SDG indicator metadata

(Harmonized metadata template - format version 1.0)

0. Indicator information

0.a. Goal

Goal 6: Ensure availability and sustainable management of water and sanitation for all

0.b. Target

Target 6.6: By 2030 protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

0.c. Indicator

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

0.d. Series

Lakes and Rivers permanent water area, km2

Lakes and Rivers permanent water area, % Total land area

Lakes and Rivers seasonal water area, km2

Lakes and Rivers seasonal water area, % Total land area

Reservoir minimum water area, km2

Reservoir minimum water area, % Total land area

Reservoir maximum water area, km2

Reservoir maximum water area, % Total land area

Wetlands area, km2

Wetlands area, % of Total land area

Lake water quality turbidity % (Low, Medium, High and Extreme)

Lake water quality trophic state % (Low, Medium, High and Extreme)

Mangrove area, km2

Mangrove area baseline, km2

Mangrove area gain, km2

Mangrove area gain, %

Mangrove area loss, km2

Mangrove area loss, %

Mangrove area change, %

Lakes and Rivers permanent water area change, %

Lakes and Rivers seasonal water area change, %

Nationally derived quantity of groundwater (millions of cubic metres per annum) [6.6.1]

Nationally derived quantity of rivers (millions of cubic metres per annum) [6.6.1]

0.e. Metadata update

July 2021

0.f. Related indicators

6.3.2, 6.4.1, 6.4.2, 6.5.1, 6.5.2, 15.3.1

0.g. International organisations(s) responsible for global monitoring

United Nations Environment Programme (UNEP)

1. Data reporter

1.a. Organisation

United Nations Environment Programme (UNEP)

2. Definition, concepts, and classifications

2.a. Definition and concepts

Definition:

Indicator 6.6.1 tracks the extent to which different types of water-related ecosystems are changing in extent over time. The indicator is multifaceted capturing data on different types of freshwater ecosystems and to measure extent change the indicator considers spatial area changes, water quality and water quantity changes. The indicator uses satellite based Earth observations to globally monitor different freshwater ecosystems types Earth observation data series on surface area are available on permanent water, seasonal water, reservoirs, wetlands, mangroves; as well as generating data on water quality the using trophic state and turbidity of water bodies. Satellite images can be represented as numerical data, which in turn are aggregated into meaningful statistics of ecosystem change attributed to administrative areas such as national, sub-national (e.g. regions and provinces) and river basin boundaries. Global data products for river flows and groundwater level have not yet been produced at useful spatial and temporal resolutions to be incorporated into this SDG 6.6.1 methodology. Currently, these data should continue to be provided from modelling or from ground-based measurements and required from the countries.

SDG indicator 6.6.1 data derived from Earth observations		
Ecosystem	***Unit***	***Features***
Lakes & Rivers	surface area	annual and multi-annual changes in **permanent water area** (1984-present) statistics for new and lost permanent water (2000-2019) statistics aggregated at national, sub-national & basin scales
Lakes & Rivers	surface area	annual and multi-annual changes in **seasonal water area** (1984-present) statistics for new and lost seasonal water (2000-2019) annual seasonality statistics for periods: 0-1, 3-6, 7-11 months statistics aggregated at national, sub-national & basin scales
Reservoirs	surface area	annual and multi-annual changes in reservoir surface area (1984-prsent) statistics for new and lost reservoir area (2000-2019) statistics aggregated at national, sub-national & basin scales
	water quality	Monthly, annual and multi-annual measurements of trophic state and turbidity for 4,200 lakes and reservoirs globally (at 300m resolution)

Mangroves	surface area	annual and multi-annual changes in mangrove area (2000-2016) statistics aggregated at national, sub-national & basin scales
Wetlands	surface area	wetlands area (baseline area comprised of data btw 2016-2018) statistics aggregated at national, sub-national & basin scales wetlands area changes will be included starting in 2021/22
Lakes	water quality	Monthly, annual and multi-annual measurements of trophic state and turbidity for 4,200 lakes and reservoirs globally (at 300m resolution)
SDG indicator 6.6.1 data derived from national in-situ measurements		
Ecosystem	***Unit***	***Features***
Rivers	flow	modelled natural runoff/streamflow and/or in-situ stream/river flow measurements, aggregated over time, of all major rivers
Groundwater	level	Changes to volume measurements, over time, of all major groundwater aquifers

Concepts:
The concepts and definitions used in the methodology have been based on existing international frameworks and glossaries unless where indicated otherwise below.

Water-related ecosystems are a sub-set of all ecosystems. They contain the world's freshwater resources and can be defined as "a dynamic complex of plant, animal, and micro-organism communities and the non-living environment dominated by the presence of flowing or still water, interacting as a functional unit." (MEA, 2005; Dickens et al, 2019). The indicator is framed around the monitoring of different types of water-related ecosystems including lakes, rivers, wetlands, groundwater and artificial waterbodies such as reservoirs. These water-related ecosystems contain freshwater, with the exception of mangroves which contain brackish water (i.e. a combination of fresh and saltwater) however mangroves are still included within indicator 6.6.1. Reservoirs are also included as a category of water-related ecosystem within the indicator methodology; while it is recognized that reservoirs are not traditional water ecosystems which should necessarily warrant protection and restoration, in many countries they hold a noteworthy amount of freshwater and have thus been included. By including data on reservoirs, it is intended that countries can better understand changes occurring to artificial water bodies in conjunction with changes occurring to natural water bodies. Ecosystems that are not included under indicator 6.6.1 are: coral reefs and sea grass which are covered within Goal 14 (Oceans); and mountains, forests, and drylands which are covered within Goal 15 (Land). The extent to which each of the water-related ecosystems included under indicator 6.6.1 can be measured, uses one or more of the following physical parameters of change: spatial area, quantity (or volume) of water, and water quality. The full monitoring methodology for indicator 6.6.1 is available here. The extent to which each of the water-related ecosystems included under indicator 6.6.1 can be measured, uses one or more of the following physical parameters of change: spatial area, quantity (or volume) of water, and water quality.

Inland vegetated wetlands include areas of marshes, peatlands, swamps, bogs and fens, the vegetated parts of floodplains as well as rice paddies and flood recession agriculture. Inland vegetated wetlands do not include coastal mangroves. Data on mangroves which are produced separately to inland wetlands. This SDG indicator methodology is used for official reporting of SDG indicator 6.6.1 statistics. The SDG indicator 6.6.1 methodology does not apply the definition of wetlands defined by the Ramsar Convention on Wetlands, which is: "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". The Ramsar definition of wetlands may be interpreted to mean all water within a country including the marine environment. The SDG indicator 6.6.1 definition refers to only a specific group of inland vegetated wetlands typologies.

Permanent and seasonal water. A permanent water surface is underwater throughout the year whilst a seasonal water surface is underwater for less than 12 months of the year. Some locations don't have observations for all 12 months of the year (for reasons such as polar night). In these cases, water is considered as seasonal if the number of months where water is present is less than the number of months where valid observations were acquired.
A second consideration is lakes and rivers that freeze for part of the year. During the frozen period water is still present under the ice (true both for rivers/lakes and the sea). If water is present throughout the observation period (i.e. unfrozen period), the water body is considered as a permanent water surface. If the area of the water body contracts during the unfrozen period, then the pixels along the borders of the lake or river are no longer water, and those pixels will be considered as a seasonal water surface.

Reservoirs are artificial (or human-made) bodies of freshwater, as opposed to lakes which are naturally occurring. The reservoirs dataset represents surface area data on artificial water bodies including reservoirs formed by dams, flooded areas such as opencast mines and quarries, flood irrigation areas, and water bodies created by hydro-engineering projects such as waterway and harbour construction.

Turbidity is an indicator of water clarity, quantifying the haziness of the water and acting as an indicator of underwater light availability.

Trophic State refers to the degree at which organic matter accumulates in the water body and is most commonly used in relation to monitoring eutrophication.

Surface Water refers to any area of surface water unobstructed by aquatic vegetation. This includes the following 3 water-related ecosystem categories: rivers and estuaries, lakes, and artificial waterbodies.

Extent – has been expanded beyond spatial extent to capture additional basic parameters needed for the protection and restoration of water-related ecosystems. Extent includes three components: the spatial extent or surface area, the quality, and the quantity of water-related ecosystems.

Change means a shift from one condition of extent to another over time within a water-related ecosystem, measured against a point of reference.

Permanent and seasonal water concept definitions and data resolution

Data on the spatial and temporal dynamics of naturally occurring surface water has been generated for the entire globe. A Global Surface Water dataset (Pekel et al., 2016) has been produced by the European Commission's Joint Research Centre. The dataset documents different facets of the long term (since 1984 onward) water dynamics at 30x30 meter pixel resolution. The dataset documents permanent and seasonal surface water surfaces. All naturally occurring surface water larger in area than 30x30 meters has been mapped and at this 30 meter grid/pixel spatial resolution satellite imagery is predominantly capturing areas of lakes and wide rivers (ie rivers over 30meters wide). The data include land areas that are temporarily inundated. Smaller rivers and waterbodies are not captured as they are too narrow to detect or are masked by forest canopy. The data include individual full-resolution images acquired by the Landsat 5, 7 and 8 and Sentinel 1 satellites. These satellites capture images which are distributed publicly by the United States Geological Survey and by the European Union's Copernicus space programme. Together they provide multispectral imagery at 30x30 meter resolution in six visible, near and shortwave infrared channels, plus thermal imagery at 60x60 meters.

The data includes land surfaces that are under water (e.g. a permanent water area) for all twelve months of a year. It also accounts for seasonal and climactic fluctuations of water, meaning lakes and rivers which freeze for part of the year are captured. Areas of permanent ice, such as glaciers and ice caps as well as permanently snow-covered land areas are not included. Areas of consistent cloud cover inhibit the observation of water surfaces in some areas and in these limited locations optical observations may not be available. A global shoreline mask has been applied to the data to prevent ocean water being included in the freshwater statistics and the methodology for this shoreline mask is published in the journal of operational oceanography, available here (Sayer et al. 2019).

The accuracy of the Global Surface Water map was determined using over 40,000 control points from around the world and across the 36 years. The full validation methodology and results have been published in the scientific journal Nature, available here, (Pekel et al., 2016). The validation results show that the water detection expert system produced less than 1% of false water detections, and that less than 5% of water surfaces were missed. The provided maps are derived from the analysis of over four million images collected over 36 years which have been individually processed using an accurate expert system classifier.

The SDG 6.6.1 data portal (www.sdg661.app) documents various water transitions relating to permanent and seasonal surface water - these are changes in water state between two points in time (e.g. 2000 - 2019). Data is available for various transitions including new permanent water surfaces (i.e. conversion of a no water place into a permanent water place.); lost permanent water surfaces (i.e. conversion of a permanent water place into a no water place) as well as new and lost seasonal water. These allow monthly water presence or absence data to be captured. It is possible to identify specific months/years in which conditions changed, e.g. the date of filing of a new dam, or the month/year in which a lake disappeared. In addition, data on seasonality are provided, capturing changes resulting from intra and inter-annual variability or resulting from appearance or disappearance of seasonal or permanent water surfaces. The data separates 'permanent' water bodies (those that are present throughout the period of observation) [nominally a year] from 'seasonal' (those that are present for only part of the year).

2.b. Unit of measure

Change in the spatial area/extent of freshwater (KM2, Percent)
Change in quality of freshwater (Percent)
Change in the quantity of freshwater (millions of cubic metres per annum)

2.c. Classifications

3. Data source type and data collection method

3.a. Data sources

Surface water area data, acquired by the Landsat 5, 7 and 8 satellites at a 30 m resolution, has been generated for the entire globe from 2000-2019. From 2016 onwards (up to and including 2030), higher spatial and temporal resolution satellites, including both optical and radar satellites, are used.). Additional datasets are used refine open water spatial area data, including the Global Reservoir and Dam (GRanD) geospatial database. To generate spatial area of vegetated wetlands, a combination of imagery from Landsat 8 and Sentinel 1 and 2 are used Global Mangrove Watch data is derived from JAXA ALOS satellites and Landsat to generate mangrove extent. Water quality is derived from MERIS and European Sentinel satellites.

Lake water trophic state and TSS lake observations are obtained from combined Landsat and Sentinel satellites paired with instruments like OLCI, MODIS, and VIIRS. The sensor instruments used to detect TSS and trophic state determine the spatial resolution of water quality within lakes which can be detected. Some of the more accurate water quality sensors have 250-350 meter resolution, while less accurate sensors can detect TSS and trophic state changes to 100 m resolution.

The source of data for monitoring stream flow and groundwater quantity is from national in situ measurements of groundwater level within aquifers and stream flow quantity. However globally derived hydrological run off modelled data will soon be available and used to measure stream flow as part of indicator 661 replacing the need for In-situ stream flow measurements to be collected.

3.b. Data collection method

Each sub-indicator (including permanent lakes and river area; seasonal lakes and river area; reservoir minimum and maximum area and water quality; inland wetlands area; mangroves area; lake water quality) is computed separately and thus Indicator 6.6.1 is undertakes several sub-indicator specific computational methods. Globally derived data using spatial area measurements are computed in a comparable and consistent manner across the different ecosystem types e.g. surface water, wetland, mangroves. Globally derived data on water quality is computed using the parameters of turbidity and trophic state to infer a measure of water quality. National data on quantity of water in ecosystems is used to measure stream flow and groundwater volumes. Below are the method descriptions:

3.c. Data collection calendar

Data collection:

Annual estimation of globally derived satellite based data released around May each year and uploaded onto the SDG 661 data portal (www.sdg661.app). Every three/four years data is communicated to national focal points for validation.

3.d. Data release calendar

Data release:
First reporting cycle: June 2018; Second reporting cycle: June 2020; Third reporting cycle: June 2023.

3.e. Data providers

1. Data on Permanent Water, Seasonal Water , and Reservoir Water - European Commission Joint Research Centre – Global Surface Water Explorer
2. Data on Water Turbidity and Trophic State- European Copernicus Land Service products
3. Data on Mangroves- Global Mangrove Watch
4. Data on Wetlands - DHI GRAS
5. Data on river flow - national institutions
6. Data on groundwater – national institutions

3.f. Data compilers

1. United Nations Environment Programme (UNEP)

3.g. Institutional mandate

4. Other methodological considerations

4.a. Rationale

Target 6.6 aims to “protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes” through Indicator 6.6.1 which aims to understand how and why these ecosystems are changing in extent over time. All of the different components of Indicator 6.6.1 are important to form a comprehensive picture that enables informed decisions towards the protection and restoration of water-related ecosystems. However, a lack of data within countries to support Indicator 6.6.1 has become clear through the 2017 pilot testing and thus a combination of national data and data based on satellite images is proposed. All data generated is processed using internationally recognized methodologies, with results assessed and approved by countries, resulting in high quality global datasets with extensive spatial and temporal scale.

4.b. Comment and limitations

To support countries in fulfilling monitoring and reporting requirements for SDG indicator 6.6.1, UNEP has worked with partner organisations to develop technically robust and internationally comparable global data series, thereby significantly contributing towards filling the global data gap on measuring changes in the extent of water-related ecosystems. The indicator methodology mobilizes the collection of available earth observation data on spatial area and water quality parameters. At the 7th IAEG-SDG meeting in April 2018 the indicator methodology was approved and classified as Tier II. Shortly afterwards, in November 2018, it was reclassified to a Tier I indicator methodology. The Tier I classification means that the indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by at least 50 per cent of countries and of the population in every region where the indicator is relevant. The full SDG indicator 6.6.1 monitoring methodology details specific limitations associated with the production of data for the different ecosystem types relevant to SDG indicator 6.6.1, including links to publications pertaining to the data production methodologies. SDG indicator 6.6.1 is designed enable countries to understand the extent to which protecting and restoring different types of water-related ecosystem (e.g. lakes, rivers, reservoirs, wetlands, mangroves). It does not measure how many water-related ecosystems have been protected and restored. It is assumed that countries use the available data to actively make decisions, but these actions are not currently being measured. The data generated should be considered alongside other data, in particular land use change and demographic data, to better enable countries to understand the drivers of ecosystem change and put in place appropriate policy and legislative mechanisms that result in the protection and restoration water-related ecosystems.

UNEP periodically invites national contact persons to participate in consultations with the aim to validate estimated national values.

4.c. Method of computation

Computation Method:

Permanent and Seasonal Surface Water

Description of the method used to globally map all surface water
Data on the spatial and temporal dynamics of naturally occurring surface water has been generated for the entire globe. A Global Surface Water dataset (Pekel et al., 2016) has been produced by the European Commission's Joint Research Centre. The dataset documents different facets of the long term (since 1984 onward) water dynamics at 30x30 meter pixel resolution. The dataset documents permanent and seasonal surface water surfaces. All naturally occurring surface water larger in area than 30x30 meters has been mapped and at this 30 meter grid/pixel spatial resolution satellite imagery is predominantly capturing areas of lakes and wide rivers. The data include land areas that are temporarily inundated such as wetlands and paddy fields. Smaller rivers and waterbodies are not captured as they are too narrow to detect or are masked by forest canopy. The data include individual full-resolution images acquired by the Landsat 5, 7 and 8 and Sentinel 1 satellites. These satellites capture images which are distributed publicly by the United States Geological Survey and by the European Union’s Copernicus space programme. Together they provide multispectral imagery at 30x30 meter resolution in six visible, near and shortwave infrared channels, plus thermal imagery at 60x60 meters.

The data includes land surfaces that are under water (e.g. a permanent water area) for all twelve months of a year. It also accounts for seasonal and climactic fluctuations of water, meaning lakes and rivers which freeze for part of the year are captured. Areas of permanent ice, such as glaciers and ice caps as well as permanently snow-covered land areas are not included. Areas of consistent cloud cover inhibit the observation of water surfaces in some areas and in these limited locations optical observations may not be available. A global shoreline mask has been applied to the data to prevent ocean water being included in the freshwater statistics and the methodology for this shoreline mask is published in the journal of operational oceanography (Sayer et al. 2019).

The accuracy of the Global Surface Water map was determined using over 40,000 control points from around the world and across the 36 years. The full validation methodology and results have been published in the scientific journal Nature (Pekel et al., 2016). The validation results show that the water detection expert system produced less than 1% of false water detections, and that less than 5% of water surfaces were missed. The provided maps are derived from the analysis of over four million images collected over 36 years which have been individually processed using an accurate expert system classifier.

The SDG 6.6.1 data portal documents various water transitions relating to permanent and seasonal surface water - these are changes in water state between two points in time (e.g. 2000 - 2019). Data is available for various transitions including new permanent water surfaces (i.e. conversion of a no water place into a permanent water place.); lost permanent water surfaces (i.e. conversion of a permanent water place into a no water place) as well as new and lost seasonal water. These allow monthly water presence or absence data to be captured. It is possible to identify specific months/years in which conditions changed, e.g. the date of filing of a new dam, or the month/year in which a lake disappeared. In addition, data on seasonality are provided, capturing changes resulting from intra and inter-annual variability or resulting from appearance or disappearance of seasonal or permanent water surfaces. The data separates 'permanent' water bodies (those that are present throughout the period of observation) [nominally a year] from 'seasonal' (those that are present for only part of the year).

Calculating the change in surface area of permanent and seasonal surface water
Data on surface water dynamics are available for a 36-year period, from 1984-onward. Every year new annual data is produced and added to this time series. To calculate percentage change in lake and river area using a 2000-2019 dataset, a baseline period is first defined against which to measure change. This methodology uses 2000-2004 as the 5-year baseline period and to be compared against any subsequent 5-year target period. For each 5-year period the water state (permanent, seasonal or no water) is decided by a majority rule, and the water transitions between the baseline and the target period is subsequently used to compute the percentage change (Δ) in the spatial area of permanent and seasonal waters:
$\Delta=[((\alpha-\beta)+(\rho-\sigma))/\gamma]\times100$

And subject to the following for computing permanent surface water dynamics:

α = New permanent water (i.e. conversion of a no water place into a permanent water place)
β = Lost permanent water (i.e. conversion of a permanent water place into a no water place)
ρ = Seasonal to permanent (i.e. conversion of seasonal water into permanent water)
σ = Permanent to seasonal (i.e. conversion of permanent water into seasonal water)
ε = Permanent water surfaces (i.e. area where water is always observed)
$\gamma = \varepsilon + \beta + \sigma$

While the following applies for computing seasonal water dynamics:

α = New seasonal water (i.e. conversion of a no water place into a seasonal water place)
β = Lost seasonal water (i.e. conversion of a seasonal water place into a no water place)
ρ = Permanent to seasonal (i.e. conversion of permanent water into seasonal water)

σ = Seasonal to permanent (i.e. conversion of seasonal water into permanent water)
ε = Seasonal water surfaces (i.e. area where seasonal water is always observed)
$\gamma = \varepsilon + \beta + \sigma$

The nature of this formula yields percentage change values as either positive or negative, which helps to indicate how spatial area is changing. On the SDG661 data portal, statistics are displayed using both positive and negative symbols. For interpretation of the statistics, if the value is shown as positive, the statistics represent an area gain while if the value is shown as negative, it represents a loss in surface area.

The use of 'positive' and 'negative' terminology does not imply a positive or negative state of the water-related ecosystem being monitored. Gain or loss in surface water area can be beneficial or detrimental. The resulting impact of a gain or loss in surface area must be locally contextualized. The percentage change statistic produced represents how the total area of lakes, rivers within a given boundary (e.g. nationally) is changing over time. Percentage change statistics aggregated at a national scale should be interpreted with some degree of caution because these statistics reflect the areas of all the lakes and rivers within a country boundary. For this reason, sub-national statistics are also made available including at basin and sub-basin scales. The statistics produced at these smaller scales reflects area changes to a smaller number of lakes and rivers within a basin or sub-section of a basin, allowing for localized, water body specific, decision making to occur.

Reservoirs

Description of the method used to globally map changes to reservoir surface area
A global reservoir dynamics dataset has been produced by the European Commission's Joint Research Centre. The dataset documents the long term (since 1984 onward) spatial area dynamics of 8,869 reservoirs at 30x30 meter pixel resolution. The reservoirs dataset represents surface area data on artificial waterbodies including reservoirs formed by dams, flooded areas such as opencast mines and quarries, and water bodies created by hydro-engineering projects such as waterway and harbour construction. The map below shows the reservoirs at their maximum extent. The dataset will be progressively complemented and continuously updated to account for newly build reservoirs. Each reservoir is documented as separate object with a unique ID assigned. The reservoirs dataset is derived from the Global Surface Water Explorer (GSWE) dataset, onto which is applied an expert system classifier designed to separate natural and artificial water bodies. The expert systems classifier is non-parametric to account for uncertainty in data, incorporate image interpretation expertise into the classification process, and uses multiple data sources. The expert system has been developed to delineate natural and artificial water using an evidential reasoning approach; the geographic location and the temporal behaviour of each pixel; and fed with the following datasets:

Global Surface Water Explorer (Pekel et al., 2016): This dataset that maps the location and long term (since 1984 onward) temporal distribution of water surfaces at global scale. The maps show different facets of surface water dynamics and document where and when open water was present on the Earth's surface. The maps include natural (rivers, lakes, coastal margins and wetlands) and artificial water bodies (reservoirs formed by dams, flooded areas such as opencast mines and quarries, flood irrigation areas such as paddy fields, and water bodies created by hydro-engineering projects such as waterway and harbour construction). The complete history of any water surface can be accessed at the pixel scale as temporal profile. These profiles allow for identifying specific months or years during which conditions changed, e.g. the date on which a new dam was created, or the month or year in which a lake disappeared. The GSWE dataset is continuously updated providing consistent global monitoring of open water bodies.

Global Reservoir and Dam Database (Lehner et al, 2011): The Global Reservoir and Dam Database v1.3 is the output of an international effort to collate existing dam and reservoir datasets with the aim of providing a single, geographically explicit and reliable database for the scientific community. The initial version (v1.1) of GRanD contains 6,862 records of reservoirs. The latest version (v1.3) augments v1.1 with an additional 458 reservoirs and associated dams to bring the total number of records to 7320.

Global Digital Surface Model: ALOS World 3D - 30m is a global digital surface model (DSM) dataset with a horizontal resolution of approximately 30 meters (1 arcsec mesh). The dataset is based on the DSM dataset (5-meter mesh version) of the World 3D Topographic Data. More details are available in the dataset documentation here.

Digital Elevation Data (Farr et al, 2004): The Shuttle Radar Topography Mission (SRTM, see Farr et al. 2007) is a digital elevation dataset at 30 meters resolution provided by NASA JPL at a resolution of 1 arc-second.

Known limitations and scope for improvements

The current version of the Global Reservoir Dynamics dataset has the following known limitations:

- Some reservoirs built prior 1984 may be missing;
- Reservoirs smaller than 3 hectares (30 000 square meters) may be missing;
- Branches of reservoirs whose width is smaller than 30 meters may be missing.

Calculating the extent to which reservoir area is changing over time

Data on reservoir areas are available for a 36-year period, from 1984-onward. Every year new annual data is produced and added to this time series. To calculate percentage change in reservoir area using a 2000-2019 dataset, a baseline period is first defined against which to measure change. This methodology uses 2000-2004 as the 5-year baseline period and to be compared against any subsequent 5-year target period. For each 5-year period the water state (permanent, seasonal or no water) is decided by a majority rule, and the water transitions between the baseline and the target period is subsequently used to compute the percentage change (Δ) in the spatial area of reservoirs:

$$\Delta=[((\alpha-\beta)+(\rho-\sigma))/\gamma]\times 100$$

The computation is based on water detection within water bodies designated as reservoirs.

The equation is subject to the following parametrization for computing changes in minimum reservoir extent:

α = New permanent water (i.e. conversion of a no water place into a permanent water place)
β = Lost permanent water (i.e. conversion of a permanent water place into a no water place)
ρ = Seasonal to permanent (i.e. conversion of seasonal water into permanent water)
σ = Permanent to seasonal (i.e. conversion of permanent water into seasonal water)
ε = Permanent water surfaces (i.e. area where water is always observed)
$\gamma = \varepsilon + \beta + \sigma$

While the following applies for computing changes in maximum reservoir area:
α = New permanent water (i.e. conversion of a no water place into a permanent water place)
β = Lost permanent water (i.e. conversion of a permanent water place into a no water place)
ρ = New seasonal water (i.e. conversion of a no water place into a seasonal water place)
σ = Lost seasonal water (i.e. conversion of a seasonal water place into a no water place)
ϑ = Permanent to seasonal (i.e. conversion of permanent water into seasonal water)
∂ = Seasonal to permanent (i.e. conversion of seasonal water into permanent water)
ε = Permanent water surfaces (i.e. area where water is always observed)
ϵ = Seasonal water surfaces (i.e. area where seasonal water is always observed)
$\gamma = (\varepsilon+\beta+\vartheta)+(\epsilon+\sigma+\partial)$

Minimum water extent of reservoirs is the lowest observed (or minimum) surface area of reservoirs in a year (intra-annual measurement). This minimum extent varies from one year to another. The data shows the extent to which the annual minimum surface area of reservoirs has changed compared to a reference period. This change is calculated by comparing the minimum extent of the most recent five years against a five year reference period (2000-2004). Change is either gain or loss both shown in both percentage and km2 units.

Maximum water extent of reservoirs is an intra-annual measurement corresponding to the highest observed (or maximum) extent a reservoir reaches within a year. The data shows the extent to which the annual maximum surface area of reservoirs has changed compared to a reference period. This change is calculated by comparing the maximum area of the most recent five years against a five year reference period (2000-2004). Change is either gain or loss both shown in both percentage and km2 units

Wetlands

Description of the method used to globally map wetlands
Inland vegetated wetlands are mapped according to the following definition: “Inland vegetated wetlands include areas of marshes, peatlands, swamps, bogs and fens, the vegetated parts of flood plains as well as rice paddies and flood recession agriculture”. This sub-indicator only measures inland vegetated wetlands and not coastal mangroves (see section 3.5 of this methodology on mangroves). This SDG indicator methodology is used for official reporting of SDG indicator 6.6.1 statistics . A high-resolution global geo-spatial mapping of inland vegetated wetlands has been produced detailing the spatial area of wetlands per country. The data on wetlands has been produced to support countries with monitoring their wetland ecosystems and bridge an existing global data gap. The data production method uses a consistent wetland monitoring mechanism based on satellite Earth Observation data and the global map includes the entire land surface of Earth except for Antarctica and a few small islands. As wetlands tend to be susceptible to high annual variations, multi-annual data was collected to even out potential annual biases and create a robust estimate of wetland area. Data was gathered from 2016, 2017 and 2018 and combined to produce a wetlands area baseline measurement (in km2). Future annual updates will enable wetlands change statistics to be produced and these once available these will be displayed on the SDG 6.6.1 data portal. Predicting wetland area using Earth Observation data relies on four components: stratification, training data, machine learning, and post-processing. The approach uses all available data from the satellites Sentinel-1, Sentinel-2, and Landsat 8 to predict wetland probability. A Digital Elevation Model is used to qualify wetland predictions and a post-processing routine converts the wetland probability map into a map of wetland area. In addition, topographic information from satellite-derived Digital Elevation Models (DEMs) are used. Close to 4 million satellite images amounting to 2.8 petabyte of

data were analysed and classified as wetland or non-wetland using an automated machine learning model. Users of the global wetland map should be aware that the map represents a first line rapid assessment of the global distribution of vegetated wetlands. The methodology applied identifies vegetated inland wetlands. This may generate underestimations compared to national statistics which may integrate metrics on surface water and coastal/marine wetlands.

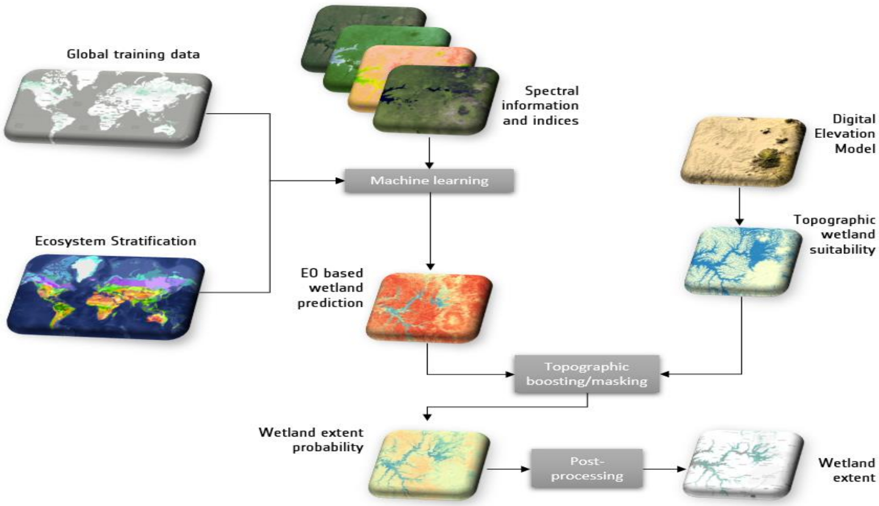

Figure 4. Workflow for mapping global wetland area

Data accuracy for the available wetlands data is approximately 70% and wetland data with 100% accuracy is not feasible at this current time. While it is based on a scientifically sound and robust mapping approach, there will inevitably be inaccuracies in the wetland predictions both in terms of commission and omission errors. Notable commission errors are for instance high-intensive irrigated agriculture parcels being classified as wetlands because they resemble many of the inherent spectral characteristics of wetlands (i.e. high moisture and vegetation presence even in dry season). Omission errors will mainly be attributed to the large diversity of wetlands. Despite best effort to train the model across the widest range of wetlands possible, there will be types of wetlands and instances of wetland behaviour that will not be adequately captured in a global model. For instance, some ephemeral wetlands are rarely flooded or wet and therefore often missed by satellite datasets. In other cases, the wet part of a wetland may occur under a dense vegetation canopy, which is difficult to assess using Earth Observation data, where the presence of water/moist conditions is not easily detected. Other limitations of the data are:

- Only regional stratification is applied including strata spanning several countries. Using a finer level of stratification will help improve local/national wetland predictions;
- The accuracy of the wetlands map will improve further once cross referenced with more national wetland inventories and ground truthing;
- Terrain information from satellite derived DEMs is key input for mapping wetlands globally. The current reference datasets are the 30-meter SRTM DEM which covers the globe from 60oNorth to 56oSouth, while the region north of 60 degrees north relied on a lower resolution 90-meter DEM model was used. Options for 30-meter DEMs north of 60oN exists and should be considered in future updates;
- Small islands and potentially even entire small island states fall outside the acquisition plan of the Sentinel satellites. As a result, no wetland prediction has been performed for these areas. It

will be possible to develop separate models for these missing islands using alternative input satellite data (e.g. using Landsat alone).

Future updates and iterations of the wetlands map will address the above limitations, including a potential shift into a deep learning model to more explicitly reflect temporal and spatial aspects of wetland predictions. Despite limitations with the methodology the production of high-resolution wetland mapping for the entire globe is at the forefront of currently available technology and computing power. It represents a huge step forward towards reporting accurate, statistically robust wetland data.

Calculating the change in surface area of wetlands per country
No change in surface area has yet been calculated. However, a baseline surface area has been calculated per country. This methodology uses a 2017 baseline (based on input imagery data from 2016 to 2018 to even out potential annual biases). Going forward, updates to this wetland area datasets will be produced annually. Once the update is produced it will be possible to calculate change of wetland area from the baseline reference period. Using this baseline period, percentage change of spatial extent is calculated using the following formula:

Percentage change in wetland area $((\beta-\gamma))/\beta\times100$
Where β is the spatial wetland area for the baseline reference period
Where γ is the spatial area for the reporting period.

Mangroves

Description of the method used to measure mangrove area
Global mangrove area maps were derived in two phases, initially producing a global map showing mangrove area (for 2010) and thereafter producing six additional annual data layers (for 1996, 2007, 2008, 2009, 2015 and 2016) (Bunting et al., 2018). The method uses a combination of radar (ALOS PALSAR) and optical (Landsat-5, -7) satellite data. Approximately 15,000 Landsat scenes and 1,500 ALOS PALSAR (1 x 1 degree) mosaic tiles were used to create optical and radar image composites covering the coastlines along the tropical and sub-tropical coastlines in the Americas, Africa, Asia and Oceania. The classification was confined using a mangrove habitat mask, which defined regions where mangrove ecosystems can be expected to exist. The mangrove habitat definition was generated based on geographical parameters such as latitude, elevation and distance from ocean water. Training for the habitat mask and classification of the 2010 mangrove mask was based on randomly sampling some 38 million points using historical mangrove maps for the year 2000 (Giri et al., 2010; Spalding et al., 2010), water occurrence maps (Pekel et al, 2017), and Digital Elevation Model data (SRTM-30).

The maps for the other six epochs were derived by detection and classification of mangrove losses (defined as a decrease in radar backscatter intensity) and mangrove gains (defined and a backscatter increase) between the 2010 ALOS PALSAR data on one hand, and JERS-1 SAR (1996), ALOS PALSAR (2007, 2008 & 2009) and ALOS-2 PALSAR-2 (2015 & 2016) data on the other. The change pixels for each annual dataset were then added or removed from the 2010 baseline raster mask (buffered to allow detection of mangrove gains also immediately outside of the mask) to produce the yearly extent maps.

Classification accuracy of the 2010 baseline dataset was assessed with approximately 53,800 randomly sampled points across 20 randomly selected regions. The overall accuracy was estimated to 95.25 %, while User’s (commission error) and Producer’s (omission error) accuracies for the mangrove class were estimated at 97.5% and 94.0%, respectively. Classification accuracies of the changes were assessed with over 45,000 points, with an overall accuracy of 75.0 %. The User's accuracies for the loss, gain and no-change classes respectively were estimated at 66.5%, 73.1% and 83.5%. The corresponding Producer's accuracies for the three classes were estimated as 87.5%, 73.0% and 69.0%, respectively.

Calculating the area of mangrove per country

Data on mangroves area are available for 1996, 2007, 2008, 2009, 2010, 2015 and 2016. New annual data for 2017 and 2018 will be released in 2021, and annual data from 2019 and onwards planned for 2022. For the purpose of producing national statistics to monitor indicator 6.6.1, the year 2000 has been used as a proxy based on the 1996 annual dataset to align with this baseline with that of the surface water dataset. National mangrove extent for the year 2000 will be used as the baseline reference period. Annual mangrove extent is compared to this baseline year. Percentage change of spatial extent is calculated using the following formula:

Percentage Change in Spatial Extent=$((\beta-\gamma))/\beta\times100$

Where β = the national spatial extent from year 2000
Where γ = the national spatial extent of any other subsequent annual period

Limitations of the mangrove data:

- The mangroves map is a global dataset, and as such, it should not be expected to achieve the same high level of accuracy everywhere as a local scale map derived through ground surveys or the use of very high spatial resolution geospatial data. A global area mapping exercise using consistent data and methods – although supplemented with ground-based data for calibration and validation – for logistical reasons generally requires a trade-off in terms of local scale accuracy. Nonetheless, global maps can be improved locally (or nationally) by adding improved information (in-situ data and aerial or drone data) for training and re-classification.
- Several different factors can affect the classification accuracy, including satellite data availability, mangrove species composition and level of degradation.
- While the original pixel spacing of the satellite data used for the mapping is 25-30 metres, a minimum mapping unit of approximately 1 hectare is recommended due to the classification uncertainty of a single pixel. The classification errors (in particular omission errors) typically increase in regions of disturbance and fragmentation such as aquaculture ponds, as well as along riverine or coastal reef mangroves that form narrow shoreline fringes of a few pixels.
- In general, the mangrove seaward border is more accurately defined than the landward side where distinction between mangrove and certain wetland or terrestrial vegetation species can be unclear.
- Striping artefacts due to Landsat-7 scanline error are present in some areas, particularly West African regions due to lack of Landsat-5 data and persistent cloud cover.
- Known data gaps in this version (v2.0) of the dataset: Aldabra island group (Seychelles); Andaman and Nicobar Islands (India); Bermuda (U.K.); Chagos Islands; Europa Island (France); Fiji (part east of Antemeridian); Guam and Saipan (U.S.); Kiribati; Maldives; Marshall Islands; Peru (south of latitude S4°), and Wallis and Futuna Islands (France).

- As with wetland mapping the production of high-resolution mangrove data for the entire globe is at the forefront of currently available technology and computing power. It represents a huge step forward towards reporting accurate, statistically robust mangrove data which can be updated continuously.

Turbidity and Trophic state

Description of the method used to globally map reservoir area
The global dataset measures two lake water parameters: Turbidity (TUR) and an estimate of Trophic State Index (TSI). The products were produced by the Copernicus, the Earth Observation program of the European Union. For the two parameters the dataset documents monthly averages as well as multi-annual per-monthly averages for the periods 2006-2010 and 2017-2019. The products are mapped at a 300x300 meter pixel resolution capturing data for a total of 4265 lakes. Each lake has individual identification information allowing it to be related to other hydrological datasets. A list of all lake IDs and additional information (location, name – where known, area) is available. Turbidity is derived from suspended solids concentration estimates and the Trophic State Index is derived from phytoplankton biomass by proxy of chlorophyll-a.

Trophic classification	**Trophic State Index, Copernicus Global Land Service TSI values**	**Chlorophyll-a (µg/l) (upper limit)**
Oligotrophic	0	0.04
	10	0.12
	20	0.34
	30	0.94
Mesotrophic	40	2.6
	50	6.4
Eutrophic	60	20
	70	56
Hypereutrophic	80	154
	90	427
	100	1183

Table *2: Trophic state index and related chlorophyll-a concentration classes (according to Carlson (1977))*

Products in the period 2006 - 2010 are based on observations from the MERIS sensor, whereas the product 2017-2019 is derived from OLCI sensors. Land/water buffer maps as well as ice maps were applied to improve the accuracy of the data. The products were tested against consistency (time series) and against in situ data, both for a selected set of lakes. A detailed technical methodology is available to download at the SDG661 data portal (SDG661.app).

Calculating Turbidity and Trophic State Index statistics

A baseline reference period has been produced comprising monthly averages across 5 years of observations for the period 2006-2010. From these five years of data, 12 monthly averages (one for each month of the year) for both trophic state and turbidity, were derived. A further set of observations are then used to calculate change against the baseline data. These monthly data comprise years 2017,18,19. The 12 monthly averages for these three years have been derived.

Monthly deviation of the multiannual baseline is computed using the following equation: month_average-Month_baseline)/Month_baseline x 100. For each pixel, and for each month, the number of valid observations has been counted and the number of months where there were monthly deviations, falling in one of the following range of values: 0-25% (low), 25-50% (medium), 50-75% (high), 75-100% (extreme). An annual deviation synthesis is also produced.

The data represent the number of lakes impacted by a degradation of their environmental conditions (i.e. showing a deviation in turbidity and trophic state from the baseline) compared to the total number of lakes within a country. The values per pixel / per lake are calculated so as to account for different sized lakes. When viewing the summary dashboard of national statistics within on the sdg 661 data platform, data on turbidity and/or trophic state is displayed as number of lakes 'affected' compared with the total number of lakes in the country. A lake is categorized as being 'affected' when the value for either turbidity or trophic state exceeds 50% when compared to the lakes baseline value. Once a turbidity or trophic state event passes this threshold, the event is then recorded within the national summary statistics to show the lake has been affected. Once an event is recorded it remains captured on the dashboard – meaning the number of affected lakes will either stay constant or accumulate over time. The number will not decrease. The data is not informing whether a lake is considered to be of good or bad quality, only that a lake water event has occurred and has been recorded. Each event is considered indicative of a degradation in water quality; however, it is important to note that the turbidity and trophic state are included in indicator 6.6.1 as indirect (or proxy) indicators for water quality. These two parameters are not a direct measurement of water quality; however, they perform a very successful proxy role. The proxy parameters are therefore used to alert countries to these events, encouraging countries to investigate why an event occurred and determine if any remedial action is required. You can trace when high and extreme events have event occurred within the advanced analysis of the data.

River Flow

Measuring or modelling river flow (discharge)
River and estuary discharge, or the volume of water moving downstream per unit of time, is an essential metric for understanding water quantity within an ecosystem and availability for human use. Countries should provide total annual discharge per major river in order to observe change in river discharge over time.

This section describes key considerations for monitoring discharge and provides criteria for discharge data generated to support Indicator 6.6.1.

Common in-situ monitoring methods: There are a variety of methods for monitoring discharge in situ and selection should be based on the size and type of the waterbody, terrain and velocity of water flow, the desired accuracy of measurement, as well as finances available. Two the most common and accessible approaches are gauging stations and using current meters. In many countries, gauging stations are the most prevalent means for measuring river discharge as they allow even for continuous and often real-time monitoring. These are fixed locations along a river or estuary where the change in water surface level (stage) is monitored at locations where a unique relationship exists between stage and flow and a so-called rating curve can be produced. Water surface height (stage) is captured frequently, and the discharge estimated, most often at monthly intervals but in many places, this is available at daily intervals or even continuously. Current meters and other instruments can be used to monitor flow and calculate discharge. For example, propeller, pygmy or electromagnetic current meters are often used to measure velocity and can be used in conjunction with cross-sectional area methods to obtain flow rates. Acoustic Doppler Current Profiler's (ADCPs) are widely used for larger rivers/estuaries to accurately measure bed depth, velocity, and discharge. They are often attached to boats and dragged along a waterbody, but permanent installations can also be found, sending out acoustic waves and measuring acoustic reflectance. Meters and instruments like ADCPs are significantly more costly than other methods of measurement and require skilled operators and good maintenance programmes. However, in larger rivers they may be the most appropriate option, especially during high flow conditions.

Location of Monitoring: The chosen monitoring method may dictate where along a river or estuary the discharge is captured. For example, if fixed weirs are in place, monitoring will always take place here. Since in situ discharge monitoring can be time and cost-intensive, choosing strategic locations which represent a whole river or estuary is recommended. The minimum monitoring effort is to locate one flow measuring site within proximity to each basin's exit (into another basin). In addition, monitoring at the exit point from all major tributaries adds a substantial level of information. Where there is a local impact on discharge due to human influence, then it is recommended to monitor flow upstream and downstream of these areas so that the overall situation can be managed.

Frequency of Monitoring: The quantity of water in a river or estuary can change rapidly in response to rainfall and weather patterns. The more data on discharge there is, the higher the accuracy is of that discharge data. However, again it is important to focus efforts and choose a strategic frequency for monitoring. Data on discharge should ideally be collected at a given location once a month at minimum (ideally at a daily frequency) and this data can then be used to determine annual and long-term trends. The quantity of water in estuaries may be significantly influenced by tidal inflows, thus this indicator is limited to the freshwater inflows to the estuary from the upstream river.

Modelling Discharge: In addition to in situ monitoring which always is impacted by all forms of flow moderation, storage or abstractions upstream, discharge may also be modelled from one of the many available models which use climatic and land-use data, amongst other data, to estimate both natural and present-day flows. Globally hydrological model applications are available and in some countries these or similar models have been developed for the local context and are calibrated using real measured data. It is recommended that modelled discharge data is complimented by measured in situ data wherever possible to ensure accuracy. Conceptual hydrological models for flow and discharge estimation are normally less amenable to detecting the flow impacts of minor land-cover changes over time as the models are calibrated on historical flow data and associated land-use conditions.

Groundwater

Measuring quantity of groundwater within aquifers

The changes to the quantity of groundwater within aquifers is important information for many countries that rely heavily on groundwater availability. For the purposes of Indicator 6.6.1 monitoring the changes to groundwater levels gives a good indication of changes to the water stored in an aquifer. Furthermore, only significant ground water aquifers, that can be seen as individual freshwater ecosystems will be included in the reporting.

Location of Monitoring: Measuring the level of groundwater within an aquifer is done through the use of boreholes. One of the challenges in setting up monitoring is choosing the location of boreholes which will adequately represent the total groundwater situation for an aquifer. The number of boreholes that need to be monitored cannot be prescribed because the distribution of groundwater can be variable depending on the location and characteristics of aquifers. It is recommended that sufficient boreholes to characterise the area should be monitored, with the capacity of the country being a factor in deciding how many would best represent the area. It is highly recommended that data should be taken from observation boreholes / monitoring boreholes (these are boreholes which are not equipped with pumps). Data from used (pumped) boreholes should be avoided. In case a pumped borehole needs to be used for measurements, then it is crucial to allow for a sufficiently long recovery period in which the borehole is not used so that the groundwater level in the borehole can stabilise prior to any measurement.

Frequency of Monitoring: Groundwater levels change as a result of changes in groundwater recharge (affected by climate conditions, and land use) and by anthropogenic removals from the system (groundwater abstraction). Seasonal and wet/dry cycle influences need to be understood and hence monthly monitoring is optimal, but collection at least twice per year, in the wet and dry seasons, is necessary.

Criteria for Indicator 6.6.1 Data

Groundwater quantity data provided to the custodian agency(s) will be quality checked to ensure data integrity. Collection of groundwater level data generates statistics that are a proxy to the quantity of groundwater in an aquifer over time. In order to examine this change over time, percentage change in groundwater level will be generated and validated between the custodian agency(s) and the country. Calculating percentage change at a national level requires the establishment of a common reference period for all aquifers, which can either be based on historical groundwater level data (preferred) or modelled data if available. In cases where these are unavailable, a more recent period can be adopted to represent the 'baseline' or reference period. Countries should provide the annual level of groundwater in order to observe change in aquifer volume over time. A data collection table is provided in the monitoring methodology as an annex.

4.d. Validation

All satellite-based Earth observation data on freshwater are updated annually and uploaded to the SDG indicator 661 data portal (www.sdg661.app) where is freely accessible and data are freely downloadable. Every 3-4 years, in alignment with the timeline of the SDG6 Integrated Monitoring Initiative coordinated by UN Water, national SDG indicator 6.6.1 data are shared with national indicator focal points (pre-confirmed SDG 661 indicator focal persons) for no-objection approval.

4.e. Adjustments

4.f. Treatment of missing values (i) at country level and (ii) at regional level

- At country level

Due to the use of satellite data for some sub-indicators, it is not expected to have missing data for these sub-indicators. For all other sub-indicators, missing values are not imputed.

- At regional and global levels

Missing values are not imputed.

4.g. Regional aggregations

For the aggregation methods, please see:
https://wesr.unep.org/media/docs/graphs/aggregation_methods.pdf.

4.h. Methods and guidance available to countries for the compilation of the data at the national level

A full SDG indicator monitoring methodology is available in all UN languages here

All documentation on methodologies, downloads, production partners are available at the Freshwater Ecosystem Explorer (www.sdg661.app)

4.i. Quality management

The production methodologies for each freshwater satellite data set comprises quality management procedures and processes integrated into the data production process to ensure a minimum and consistent quality standard is met.

4.j Quality assurance

The data production processes for each freshwater satellite data set comprises quality assurance (mathematical formulas) as an integrated component of the data production process to ensure a minimum and consistent quality standard is met and guarantying statically robust and internationally comparable data across time and space produced for all countries. The data production processes are published, including through peer reviewed scientific journals. Quality assurance processes are additionally carried out by data production teams at the European Commission. Data is shared and approved by countries and quality management processes are conducted at the United Nations Environment Programme according to approved standard operating procedures on data handling, aggregation, and management, prior to indicator data submission to UNSD.

4.k Quality assessment

5. Data availability and disaggregation

Data availability:

All SDG 661 indicator data is freely available and downloadable at the Freshwater Ecosystem Explorer (www.sdg661.app)

Time series:
The reporting on this indicator will follow an annual cycle.

Disaggregation:

Indicator 6.6.1 can be disaggregated by ecosystem type (which enables decision at ecosystem level to be taken). The SDG 661 data can also be disaggregated at different spatial scales i.e. National, basin, sub-administrative level, lakes, and reservoirs.

6. Comparability / deviation from international standards

Sources of discrepancies:
NA

7. References and Documentation

URL: http://www.sdg6monitoring.org/indicators/target-66/indicators661/

All documentation on methodologies, downloads, production partners are available at the Freshwater Ecosystem Explorer (www.sdg661.app)

In developing the methodology for indicator 6.6.1 UNEP set up a technical expert group . This group provided inputs into the development of the monitoring methodology. A first draft (Tier III) methodology was piloted in 2017 and sent to all UN Member States accompanied with relevant capacity support materials. A limited number of Member States (19 per cent) submitted data to UNEP after a period of 8 months. The data that was received was of poor quality and coverage. Countries cited a lack of data to report, and neither time nor resources to initiate new ecosystem monitoring.

Following on from the global piloting and testing phase, and to address a known global data gap for the indicator, the methodology was revised to incorporate data on water-related ecosystem derived from satellite-based Earth observations. UNEP engaged with a series of partners working with global data products considered relevant and suitable for the indicator. The assessment of global data sources considered data quality, resolution, frequency of measurements, global coverage, time series, and scalability (i.e. disaggregated data at national and sub-national levels). The result was a methodology that is statistically robust producing internationally comparable data without being too onerous for countries to report on. The technical expert group was consulted on the updated methodology before submission to the IAEG-SDG for approval.

At the 7th IAEG-SDG meeting in April 2018 the indicator methodology was approved and classified as Tier II. Shortly afterwards, in November 2018, it was reclassified to a Tier I indicator methodology. The Tier I classification means that the indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by at least 50 per cent of countries and of the population in every region where the indicator is relevant.

Throughout 2019 UNEP continued to work with its partners to improve the globally available datasets relevant to SDG indicator 6.6.1 and the measurement of changes occurring to different types of water-related ecosystem. As such, this methodology was updated in March 2020 to include more detailed information about the approach used to obtain satellite-based Earth observation data with regard to the sub-indicators.

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