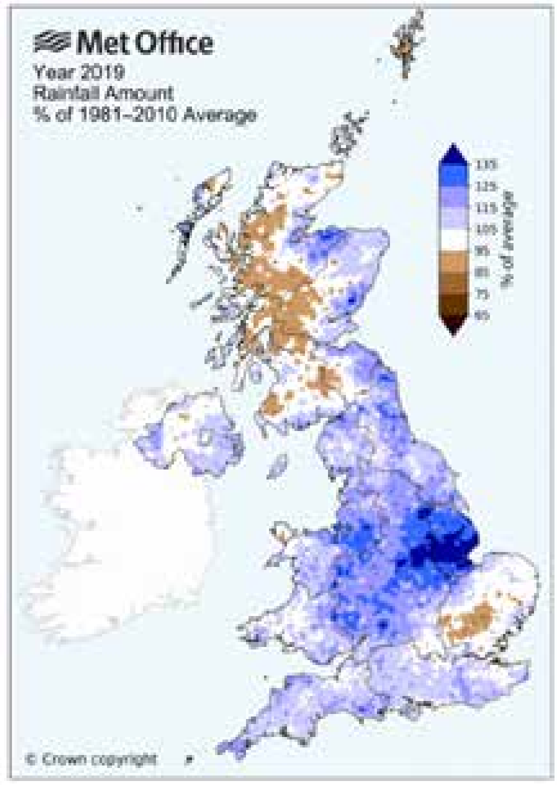
Seasonal water extent has increased significantly in the United Kingdom due to various drivers, such as precipitation pattern changes, temperature changes, increasing river flows and sea level rise. Six of the 10 wettest years on record have occurred in the country since 1998, with the top 10 warmest years having occurred since 2002 (Kendon and others, 2020).

In recent years, the United Kingdom has experienced a series of record temperatures, droughts, floods and heavy rain (Watts and Anderson, 2016). Although regional rainfall trends are not yet discernible due to the high variability of rainfall throughout the country, recent studies are beginning to evidence how climate change may impact certain types of extreme events (Herring, 2015; McCarthy, 2020). For example, climate change has very likely increased the risk of extreme rainfall events and ensuing floods, as seen in northern England and Scotland in December 2015, and more recently in Lincolnshire and South Yorkshire in June and November 2019, respectively.

Heavy rainfall is often linked to flooding, yet the mechanisms behind the magnitude and severity of flood events are more complex and related to infiltration capacity, increased run-off rates and evapotranspiration. The United Kingdom has become more urbanized in the past decades, with many recent flood events at least partly attributable to the increased run-off from these new impermeable built environments (Rubinato and others, 2019). However, other land-use changes are also responsible. Agricultural practices, such as grazing, may contribute to soil degradation and increased overland flows, with smaller-scale practices, such as deforestation, reducing the water storage capacity of soil and evapotranspiration rates (Weatherhead and Howden, 2009). Climate change and increasing water demand will continue to impact the scale and frequency of floods and droughts both directly and indirectly in the United Kingdom, and as a result the country's seasonal surface-water extent. Heavy and intense rainfall events, together with bigger storm surges due to sea level rise, are expected to greatly intensify flood risks in the United Kingdom (Pidcock, 2014).

Figure 15. Seasonal water changes (left) and percentage of rainfall anomalies (right) for 2019





Sources: UNEP (n.d.); United Kingdom, Met Office (2019).

Ben Collins on Unsplash

3.4 Reservoir water trends

The construction of dams and the development of associated infrastructure, such as irrigation systems, bring economic and social benefits to regions, nations and/or river basins (World Commission on Dams, 2000). However, dams and reservoirs (especially large ones) have both advantages and disadvantages, as their benefits often come with high environmental and social costs. Forced population displacement to make way for dam construction is one of the most serious social consequences, but other ecological and cultural impacts are also significant. Flooding for new reservoirs may cause an irretrievable loss of arable land as well as river, forest and swamp ecosystems of high environmental and landscape value. Architectural and historical assets may also disappear beneath the water, with changes in downstream flows potentially affecting livelihoods when rivers run dry. Dams also disrupt the ecological balance of rivers and affect the migration and reproduction of fish and other freshwater species (Kornijów, 2009).

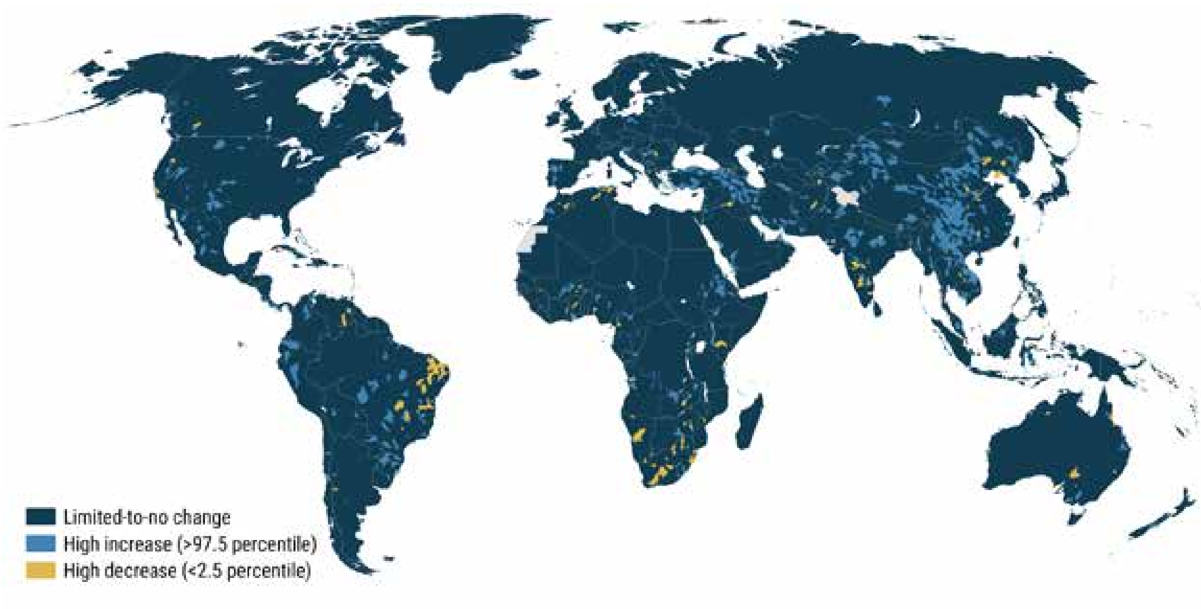
Estimates indicate that dams, diversions and canals severely fragment 60 per cent of the world's largest and most important rivers, including the Yangtze River in China, Tigris River and Euphrates River in the Middle East and the La Plata River in South America, causing significant changes to freshwater ecosystems (World Wide Fund for Nature [WWF], 2004). Figure 16 shows the global changes in reservoir surface-water extent.

This is based on measurements of the change in the minimum water extent, which is arguably the most critical parameter for reservoir monitoring. As a managed ecosystem, reservoir surface-water extent might be expected to have less variability than natural surface waters. However, many countries and basins show signs of either increases or decreases in reservoir extent – a pattern that can be explained by two main trends. First, within the past five years there have been many droughts in Brazil, India and South Africa, causing many reservoirs to reach critically low levels. Second, in the past decades there has been a global boom in new reservoirs, mainly along some of the world's largest river systems, in particular the Yangtze, Euphrates, Tigris and La Plata rivers (Figure 19).

Online story maps can be accessed on the dedicated case studies website.

National data of reservoir surface-water changes per country are available for download from the indicator 6.6.1 report website. The table provides country information on changes in reservoir surface-water area observed in 2015 and 2020, which are compared against a 20-year reference period. Countries can use this tabulated data to observe the extent to which reservoir surface waters are increasing or decreasing.

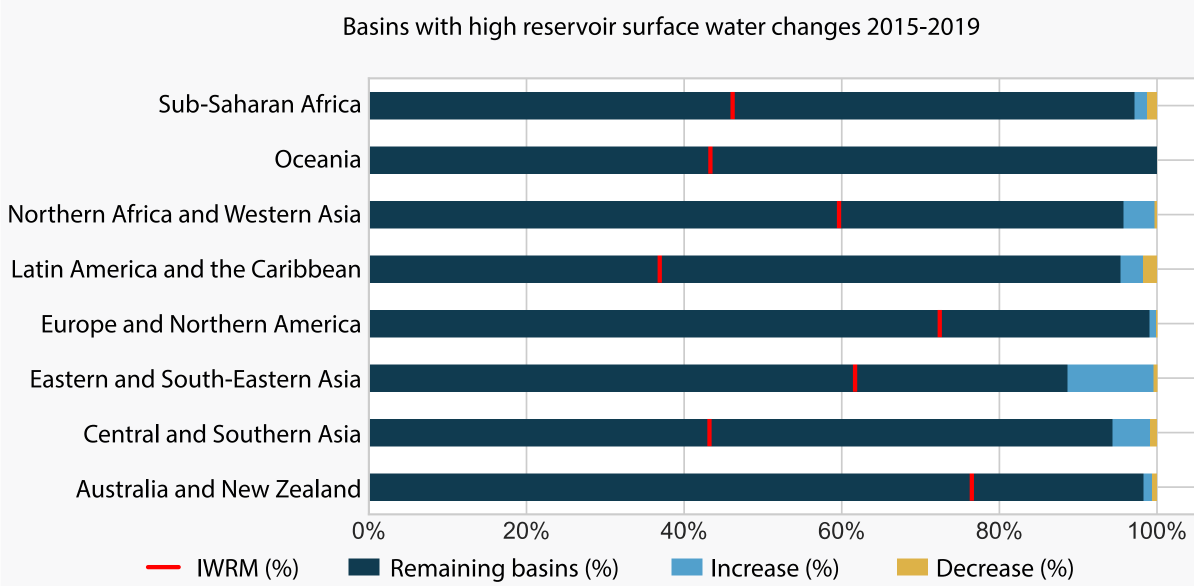
Figure 16. Basins with a high increase or decrease in reservoir water during 2015–2019 compared with 2000–2019



Notes: For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

Lough Doo atop Fair Head in the Glens of Antrim, June 2020 by K. Mitch Hodge on Unsplash

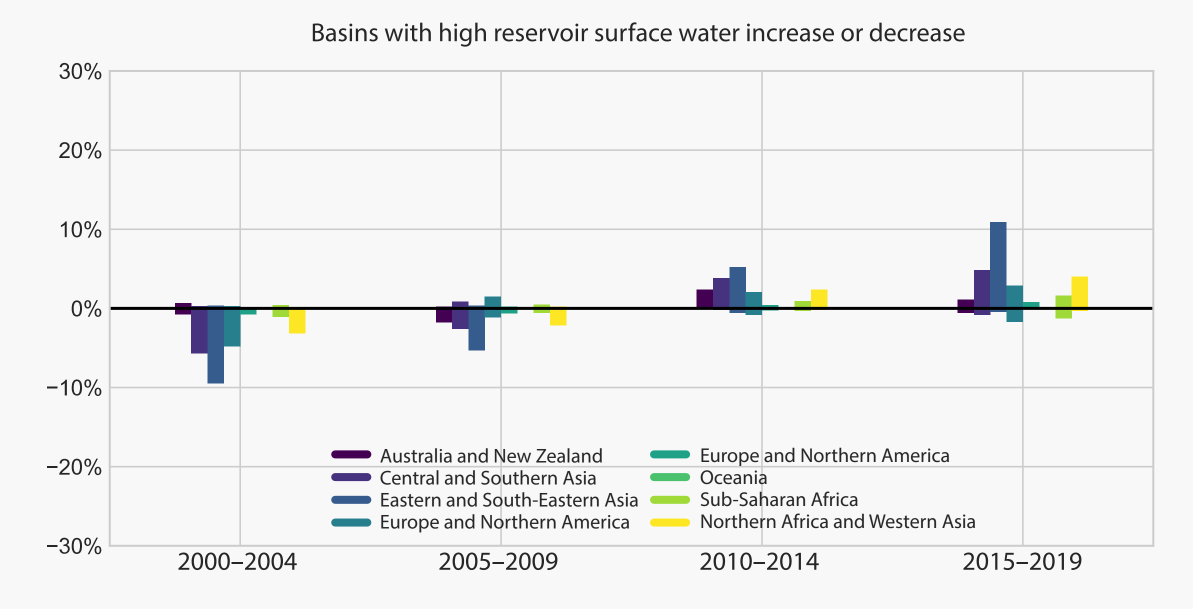
Figure 17. Share of basins per SDG region with either a high increase or decrease in permanent surface water during 2005–2019 relative to the total number of basins and compared with the 2000–2019 baseline



Notes: Red lines indicate the average degree of IWRM implementation in the respective SDG regions (refer to indicator 6.5.1). For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

Lough Doo atop Fair Head in the Glens of Antrim, June 2020 by K. Mitch Hodge on Unsplash

Figure 18. Evolution of the relative share of basins per SDG region with high changes in permanent surface water in each five-year period since 2000 and compared with the 2000–2019 baseline



Source: DHI GRAS / UNEP

The reservoir case studies present reservoir-related issues (such as the prolonged drought in Southern Africa, which had almost fatal consequences for Cape Town's water supply),[13] hot-spot locations for new reservoirs and specific developments along the Yangtze, Mekong, Euphrates, Tigris and La Plata rivers.[14] These examples also have tight linkages to the case studies on Australia, Brazil and India,[15] where permanent water is the focus, but reservoirs are also important.

The case studies illustrate the value of the SDG indicator 6.6.1 app as a first-line assessment tool for evaluating the status of reservoirs both nationally and subnationally.

Countries are encouraged to use the SDG indicator 6.6.1 app and based on the observed changes, consider whether action is needed to ensure that reservoirs deliver their expected services and are planned and operated in a way that does not harm the freshwater ecosystems of which they are an integral part.

13 See Cape Town.
14 See Yangtze; Mekong; Euphrates and Tigris; La Plata.
15 See Australia; Brazil; India.

CASE STUDY: RESERVOIRS

Global boom in reservoirs: what are the consequences?

The unprecedented number of dams either under construction or in planning (Zarfl and others, 2015; Winemiller and others, 2016) may impact freshwater ecosystems. Emergency recovery plans are therefore needed to mitigate the detrimental effects of new dams and reservoirs on freshwater ecosystems. Possible immediate actions include dam decommissioning to ensure minimum environmental disruptions to water flows, improvements in water quality and the protection and restoration of critical freshwater habitats (Tickner and others, 2020).

Figure 19. Heatmap of new dam locations since 2000

Source: Lehner and others (2011).
Note: The standout regions (apart from the Mekong River in China) are the Euphrates, Tigris and La Plata rivers.

China

In recent decades, human activities and climate change have driven complex physical and ecological changes in China's inland water bodies. The main driver of such changes has been the steady annual increase in large reservoirs since the 1970s, with the greatest rate of increase in storage capacity occurring after 2000 (Yang and Lu, 2014). The most notable changes have been in the basin of China's largest river, the Yangtze, which is home to almost 500 million people with livelihoods that depend on the river and its floodplains. This dependence, however, is putting increased pressure on the ecosystem, through the conversion of natural floodplains into farmland, along with deforestation in the upper watershed, which are causing serious flooding (Pittock and Xu, 2011) affecting millions of people (Stuber, 2020).

New reservoirs are also being increasingly built on the Mekong River. Most natural waters in China are regulated and around 20 per cent of assessed river basins (concentrated in the north and north-east of the country) have increased reservoir capacity in their upstream catchments. In addition, it is widely acknowledged that surface water has increased – albeit less dramatically – in the Tibetan Plateau due to increased stream run-off from glacial meltwater (Lei and others 2017). Water losses have also occurred, most notably in Inner Mongolia, where lakes have shrunk and even vanished due to the observed warming trend that started in the 1950s.

China's water landscape is rapidly changing and faces increasingly serious challenges. As water is key to China's economic prosperity, improved water governance, with more ambitious goals, must be an integral part of the country's continued social, economic and sustainable development (World Bank, 2018).

Figure 20. Three Gorges Dam, Yangtze River (Hubei Province, China), captured by satellite on 10 July 2018

Source: © Contains modified Copernicus Sentinel data.

The Euphrates and Tigris rivers

IWRM [43%]

The Tigris–Euphrates River Basin covers Iran, Iraq, Jordan, Saudi Arabia, Syria and Turkey. Due to the region's aridity, there is potential for conflict over water withdrawal between upstream and downstream countries. The Southeastern Anatolia Project (*Güneydoğu Anadolu Projesi* – GAP) in Turkey, for example, has been controversial, with Iraqi Government estimates indicating the project has reduced river flow into Iraq by 80 per cent. Other Turkish infrastructure projects in the region, including the Atatürk, Ilisu and Cizre dams, have exacerbated the problem. During intense droughts, these dams could lead to regional conflict unless a transboundary agreement on water flows is reached between Ankara and Baghdad (EPIC, 2017). Elsewhere, in northern Iran, there is evidence that Lake Urmia is shrinking, despite being fed by streams of considerable size. This shrinking has been attributed to high evaporation rates and the increasing number of reservoirs damming the rivers that flow into the lake (ESA, n.d.). However, there are signs that Lake Urmia is recovering, as more water now flows into the lake following coordinated efforts to unblock feeder rivers which has released water from dams in the surrounding hills, along with the adoption of new technologies to optimize water-use efficiency in agriculture (UNEP, 2017).

Figure 21. Water in Lake Urmia (Iran) is slowing returning after years of human-caused disruption

Source: UNEP (2017).

La Plata

IWRM [37%]

The La Plata River Basin is the second largest in South America (after the Amazon) and is shared by Argentina, Bolivia, Brazil, Paraguay and Uruguay. The basin is home to more than 110 million people and includes the world's largest wetland, the Pantanal, which has a great diversity of flora and fauna, including 80 species of mammals, 650 species of birds and 400 species of fish (WWF, 2004).

In the past few decades, a significant number of dams have been built in the basin, with many more dams proposed, further threatening the basin's integrity. Thus, there is an urgent need to balance biodiversity conservation with dam development to achieve SDG 6 on the restoration of water-related ecosystems as well as SDG 15 on species conservation (Zarfl and others, 2019).

Figure 22. Location of the La Plata River Basin (insert) and extent of the Pantanal wetlands (main)

Sources: DHI GRAS/UNEP data; Tottrup, and others (2020).

3.5 Water quality trends

Various natural and human influences impact and deteriorate water quality, which affects men and women differently. Natural events such as heavy rainfall and hurricanes may lead to excessive erosion and landslides, which in turn increase the content of suspended material in affected rivers and lakes. Natural geophysical conditions in some areas may make water unfit for drinking or specific uses, such as irrigation (Chen and others, 2017). Common examples of this are the salinization of surface waters through evaporation in arid and semi-arid regions and the high salt content of some groundwaters under certain geological conditions (Williams, 1999).

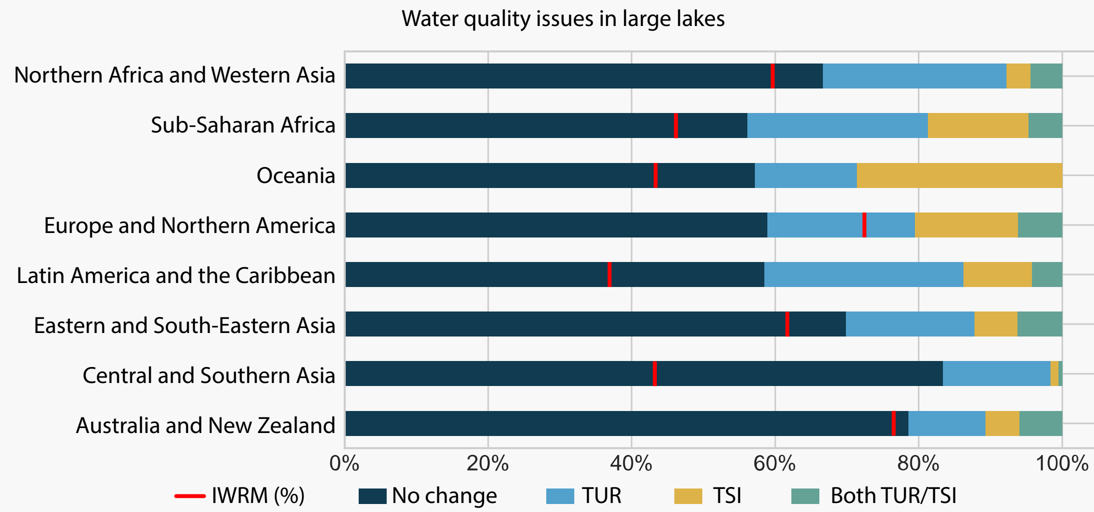
Human activities also deteriorate water quality. Although essentially a natural phenomenon, eutrophication (nutrient enrichment of water) is now mainly associated with human activities such as clearing of land for agriculture, accelerated run-off, urbanization and industrialization, which are increasing discharges of chemical nutrients into water systems. Nutrients from animal waste, fertilizers, industrial waste and sewage are also washed by rain or irrigation into water bodies through surface run-off. Such inflows of phosphorus and nitrogen can cause dense algal and plant growth, leading to the formation of extensive mats of floating plants (algal blooms, Nile cabbage, water hyacinths) that can be detrimental to lakes' hydrology and ecological services. Such pollutants, whether organic or inorganic, lower water quality and adversely affect human and ecosystem health. For example, harmful algal blooms produce toxins and reduce oxygen levels, which can lead to acute poisoning and mass mortality of aquatic organisms (Landsberg, 2002). Deterioration of water quality is also a serious threat to humans as it impacts access to safe drinking water, putting people at risk of waterborne diseases such as cholera and typhoid, which afflict hundreds of millions of people worldwide, especially those living without safe, accessible water in developing countries (World Health Organization [WHO], 2019).

Indicator 6.6.1 assesses the ecological state of the world's largest and most important lakes by measuring two water parameters: turbidity and trophic state. Turbidity is a key indicator of water clarity, quantifying the cloudiness of the water and acting as an indicator of underwater light availability. The Trophic State Index refers to the degree to which organic matter accumulates in a water body and is most commonly used in relation to monitoring eutrophication. The two water parameters may be used to infer a particular state or quality of a freshwater body. The global map (Figure 25) and summary statistics for the SDG regions (Figure 23 and Figure 24) suggest that there is no dominant global trend in water-quality issues for large lakes. All SDG regions have experienced issues with turbidity and trophic state, and while there is a tendency for turbidity to be the more common issue, it is not always the case (such as in Oceania). The highest share of impacted lakes is in sub-Saharan Africa, Latin America and the Caribbean, Europe and Northern America, and Oceania, where more than 40 per cent of lakes show signs of deterioration relative to the 2006–2010 baseline. In contrast, Australia and New Zealand, and Central and Southern Asia have much lower shares of affected lakes.

Online story maps can be accessed on the dedicated case studies website.

National data on the turbidity and trophic state of large lakes and reservoirs per country are available from the indicator 6.6.1 report website. Countries can use this tabulated data to observe the number of affected lakes (i.e. high turbidity or trophic state) in their country.

Figure 23. Distribution and relative share of large lakes per SDG region with observed changes in turbidity (TUR) and Trophic State Index (TSI) in 2017–2019 compared with the 2006–2010baseline



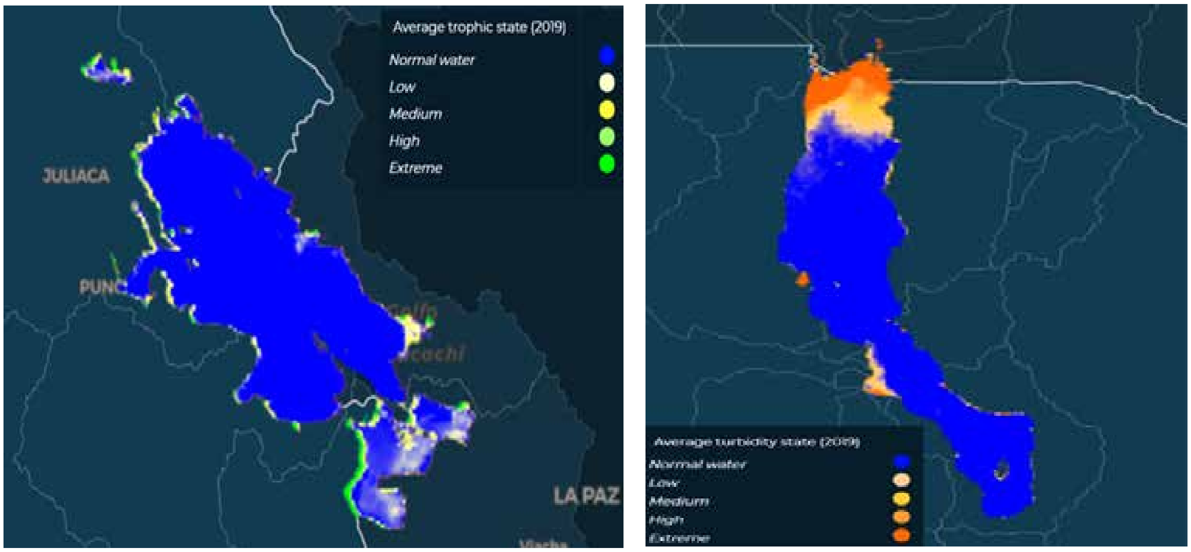
Source: DHI GRAS / UNEP

The case study examples for water quality are Lake Turkana, the largest lake in the East African Rift Valley, and Lake Titicaca,[16] the highest navigable lake in the Andes. Importantly, both lakes are transboundary. Their environmental and ecological state is highly dependent on the creation and development of effective water quality monitoring systems and programmes between the riparian states (Ethiopia and Kenya for Lake Turkana and Peru and Bolivia for Lake Titicaca).

Jason Zhao on Unsplash

16 See Lake Turkana; Lake Titicaca.

Figure 24. Map of SDG indicator 6.6.1 visualizations of the Trophic State Index for Lake Titicaca (left) and the turbidity of Lake Turkana (right)



Source: UNEP Freshwater Ecosystem Explorer (www.sdg661.app)

The case studies illustrate the value of the SDG indicator 6.6.1 app as a first-line assessment tool for evaluating the environmental and ecological status of the world's largest lakes. Countries are encouraged to use the SDG indicator 6.6.1 app and based on the observed changes, consider whether action is needed to implement regulatory frameworks to achieve a good qualitative and quantitative status of their water bodies.

Figure 25. Global map of large lakes affected by changes in turbidity (TUR) and Trophic State Index (TSI) in 2017–2019 compared with the 2006–2010 baseline

Note: For more information about the data analysis methodology, please refer to annex II of this report.
Source: DHI GRAS / UNEP

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CASE STUDY: WATER QUALITY

IWRM
[41% - PE]
[52% - BO]

Pollution and climate change threaten the cradle of Andean civilization

The online story map can be accessed on the dedicated case studies website.[17]

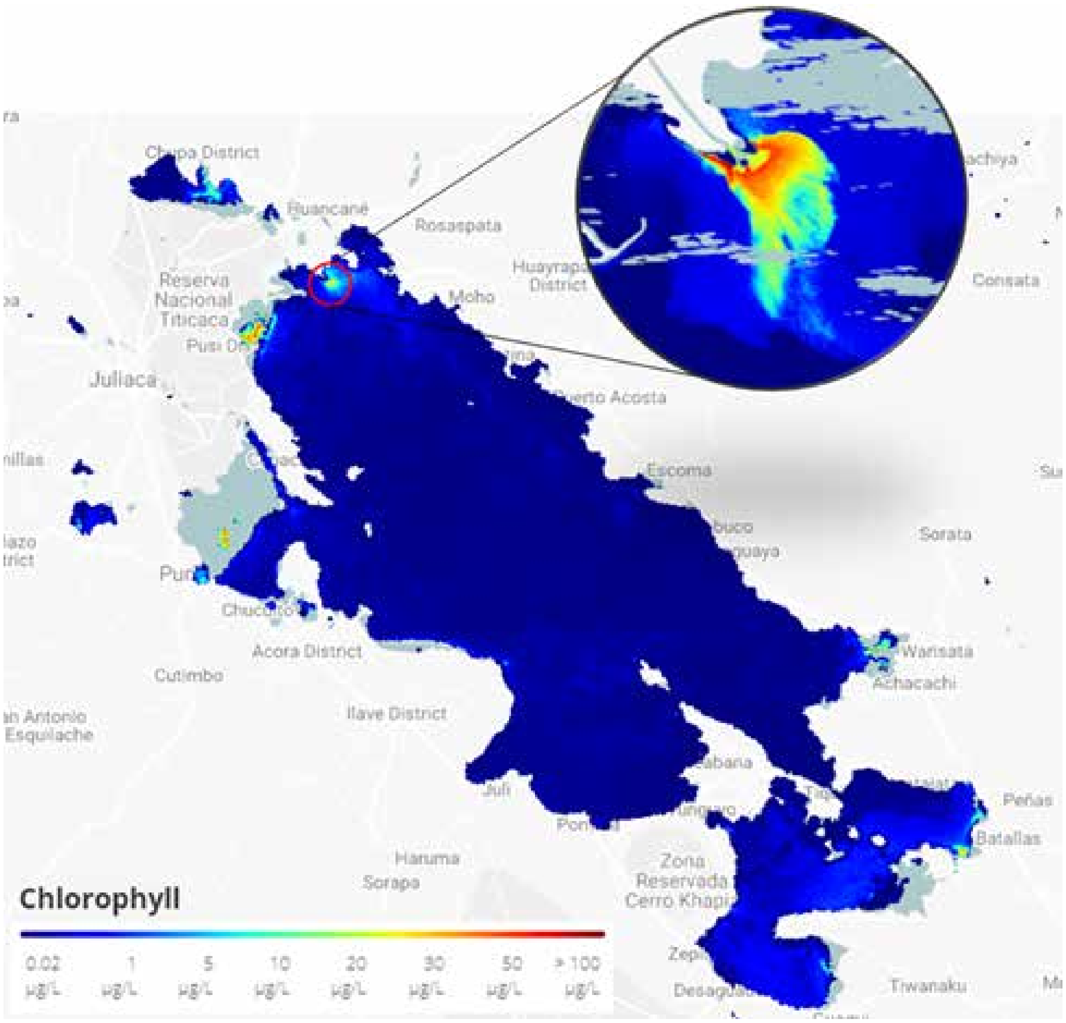
The waters of Lake Titicaca – a transboundary lake straddling Peru and Bolivia – are considered the cradle of Andean civilization. The lake is the largest in South America and the highest navigable lake in the world (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2019). It is an extremely complex, unique, yet fragile ecosystem, which is being negatively impacted by natural and anthropogenic factors.

As a high-altitude lake, natural soil erosion and subsequent sediment run-off have always been a serious problem. Land-use changes and uncontrolled mining have exacerbated the situation by increasing the transport of solid material to the lake. Organic, chemical and bacterial water pollution is also increasing, primarily as a result of untreated or insufficiently treated wastewater and industrial discharges from urban centres (Puno, El Alto, Viacha, Oruro and Juliaca) (Global Environment Facility, n.d.). Global warming is also impacting the lake as a result of higher evaporation and the disappearance of glaciers, which were its main source of replenishment (Cordova, 2011).

Amy Rollo on Unsplash

17 See https://mango-river-0ac1c3d03.azurestaticapps.net/#/story/0/0/0.

Figure 26. Chlorophyll concentration map of Lake Titicaca showing elevated concentrations around the northern inlet



Sources: DHI GRAS; © Contains modified Copernicus Sentinel data.

These processes are threatening this fragile ecosystem, on which 2.6 million people currently depend. Action is therefore urgently needed to mitigate climate change impacts and prevent ecological collapse and a social disaster (Thuringer, 2016).

CASE STUDY: WATER QUALITY

IWRM
[41% - ET]
[59% - KE]

Lake Turkana: a UNESCO World Heritage Site in danger

Lake Turkana is the world's largest desert lake. Located in northern Kenya, it receives 90 per cent of its fresh water from the Omo River in Ethiopia. It is the most saline of Africa's great lakes and contributes to the livelihoods of more than 300,000 people, including smallholders, fishers and tourism operators. Lake Turkana is a major breeding ground for hippos, Nile crocodiles and more than 350 species of fish and birds, and was thus made a UNESCO World Heritage Site in 1997. Due to its algal colouration, the lake is also commonly known as the Jade Sea.

A series of hydropower dams are being expanded along the Omo River and in the Lower Omo Valley (in Ethiopia), including Africa's highest dam, the Gilgel Gibe III. Although these dams are expected to double Ethiopia's electricity output, supply water for industrial farming and help expand sugar cultivation, they are threatening Lake Turkana and its local communities. In fact, the International Union for Conservation of Nature (IUCN) (2018) has reported rapidly declining water levels downstream of the Gilgel Gibe III Dam since January 2015, which has disrupted water flows into Lake Turkana. Such disruptions will likely impact the lake's wildlife and fish stocks on which these communities depend.

In the past 30 years, the Lake Turkana basin has also experienced significant land-cover and land-use changes. Forest area, for example, has decreased mostly at the expense of agriculture and woodland. The land-use changes and the annual volume of, and patterns in, inflows into the lake have affected its turbidity, salinity, algal productivity and habitats, all of which impact the lake's fish populations (Ojwang and others, 2018) and people's livelihoods, which along with water quality, natural protected areas and World Heritage Sites are now at risk (National Geographic, 2015; Tadesse, 2015; Avery, 2018; Ratner, 2020).

The decade-long monitoring of turbidity and algal concentration using satellite data – also available via the SDG indicator 6.6.1 app – highlights some of these complex issues and how the priceless value of freshwater ecosystems is at risk globally.

Figure 27. Gilgel Gibe III – a controversial hydroelectric dam in Ethiopia

Source: Abebayehu (n.d.).

3.6 Mangrove trends

Mangrove swamps are forested inter-tidal ecosystems which perform critical landscape-level functions related to the regulation of fresh water, nutrients and sediment inputs into marine areas. They also help control the quality of marine coastal waters and are of critical importance as breeding and nursery sites for birds, fish and crustaceans.

Once abundant along the world's tropical and subtropical coastlines, mangroves are now declining at a rate similar to that of terrestrial (natural) forests, with 4–5 per cent of the global coverage lost since 1996 (The Nature Conservancy, n.d. a) and an additional significant proportion either fragmented or degraded. Significant drivers of change include their removal for aquaculture, agriculture, energy exploitation and other industrial development, though they are also sensitive to climate change-induced sea level rise and changes in hydrology (Goldberg and others, 2020).

Mangrove soils hold over 6 billion tons of carbon and, despite being categorized as forests within the UNFCCC Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) scheme, can sequester 3–4 times more carbon than their terrestrial counterparts (IUCN, 2017). They should therefore be included in national emissions reports.

Recent analysis based on multi-year satellite imagery estimates a +4 per cent net loss of mangroves globally (Figure 28) from 1996 to 2016 (an annual average loss of 0.21 per cent), which is above average for tropical and subtropical forest losses. At the national level, 89 out of 109 countries (82 per cent) have experienced a net loss in mangroves, with the most significant losses observed in Eastern and South-Eastern Asia and Latin America and the Caribbean (Figure 29). The main drivers of mangrove losses include human-induced land-use change, mainly due to aquaculture and agriculture conversions, and to a lesser extent urban expansion and exploration activities. Mangroves are also affected by coastal erosion and extreme weather events, both of which are expected to increase in severity with global warming.

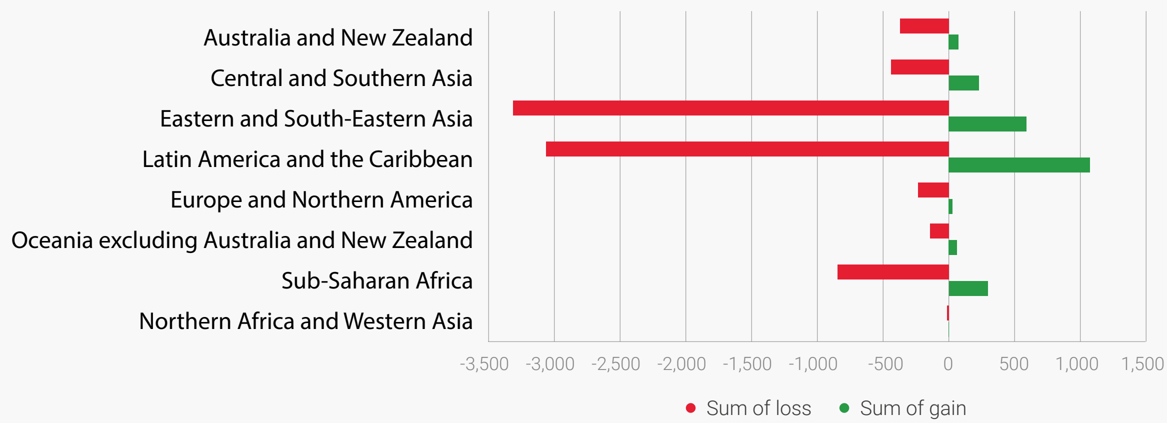
Online story maps can be accessed on the dedicated case studies website.

National data on changes in mangrove area per country are available from the indicator 6.6.1 report website. Countries can use this tabulated data to observe the extent to which mangrove areas are changing.

Figure 28. Global distribution of mangroves in 2016

Source: Global Mangrove Watch (n.d.).

Figure 29. Global mangrove net losses and gains, 1996–2016 by SDG region



Source: Global Mangrove Watch (n.d.)

Although humans have historically been the primary driver of mangrove loss, human impacts have gradually decreased, with natural events emerging as the main cause of their loss. This shift can be explained by the increasing impact of climate change on mangroves through processes such as sea level rise, increased storms and changing ocean currents and temperatures. Another factor is that the remaining mangroves are more remote and less viable for deforestation, coupled with the steady increase in new conservation initiatives (Goldberg and others, 2020). These trends are reflected in mangrove case studies, which review development in Myanmar's Ayeyarwady Delta[18] (where agricultural expansion has led to a massive loss of mangroves since the mid-1970s, and which contributed to the fatal impacts of Cyclone Nargis) and examine mangrove restoration in Suriname (South America) and Guinea-Bissau (West Africa).[19]

The case studies illustrate the value of the SDG indicator 6.6.1 app as a first-line assessment tool for evaluating the status of mangroves both nationally and subnationally. Countries are encouraged to use the SDG indicator 6.6.1 app and based on the observed changes, consider whether action is needed to develop coastal management plans that prioritize mangrove conservation and development.

18 See Myanmar's Ayeyarwady Delta.
19 See Guinea-Bissau; Suriname.

CASE STUDY: MANGROVES

IWRM [33%]

Mangroves: a bio-shield against tropical storms

Mangrove forests, which in most places are no more than a couple of hundred metres wide, are found along tropical coasts. They act as a first and vital line of defence against storm and wave damage. In the wake of the Indian Ocean tsunami in 2004 and Cyclone Nargis in 2008, it became clear that the damaged caused was exacerbated by the over-felling of mangroves, inappropriate coastal development and a lack of preparedness. Global warming is responsible for rising sea levels and other more extreme weather events such as tropical cyclones and floods. It is therefore crucial that decision makers and practitioners develop coastal management plans that prioritize mangrove conservation and development to mitigate these climate change impacts.

When Cyclone Nargis made landfall on Myanmar's Ayeyarwady Delta in May 2008, 84,500 people were killed (United States Agency for International Development [USAID], 2008). This huge mortality has been blamed on insufficient warnings (Human Rights Watch, 2010), though other factors are also important. Among these is the large-scale agricultural expansion into the natural habitats of low-lying areas, which left them exposed to waves. The most extensive flooding (271,000 hectares or 57 per cent of the area) occurred in the townships of Labutta and Bogalay, which are home to 389,000 people (United Nations Institute for Training and Research [UNITAR], n.d.). Around half of the flooded area comprised reclaimed land where mangroves had been cleared, mostly since 1989 for paddy fields (Water Resources Management ES4OD, n.d.), with some later converted for salt production. Cyclone Nargis generated a 3–4-metre-high surge, which easily flooded the largely unprotected paddies and salt pans. Elsewhere in the world, intact coastal wetlands reduce the height of hurricane surges by 4.7–7.9 cm per kilometre (Day and others, 2007). Although wave attenuation varies from site to site, 20 km of wetlands have the potential to reduce storm surges by 0.94–1.58 m.

With the clearing of the Ayeyarwady Delta's mangroves in the past two decades, this buffer has been lost. Prior to Cyclone Nargis, the last severe hurricane or cyclone in central Myanmar occurred in 1982. Given predicted sea level rise and the increased frequency of extreme weather events, post-Nargis reconstruction efforts should reconsider agricultural expansion into the delta and instead focus on recovering coastal wetlands to buffer storm surges, while also supporting locally-based coastal resource management and social development to improve communities' resilience. Such restoration efforts could also inform resilience-building in other heavily populated Asian deltas.

Figure 30. The conversion of mangroves into rice paddies was partly to blame for the many casualties of Cyclone Nargis

Source: Neryl Lewis (2008).

3.7 Vegetated wetland trends

Wetlands exist worldwide, from the tundra to the tropics. Some wetlands, such as tidal marshes, fit the definition of a transitional zone because they occur where open water and land meet, while some are not associated with a distinct water body and instead are fed mostly by precipitation or groundwater. Others, such as fen and bog mosaics, are the main features of a landscape. Wetlands are most abundant in boreal and tropical regions, though a wide variety of inland and coastal wetlands are also found in temperate regions. This distribution is generally due to conditions that result in large quantities of water. For example, the peatlands of Borneo, Central Africa and the Amazon occur within a tropical rainforest biome. In the treeless tundra of Alaska and Canada, saturated and flooded wetlands are underlain by permafrost. Wetlands are also found in hot desert biomes, such as the Mesopotamian marshlands at the confluence of the Tigris and Euphrates rivers. In temperate regions, wetlands typically occur near coastlines, rivers, lakes or other locations where local water input exceeds output (Crandell, 2020). Human-made wetlands also exist and are found in mega deltas around the world (Ganges, Nile, Mekong), where rice paddy cultivation dominates.

Wetlands are considered the most biologically diverse type of ecosystem. According to IUCN's Freshwater Biodiversity Unit, an estimated 126,000 species rely on freshwater habitats, including species of fish, molluscs, reptiles, insects, plants and mammals.

Wetlands provide tremendous economic and societal benefits, such as water supply (quantity and quality), fisheries (over two thirds of the world's fish harvest is linked to the health of coastal and inland wetland areas), agriculture, through the maintenance of water tables and nutrient retention in floodplains, timber production, energy resources (for example, peat and plant matter), wildlife resources, transport and recreation and tourism opportunities.

Wetlands also have special attributes linked to humanity's cultural heritage, providing the basis for religious and cosmological beliefs and local traditions, a source of aesthetic inspiration and an area for wildlife sanctuaries. The full monetary value of wetlands was recently estimated to total between 40 and 45 per cent of the value of all global ecosystems, contributing around $47 trillion per year in ecosystem services. The majority of this value (68 per cent for inland wetlands and 89 per cent for coastal wetlands) comes from regulating the services that these ecosystems provide, such as maintaining water and soil quality through filtration and nutrient cycling, as well as protecting riverbanks and coastlines from flooding and erosion (Davidson and others, 2019). Protecting and restoring wetlands is a valuable climate change mitigation action, as wetlands act as carbon sinks and absorb greenhouse gas emissions. Peatlands have been estimated to store twice as much carbon as all of Earth's forests, with mangrove soils holding more than 6 billion tons of carbon and sequestering 3–4 times more carbon than natural forests (IUCN, 2017).

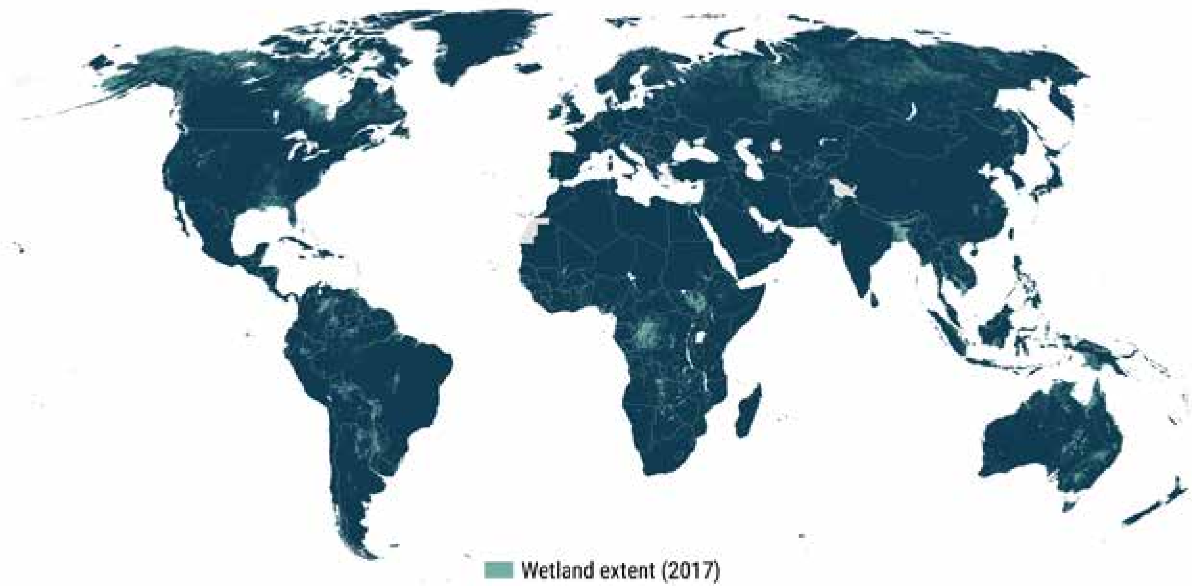
Despite their importance, wetlands are under threat. Estimates suggest that more than 80 per cent of wetlands have been lost through drainage and conversion since the pre-industrial era, with remaining wetlands significantly degraded (Davidson, 2014). Some wetlands are receding due to reduced flows caused by droughts and water extraction – trends that are expected to be amplified by climate change and higher global demand for water.

Aquatic weed infestations are degrading some wetlands, while others are being exposed to persistent organic pollutants or inundated due to dam construction. Additional threats to wetlands include overexploitation of resources, uncontrolled fires, pollution and deforestation, all of which alter wetlands' ecosystems, causing habitat change and species loss, and ultimately affecting their ability to deliver raw water, raw materials and food. Wetlands are essential for life and crucial for maintaining people's livelihoods and the sustainability of the world's economies.

The new high-resolution global map of the distribution of vegetated wetlands was produced using machine learning and a representative network of training data to automatically predict wetlands from multi-temporal satellite imagery (Figure 31). The input satellite imagery includes pre-processed Sentinel-1 and Sentinel-2 data as well as thermal imagery from Landsat. As wetlands tend to be susceptible to high annual variations, all available data from 2016 to 2018 was used to even out potential annual biases and to create a more solid estimate of wetland extent around the baseline year of 2017. Although surface-area changes have not yet been calculated, baseline surface areas have been determined per SDG region and country for the 2017 baseline. Updates will be made to these wetland area data sets, thus making it possible to calculate the change of wetland area from the baseline reference period.

National data on wetlands per country are available from the indicator 6.6.1 report website.

Figure 31. Global extent of vegetated wetlands at a 30-metre spatial resolution for the 2017 baseline year



Source: DHI GRAS/UNEP.

Maxwell Ridgeway on Unsplash

CASE STUDY: WETLANDS

African wetlands: part of our global commons

Africa is the world's second-largest continent, comprises one fifth of the world's land area and was home to 1.3 billion people in 2019 (16 per cent of the world's population). Half the people in Africa are thought to be aged 19 years or younger.

From freshwater forests to saline lakes to large floodplains, Africa's many wetland types support diverse plants and animals and are an important source of natural resources that provide rural economies with food, energy, medicine, building materials, dry-season grazing and transportation (Kabii, 1996). Although sources of carbon dioxide and methane emissions, wetlands also act as carbon sinks.

Despite the abundance of valuable wetlands (Figure 32) and other natural resources, Africa is currently the world's poorest and least developed continent. Poverty, illiteracy, malnutrition and inadequate water supply and sanitation affect much of the population and are leading to a poor overall health status. However, in the past two decades, Africa has achieved unprecedented economic growth and its longest sustained period of sustained economic growth since the 1960s (Mukasa and others, 2017), though this is projected to decline in 2021–2021 due to the COVID-19 pandemic (World Bank, 2021).

The combination of a young and growing population, ongoing widespread poverty and increasing economic growth represent a serious threat to African wetlands. Some wetlands in Africa are receding due to reduced flows resulting from droughts and water extraction, while others are being increasingly infested with aquatic weeds or exposed to persistent organic pollutants. Some wetlands have also been flooded as a result of dam construction. Additional threats to wetlands include overexploitation of resources, uncontrolled fires, pollution and deforestation, which alter their ecosystems, causing habitat change and species loss. However, attitudes are changing and there is increasing recognition of their value in delivering water, raw materials and food, in maintaining livelihoods and for ensuring the sustainability of the world's economies (Russi and others, 2013).

African wetlands require political will to protect them, as well as sound wetland-specific policies and the encouragement of community participation in their management. The 1971 Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) is the intergovernmental treaty that provides the framework for national actions and international cooperation to conserve wetlands and use them wisely.

Mohmed Nazeeh on Unsplash

Lac Télé-Lac Tumba, Congo Basin

The Lac Télé-Lac Tumba wetlands are the world's largest tropical peatland. The area is estimated to store the equivalent of three years' worth of global fossil fuel emissions, with its swamps locking in around 30 billion tons of carbon; this makes the region one of the most carbon-rich ecosystems in the world.

As the world's largest Ramsar site, this peatland is crucial to controlling climate change and sustaining the livelihoods of around 2 million people who depend on the area's water, forests and swamps. However, protection of this important freshwater wetland is urgently needed, due to major threats of logging and deforestation, expansion of oil palm and rubber, new road developments, and unplanned and unsustainable agricultural practices (USAID, n.d.; WWF, n.d.).

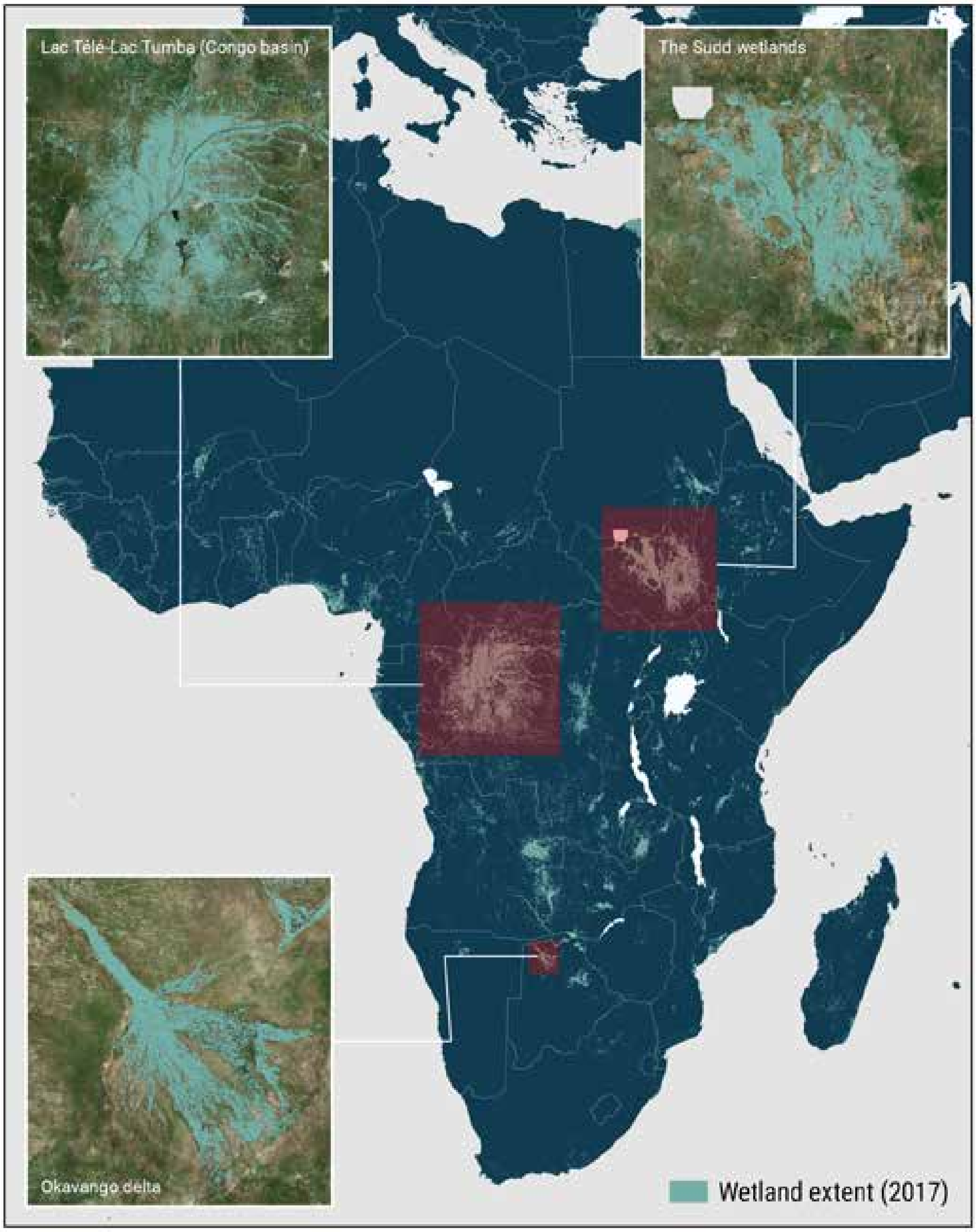
The Sudd wetlands

Methane is a potent greenhouse gas and around 30 times better at trapping heat in the atmosphere than carbon dioxide. The anaerobic conditions in wetlands force soil microbes and plants to metabolize, a process that produces methane. As a result, wetlands are estimated to account for around 40 per cent of all methane emissions globally. Recent changes in river inflows to the Sudd wetlands suggest that soils have become wetter, resulting in increased soil microbe activity and a huge increase in methane emissions between 2011 and 2014 (Amos, 2019; Lunt and others, 2019). However, there is some uncertainty around the cause of this, thus indicating the importance of monitoring wetlands and their associated emissions given the current climate crisis.

Okavango Delta

Wetlands are estimated to be the primary habitat for around 40 per cent of all plant and animal species (UNEP, 2020). The extraordinary biodiversity in the Okavango Delta is well documented and largely driven by flooding peaks during the region's dry months from June to August. In the dry season, the delta is a strong natural safeguard against drought, helping people to sustain their livelihoods and attracting animals to create one of Africa's greatest concentrations of wildlife. A UNESCO World Heritage Site, the Okavango Delta is under pressure from human activity, reduced annual rainfall and increasing temperatures due to global warming (Bouwer, Nkemelang and New, n.d.). This is a cause for broader concern, since wetland habitats are estimated to be disappearing at a rate three times faster than forests (UNEP, 2020).

Figure 32. Africa's wetlands



Sources: DHI GRAS/UNEP data; Tottrup and others (2020).

Wynand Uys on Unsplash

4. Accelerating actions towards target 6.6

In the context of the 2030 Agenda, SDG target 6.6 asks countries to protect and restore their water-related ecosystems so that they can continue to provide goods and services to society and allow plant and animal species to remain in their natural habitat. The target does not quantify an intended physical area to be protected globally, nor does it specify a number of ecosystem types requiring protection. Given the complex and context-specific interactions between ecosystems and the pressures that cause above-normal variations in ecosystem extent, the scope and scale of their protection varies considerably within and between countries and must take into account localized contexts. As the data analysis within this report has shown, some countries and subregional areas are experiencing significant changes in ecosystem extent, across ecosystem types. Countries are encouraged to assess the global maps and regional trend charts, and access the data available on the Freshwater Ecosystems Explorer to determine where specific ecosystem changes are occurring in their country, and to act on this information to halt ecosystem loss and degradation where necessary.

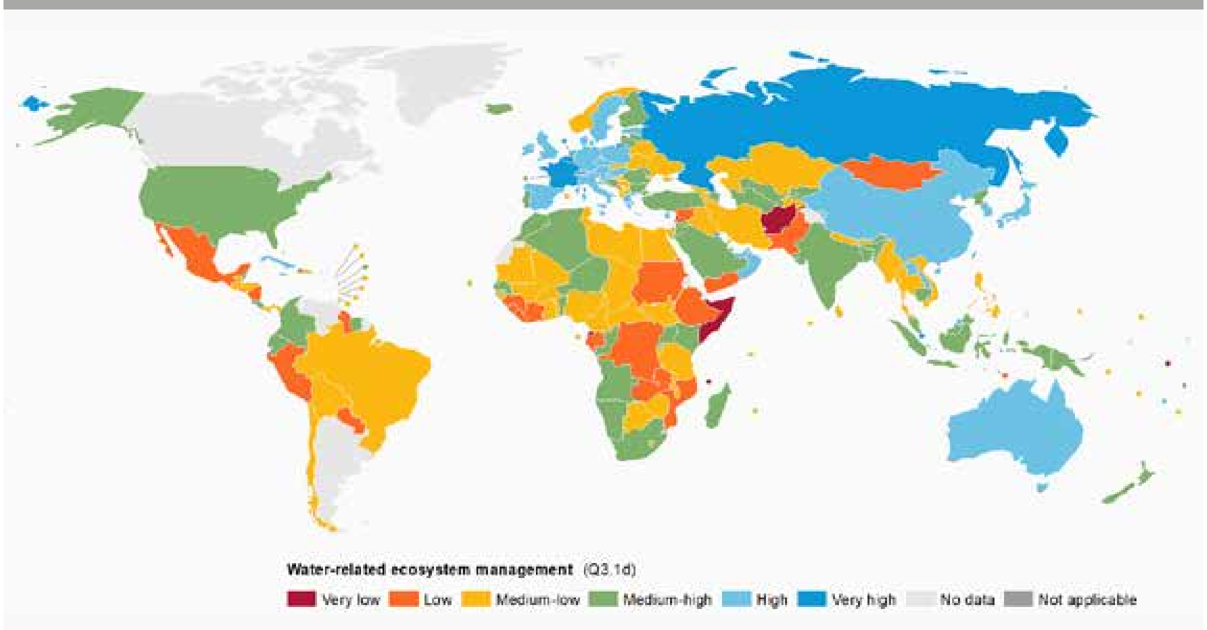
4.1. Advancing integrated water resources management to achieve good ecosystem management

IWRM is one of the most effective means of ensuring the sustained provision of ecosystem goods and services, as it specifically tackles the challenge of balancing water needs for social and economic purposes, without compromising the sustainability of vital ecosystems. IWRM involves a coordinated, multisectoral approach to actions being taken with respect to laws, policies and plans, institutions and stakeholder participation, management instruments and financing.

For ecosystem management to be effective, it is important to establish laws, policies and plans and ensure that there is adequate institutional capacity (including human and financial resources) to implement and enforce these at various levels (national to basin). Cross-sector coordination and stakeholder participation should also be effective (including the private sector) and there should be sufficient data and information-sharing and support systems for informed and inclusive decision-making, as well as sufficient funding, including innovative revenue funding and "valuing" of ecosystems and their role/function in order to tap into various revenue streams (for example, for climate resilience, flood and drought mitigation, water security and water quality).

SDG indicator 6.5.1 monitors the degree of IWRM implementation and progress on target 6.5, and can therefore strongly support progress on target 6.6. Figure 33 shows the degree of implementation of management tools for freshwater ecosystems as reported under indicator 6.5.1. It shows that around 50 per cent of all countries consider their management tools as insufficient for effective ecosystem management, due to being either ad hoc projects or programmes with limited reach across ecosystem types found throughout their territories. Advancing water-related ecosystem management, and in turn supporting target 6.6, is a particularly high priority in these countries.

Figure 33. Development and implementation of management tools for freshwater ecosystems as reported under SDG indicator 6.5.1 (2020)



Sources: UNEP, 2021

The SDG 6 IWRM Support Programme assists governments in designing and implementing IWRM action plans as an entry point to accelerate progress towards the achievement of water-related SDGs and other development goals, in line with national priorities.

The IWRM Acceleration Package[20] is available to all countries to facilitate government-led multi-stakeholder processes to develop these action plans. The inclusion in this process of institutions with responsibility for protecting and restoring ecosystems will directly support action for target 6.6.

20 See https://www.gwp.org/en/sdg6support/consultations/where-we-need-to-go/acceleration-package/.

In a similar manner, it is recommended that indicator 6.6.1 focal points participate in the multi-stakeholder reporting process under indicator 6.5.1 so that they have the opportunity to communicate with stakeholders from across the water community (subsectors) on the importance of the management of freshwater ecosystems for achieving multiple development objectives. For more information on ecosystem management tools that countries can use, please refer to annex IV of this report.

4.2. Advancing the protection of freshwater ecosystems

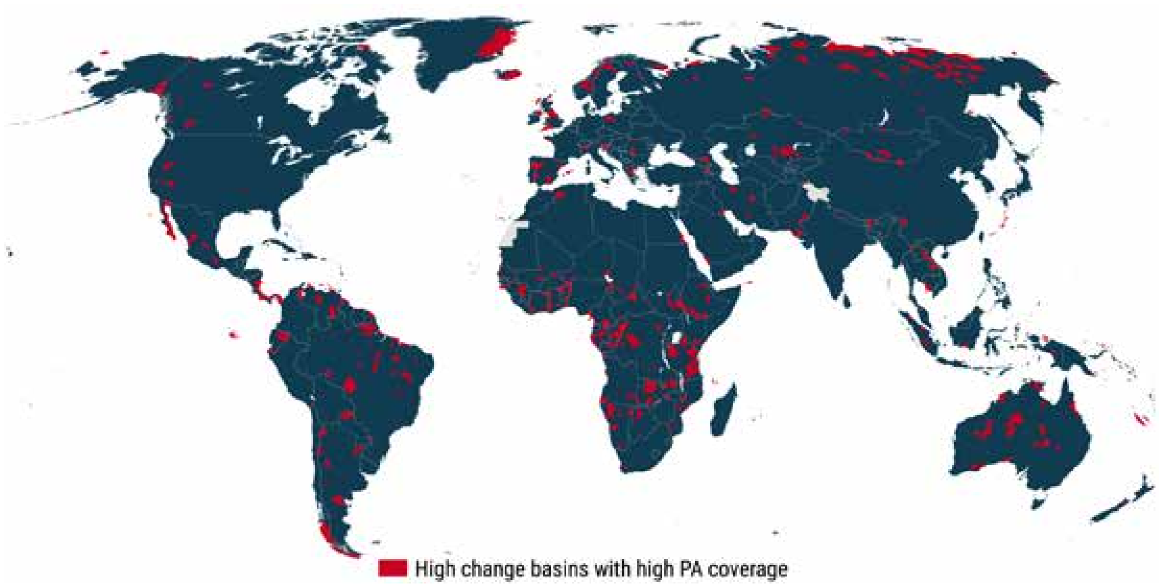
By globally mapping both river basins and known protected areas[21] it is possible to observe the number of "protected river basins", i.e. basins with more than 25 per cent of their area under formally designated protection. A global analysis of all 8,518 river basins shows that 1,766 are within existing protected areas. Assessing the extent of surface-water changes within these 1,766 protected basins reveals that 722 basins (40 per cent) are experiencing high surface-water changes (Figure 34).

High surface-water extent changes are most commonly due to human intervention in natural hydrological regimes. The observation that 40 per cent of protected basins are experiencing high degrees of surface-water change suggests that freshwater ecosystem protection is currently insufficient and largely ineffective.

Tettegouche State Park, Silver Bay, United States of America by Josh Hild on Unsplash

21 The World Database on Protected Areas (WDPA) includes all sites designated at a national level (e.g. national parks), under regional agreements (e.g. the Natura 2000 network in the European Union) and under international conventions and agreements (e.g. natural World Heritage and Ramsar sites). As in other global protected area assessments, the following areas were excluded from the analysis: sites with a "proposed" or "not reported" status, sites without an associated reported area, and UNESCO Man and the Biosphere reserves (as their buffer areas and transition zones may not meet the IUCN protected area definition, and because most of their core areas overlap with other protected areas).

Figure 34. Global map of river basins experiencing high surface-water changes within protected areas



Source: DHI GRAS / UNEP

At present, protection measures for freshwater ecosystems are not able to ensure that ecosystem integrity is sufficiently maintained to deliver consistent quantity and quality of freshwater. Additionally, the effective management of freshwater ecosystems requires technically capable and politically empowered bodies that are able to finance enforcement measures in the long term and prioritize protection for ecosystem services above competing social and economic demands. National decision makers and river basin authorities should increase the protection offered to freshwater ecosystems and ensure that adequate enforcement, financing and governance structures exist to manage the protected area (UNEP, 2021). These recommendations can be partially addressed through the implementation of IWRM (indicator 6.5.1), but it is crucial that the importance of healthy ecosystems in underpinning multiple development objectives is communicated across sectors and at all levels to ensure political will for accelerating progress towards SDG target 6.6.

4.3. Increasing the uptake of freshwater data into water-dependent sectoral processes

To ensure that good water-related decisions are made, water data from all water-dependent sectors (agriculture, energy, industry, etc.) must form part of decision-making processes. Governments must also promote, share and disseminate available freshwater ecosystem data across sectors, institutions and companies that depend on such water to improve data access. The existing national SDG 6 and indicator 6.6.1 focal points are well positioned to promote planning across sectors and process data and trends (particularly at the basin level) using data available on the Freshwater Ecosystems Explorer.

5. Next steps

Indicator 6.6.1 monitoring and reporting timeline

This report has presented global and regional freshwater trends using indicator 6.6.1 data, up to and including the most recent data approved by countries in 2020. The next round of global SDG monitoring and reporting for indicator 6.6.1 is planned for 2023. The indicator 6.6.1 data will continue to be updated annually (around May), with the annual updates incorporated into the Freshwater Ecosystems Explorer.

Development of indicator 6.6.1 data sets

Data for indicator 6.6.1 remain sparse on river flow and groundwater. It may be possible to model river flow data globally using precipitation and run-off data that are correlated to in situ measurements, but at present, a method has not yet been fully developed and tested. However, it is likely that such a method could be available before the next round of reporting. Groundwater data remains notoriously difficult to gather for many countries. It is currently not possible to generate a global data set on groundwater, and countries are therefore encouraged to establish groundwater monitoring regimes to assess and report on aquifer levels over time.

Garaw Pond in Iraq, Ranya City by Haryad Abdullah on Unsplash

Annexes

Annex I. Further information on the freshwater ecosystem data portal and accessing country statistics

Actionable freshwater data at the national, district, transboundary and river basin levels

The purpose of presenting subnational and basin-level statistics in the SDG indicator 6.6.1 data portal is to facilitate the process of subnational decision-making on freshwater ecosystems, especially since subnational authorities may be responsible for making decisions relating to a particular water body (i.e. a lake). Assessing changes across several ecosystem types enables decisions to be made on the protection and restoration of multiple ecosystems within an area. For example, data for a particular river basin may reveal that the spatial area of lakes is decreasing while the spatial area of reservoirs is increasing. When presented with several interlinked data sets within a watershed boundary, decision makers can better discern the causes and impacts of changes in ecosystem extent. Assessing trends across all subindicator data can provide a more comprehensive picture and generate policy and planning decisions that promote ecosystem health and the ability of ecosystems to maintain their structure and function over time in the face of external pressures.

For global reporting purposes, national statistics are reported per ecosystem type. The Global Administrative Unit Layers (GAUL)[22] global map is used for national statistics and allows freshwater data to be presented at the level of subnational administrative units for all countries. In many countries, subnational regional authorities are the decision-making entity with regard to water within their region or district. However, GAUL was last updated in 2014 and therefore does not map all country boundaries accurately. In 2020, the United Nations cartographic unit released a new global base map delineating country administrative boundaries agreed by United Nations Member States. The Freshwater Ecosystems Explorer will integrate the new United Nations base map, but will lose subnational boundaries in the process.

In addition to national statistics, data are available for river basins. Developed on behalf of the World Wide Fund for Nature (WWF), the HydroBASINS[23] map layer in the Freshwater Ecosystems Explorer depicts watershed boundaries at the basin and sub-basin levels

22 See http://www.fao.org/geonetwork/srv/en/metadata.show%3Fid=12691.
23 See http://www.hydrosheds.org/page/hydrobasins.

worldwide. A key advantage of compiling freshwater data using river basins (also commonly called catchments or watersheds) is that it makes it possible to present data within geographically recognized areas.

All the global and regional analysis in this report uses river basins as the common spatial denominator. Without an in-depth analysis of more local water data, there is an inherent risk of masking local areas that are experiencing a loss or degradation of freshwater ecosystems. For example, if a country has 10 river basins and nine are performing normally, with just one experiencing adverse changes, the national-level data would not identify the one degraded basin, which would be masked within the national statistic. Although national-level statistics are used for SDG reporting, there is considerable added value in providing freshwater ecosystem information to countries at the river basin level.

Aquifers, lakes and river basins shared by two or more countries account for an estimated 60 per cent of global freshwater flow and are home to more than 40 per cent of the world's population. The need for collaboration between riparian states to address the objectives of target 6.6 is therefore crucial.

Advanced analysis is available for each of the global data sets. This allows for more detailed data to be accessed, such as particular years or months when ecosystem conditions were changing more than normal.

Countries' national statistics on subindicators (including combined surface water, permanent water, seasonal water, reservoir water, water quality, inland wetlands, and mangroves) are available online at the SDG indicator 6.6.1 Freshwater Ecosystems Explorer and can also be directly accessed on the dedicated indicator 6.6.1 website.

Annex II. Methodological approaches used to analyse water data

Analysing surface-water extent over 20 years

SDG indicator 6.6.1. was developed to measure changes in freshwater ecosystems between 2000 and 2030. Since freshwater ecosystems (including surface-water bodies) are dynamic, a long time series of annual data is needed to identify changes that depart significantly from the longer-term mean. Changes in surface-water bodies are therefore measured in five-year intervals relative to the 2000–2019 reference period and based on the annual aggregation of monthly water occurrence maps derived from a time series of Landsat data.

High-change basins were identified by calculating the percentage change of spatial extent (Δ) of permanent waters (P), seasonal waters (S) and reservoirs (R) for each hydrological basin using the formula:

$$\Delta = ((\gamma-\beta)/\beta)\times 100$$

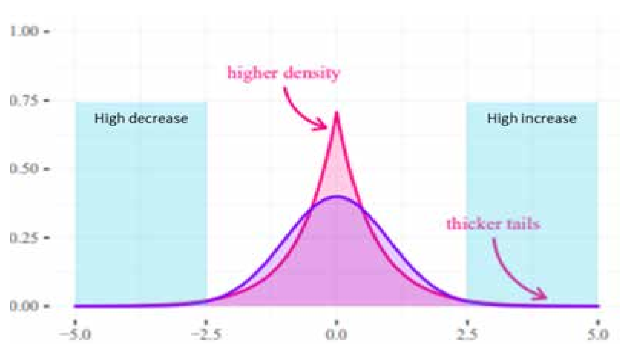
Where:

β = median value of the spatial extent for the 2000–2019 baseline period

γ = median value of the spatial extent for the 2015–2019 reporting period

The deviations were calculated for each five-year period (2000–2004, 2005–2009, 2010–2014 and 2015–2019), with their distributions then analysed to identify the cut-off points for basins lying within the nominal range of deviations compared with those considered as differing significantly from natural variability.

FIGURE II.1. LAPLACE AND GAUSSIAN DISTRIBUTIONS WITH EXCEEDANCE THRESHOLDS FOR BASINS WITH A HIGH INCREASE OR DECREASE IN SURFACE WATERS.



Note: Laplace distribution (red) compared with Gaussian distribution (purple).

A Laplace probability density function can be applied to the deviation frequency distributions of all subindicators. The Laplace distribution is sharper at the centre and thicker at the tails compared with the better-known Gaussian distribution (Figure II.1). High-change basins for each subindicator (P, S and R) were identified by the 95 per cent confidence interval of their respective cumulative Laplace distribution functions (i.e. using the 2.5th and 97.5th percentiles as cut-off points) after adjusting for high-end outliers and excluding deserts, hyperarid basins and basins covered by permanent snow and/or ice. Although statistical anomalies, the outliers still reflect real changes, which is why they were brought back into the analysis as high-change basins despite the percentile cut-offs. Figure 0.1 depicts any basins experiencing a high change in any of the three subindicators (P, S and R), with Figures 6, 11 and 16 (and their respective sections in this report) reflecting each subindicator's individual results, respectively.

Method for calculating changes in mangroves extent

Global mangrove area maps were generated in two phases: (i) a global map of mangrove extent for 2010; (ii) a global map of mangrove extent for 2010 with the addition of six annual data layers (1996, 2007, 2008, 2009, 2015 and 2016). Mangrove classification was limited to the use of a mangrove habitat mask, a method that uses a combination of radar (ALOS PALSAR) and optical (Landsat-5 and -7) satellite data. These were merged into optical and radar image composites covering tropical and subtropical coastlines in the Americas, Africa, Asia and Oceania. Mangrove changes were identified from measured changes in radar backscatter intensity between 2010 ALOS PALSAR data and JERS-1 SAR (1996), ALOS PALSAR (2007, 2008 and 2009) and ALOS-2 PALSAR-2 (2015 and 2016) data. The pixel changes for each annual data set were then added (gains) or removed (losses) from the 2010 baseline raster mask. In order to produce national statistics for indicator 6.6.1 monitoring, the year 2000 was used as a proxy and based on the 1996 annual data set, to align this baseline with that of the surface water data set.

The percentage change of spatial extent was calculated using the formula:

$$\text{Percentage change in spatial extent} = ((\gamma-\beta)/\beta)\times 100$$

Where β is the national spatial extent from the baseline and γ is the national spatial extent for the reporting period. This means that a positive value represents a gain in mangrove extent and a negative value represents a loss in extent.

Method for calculating water quality statistics and classifying "affected" lakes

A baseline reference period has been produced comprising monthly averages for the trophic state and turbidity of lakes from observations made during the five-year 2006–2010 period. A further set of monthly observations made during 2017– 2019 were then used to calculate the change (Δ) against the baseline data using the formula:

$$\Delta = ((\gamma-\beta)/\beta)\times 100$$

Where:

β = monthly average for the baseline period (2006–2010)

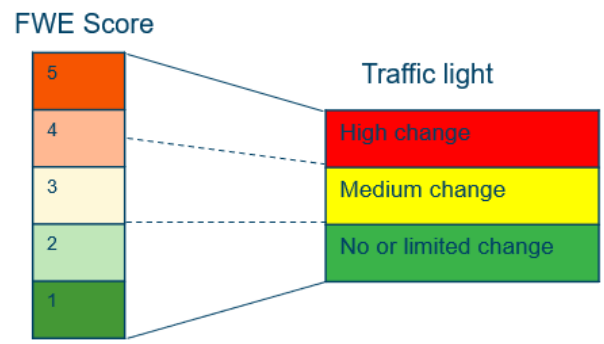
γ = average for each month in 2017, 2018 and 2019

Zero and below-zero values indicate normal or improved water quality conditions, whereas positive values indicate a water quality deterioration. Water quality parameters are intrinsically dynamic both in space and time, which is why both temporal and spatial criteria are used to classify the ecological state of lakes relative to the baseline. For each pixel, and for each month, monthly deviations were analysed and categorized into one of the following ranges: 0–25 per cent (no to low change); 25–50 per cent (medium change); 50–75 per cent (high change) and 75–100 per cent (extreme change). An annual temporal aggregation was then performed, with the spatial coverage of each lake in the low, medium, high and extreme categories for the years 2017, 2018 and 2010 calculated thereafter. The last step involved isolating lakes with deteriorating conditions using a 50:50 rule, i.e. lakes whose area mostly fell within the high to extreme change categories if any of the three reporting years were classified as deteriorating relative to the baseline. For transboundary lakes, the rule was applied to national shares of the lake, i.e. if a riparian state exceeded the 50:50 rule, the entire lake was classified as high change. Lakes falling within the tundra and boreal forest/taiga biomes (Dinerstein and others, 2017) were excluded due to known issues with the water quality detection method in high latitudes.

Annex III. Globally mapping river basin vulnerability

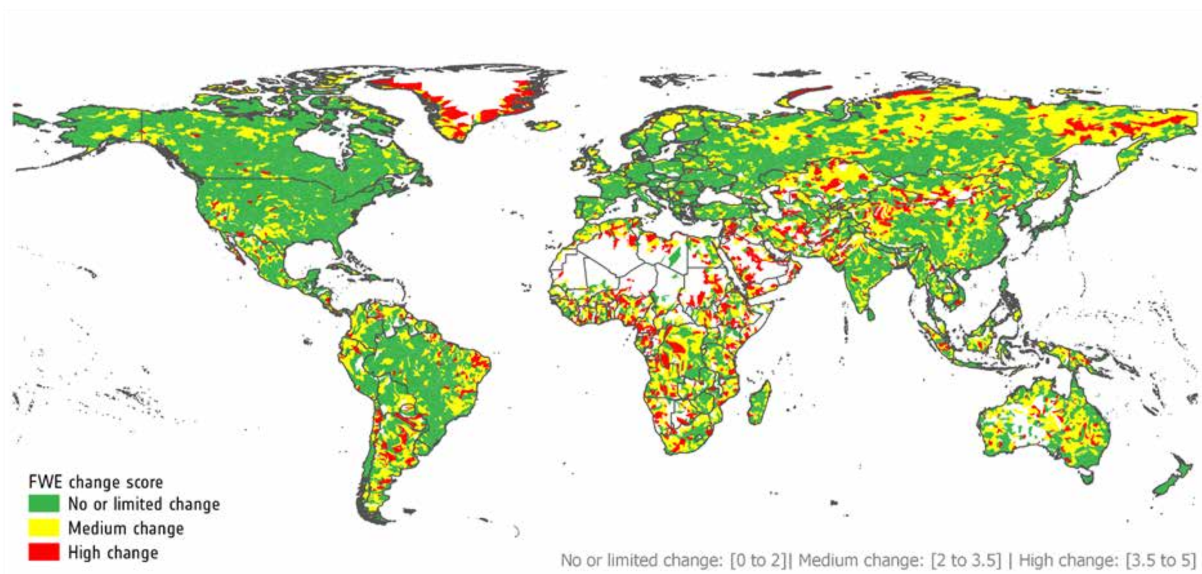
To accelerate action towards achieving the global target on the protection and restoration of water-related ecosystems, subindicator data must be combined into an aggregate score. However, this is inherently challenging when dealing with dynamic changes to different ecosystem types. A simple aggregation of each subindicator (ecosystem type) into a national percentage change will mask important ecosystem-specific changes (both in time and in space), which need to be identified for targeted action to occur. At the same time, only reporting data disaggregated per ecosystem type will prevent the monitoring of national progress in achieving the target. Overcoming this issue could involve the implementation of a river basin scorecard system, which would develop a combined subindicator score for ecosystem changes per river basin. Freshwater ecosystem changes per basin could be calculated using a weighted sum of changes in the subindicators, with the extent of change per subindicator corresponding to a numerical scale from 1 to 5, which are then brought together in a simple, flexible and robust traffic light scoring system.

FIGURE III.1. MODEL TRAFFIC LIGHT BASIN SCORECARD SYSTEM



Source: DHI GRAS / UNEP

FIGURE III.2. MODEL GLOBAL MAP OF THE BASIN SCORECARD SYSTEM



Note: Figures III.1 and III.2 are for illustrative purposes only to show how the basin scorecard system could be developed and used to readily identify at-risk basins and help promote action in these areas.
Source: DHI GRAS / UNEP

Annex IV. Ecosystem management tools

Environmental risk and environmental impact assessments are established management tools used to identify hazards and appropriate mitigation measures to protect freshwater ecosystems at risk of multiple development pressures. While these environmental hazard identification tools are commonplace, they need to be applied by experienced independent experts to ensure that any conflicting institutional interests are also recognized and made public. Moreover, the environment must not only be considered in its physical form but also in terms of social and economic perspectives, which are also gendered.

Ecosystem management plans are a recommended practical approach to document ecosystem trends, locations, drivers, pressures and impacts, and to translate this information into a set of implementable actions. The ecosystem management plan can serve as a multisectoral investment road map, documenting and coordinating the implementation of agreed sets of actions to be funded and undertaken by various interested parties. It is important to include both women and men in ecosystem management, including at decision-making levels.

Effectively managed systems of protected areas are critical instruments in achieving SDG target 6.6. Freshwater ecosystems can be protected by designating the ecosystem-containing area as under protection, meaning it has a defined geographical space that is recognized and managed through legal or other effective means to achieve the long-term conservation of ecosystem services (IUCN, n.d.). Protected area designations have different forms and may include national parks, nature reserves, biosphere reserves, sites of scientific, cultural or environmental interest, species conservation and wildlife areas. Protected area systems should directly conserve ecosystems and ecosystem processes and enable conservation objectives through in situ implementation, governance and equitable sharing.

Water funds and investments in green infrastructure can prove more cost-effective than upgrading grey infrastructure such as dams and reservoirs. Water funds create a system through which municipal utilities and businesses can invest in the source of their water upstream, thereby protecting critical watersheds to improve water security, water quality and wildlife habitat. Water funds have so far proven successful in more than 30 cities around the world. A further 28 cities in sub-Saharan Africa are suitable for water fund investments (The Nature Conservancy, n.d. b).

SDG indicator 6.6.1 data can be used within **ecosystem accounting**. The System of Environmental Economic Accounting for Ecosystem Accounting (SEEA EA) is an integrated and comprehensive statistical framework for organizing data on habitats and landscapes, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity. The United Nations Statistical Commission[24] adopted the SEEA EA at its fifty-second session in March 2021. The various freshwater ecosystem data collected and reported under indicator 6.6.1 can fulfil the first (ecosystem extent) of the five ecosystem accounts (System of Environmental Economic Accounting for Ecosystem Accounting [SEEA EA], n.d.). Comprehensive ecosystem accounting allows the ecosystems' contributions to society and society's well-being to be expressed in monetary terms, thus enabling them to be more easily compared against more familiar goods and services. Monetary estimates can provide useful information for decision makers (for example, informing economic policy planning and cost-benefit analyses) and can support awareness-raising on the importance of nature to society.

24 See https://unstats.un.org/unsd/statcom/52nd-session/.

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Learn more about progress towards SDG 6

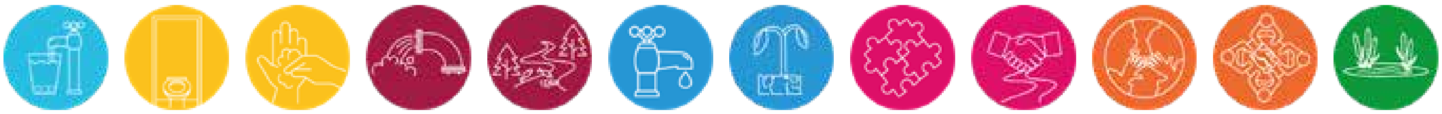
How is the world doing on **Sustainable Development Goal 6**? View, analyse and download global, regional and national water and sanitation data: https://www.sdg6data.org/

Sustainable Development Goal (SDG) 6 expands the Millennium Development Goal (MDG) focus on drinking water and basic sanitation to include the more holistic management of water, wastewater and ecosystem resources, acknowledging the importance of an enabling environment. Bringing these aspects together is an initial step towards addressing sector fragmentation and enabling coherent and sustainable management. It is also a major step towards a sustainable water future.

Monitoring progress towards SDG 6 is key to achieving this SDG. High-quality data help policymakers and decision makers at all levels of government to identify challenges and opportunities, to set priorities for more effective and efficient implementation, to communicate progress and ensure accountability, and to generate political, public and private sector support for further investment.

The 2030 Agenda for Sustainable Development specifies that global follow-up and review shall primarily be based on national official data sources. The data are compiled and validated by the United Nations custodian agencies, who contact country focal points every two to three years with requests for new data, while also providing capacity-building support. The last global "data drive" took place in 2020, resulting in status updates on nine of the global indicators for SDG 6 (please see below). These reports provide a detailed analysis of current status, historical progress and acceleration needs regarding the SDG 6 targets.

To enable a comprehensive assessment and analysis of overall progress towards SDG 6, it is essential to bring together data on all the SDG 6 global indicators and other key social, economic and environmental parameters. This is exactly what the SDG 6 Data Portal does, enabling global, regional and national actors in various sectors to see the bigger picture, thus helping them make decisions that contribute to all SDGs. UN-Water also publishes synthesized reporting on overall progress towards SDG 6 on a regular basis.



Summary Progress Update 2021: SDG 6 – Water and Sanitation for All	Based on latest available data on all SDG 6 global indicators. Published by UN-Water through the UN-Water Integrated Monitoring Initiative for SDG 6. https://www.unwater.org/publications/summary-progress-update-2021-sdg-6-water-and-sanitation-for-all/
Progress on Household Drinking Water, Sanitation and Hygiene – 2021 Update	Based on latest available data on SDG indicators 6.1.1 and 6.2.1. Published by World Health Organization (WHO) and United Nations Children's Fund (UNICEF). https://www.unwater.org/publications/who-unicef-joint-monitoring-program-for-water-supply-sanitation-and-hygiene-jmp-progress-on-household-drinking-water-sanitation-and-hygiene-2000-2020/
Progress on Wastewater Treatment – 2021 Update	Based on latest available data on SDG indicator 6.3.1. Published by WHO and United Nations Human Settlements Programme (UN-Habitat) on behalf of UN-Water. https://www.unwater.org/publications/progress-on-wastewater-treatment-631-2021-update/
Progress on Ambient Water Quality – 2021 Update	Based on latest available data on SDG indicator 6.3.2. Published by United Nations Environment Programme (UNEP) on behalf of UN-Water. https://www.unwater.org/publications/progress-on-ambient-water-quality-632-2021-update/
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Progress on Level of Water Stress – 2021 Update	Based on latest available data on SDG indicator 6.4.2. Published by FAO on behalf of UN-Water. https://www.unwater.org/publications/progress-on-level-of-water-stress-642-2021-update/
Progress on Integrated Water Resources Management – 2021 Update	Based on latest available data on SDG indicator 6.5.1. Published by UNEP on behalf of UN-Water. https://www.unwater.org/publications/progress-on-integrated-water-resources-management-651-2021-update/
Progress on Transboundary Water Cooperation – 2021 Update	Based on latest available data on SDG indicator 6.5.2. Published by United Nations Economic Commission for Europe (UNECE) and United Nations Educational, Scientific and Cultural Organization (UNESCO) on behalf of UN-Water. https://www.unwater.org/publications/progress-on-transboundary-water-cooperation-652-2021-update/
Progress on Water-related Ecosystems – 2021 Update	Based on latest available data on SDG indicator 6.6.1. Published by UNEP on behalf of UN-Water. https://www.unwater.org/publications/progress-on-water-related-ecosystems-661-2021-update/
National Systems to Support Drinking-Water, Sanitation and Hygiene – Global Status Report 2019	Based on latest available data on SDG indicators 6.a.1 and 6.b.1. Published by WHO through the UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) on behalf of UN-Water. https://www.unwater.org/publication_categories/glaas/

UN WATER

UN-Water reports

UN-Water coordinates the efforts of United Nations entities and international organizations working on water and sanitation issues. By doing so, UN-Water seeks to increase the effectiveness of the support provided to Member States in their efforts towards achieving international agreements on water and sanitation. UN-Water publications draw on the experience and expertise of UN-Water's Members and Partners.

SDG 6 Progress Update 2021 – summary	This summary report provides an executive update on progress towards all of SDG 6 and identifies priority areas for acceleration. The report, produced by the UN-Water Integrated Monitoring Initiative for SDG 6, present new country, region and global data on all the SDG 6 global indicators.
SDG 6 Progress Update 2021 – 8 reports, by SDG 6 global indicator	This series of reports provides an in-depth update and analysis of progress towards the different SDG 6 targets and identifies priority areas for acceleration: Progress on Drinking Water, Sanitation and Hygiene (WHO and UNICEF); Progress on Wastewater Treatment (WHO and UN-Habitat); Progress on Ambient Water Quality (UNEP); Progress on Water-use Efficiency (FAO); Progress on Level of Water Stress (FAO); Progress on Integrated Water Resources Management (UNEP); Progress on Transboundary Water Cooperation (UNECE and UNESCO); Progress on Water-related Ecosystems (UNEP). The reports, produced by the responsible custodian agencies, present new country, region and global data on the SDG 6 global indicators.
UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS)	GLAAS is produced by the World Health Organization (WHO) on behalf of UN-Water. It provides a global update on the policy frameworks, institutional arrangements, human resource base, and international and national finance streams in support of water and sanitation. It is a substantive input into the activities of Sanitation and Water for All (SWA) as well as the progress reporting on SDG 6 (see above).
United Nations World Water Development Report	The United Nations World Water Development Report (WWDR) is UN-Water's flagship report on water and sanitation issues, focusing on a different theme each year. The report is published by UNESCO, on behalf of UN-Water and its production is coordinated by the UNESCO World Water Assessment Programme. The report gives insight on main trends concerning the state, use and management of freshwater and sanitation, based on work done by the Members and Partners of UN-Water. Launched in conjunction with World Water Day, the report provides decision-makers with knowledge and tools to formulate and implement sustainable water policies. It also offers best practices and in-depth analyses to stimulate ideas and actions for better stewardship in the water sector and beyond.

The progress reports of the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP)	The JMP is affiliated with UN-Water and is responsible for global monitoring of progress towards SDG6 targets for universal access to safe and affordable drinking water and adequate and equitable sanitation and hygiene services. Every two years the JMP releases updated estimates and progress reports for WASH in households, schools and health care facilities.
Policy and Analytical Briefs	UN-Water's Policy Briefs provide short and informative policy guidance on the most pressing freshwater-related issues that draw upon the combined expertise of the United Nations system. Analytical Briefs provide an analysis of emerging issues and may serve as basis for further research, discussion and future policy guidance.

UN-Water planned publications

- **UN-Water Policy Brief on Gender and Water**
- **Update of UN-Water Policy Brief on Transboundary Waters Cooperation**
- **UN-Water Analytical Brief on Water Efficiency**

More information: https://www.unwater.org/unwater-publications/