Measuring changes in surface water area of lakes and rivers

Why measure surface water area?

The freshwater found in our lakes, rivers, wetlands and groundwater collectively contain less than 0.01% of Earth's total water [96.5% is held in the oceans and seas, with the remainder held by ice caps, glaciers, ice and snow, groundwater, held in the soil, contained in biological cells (including us!) and in the atmosphere]. It is surface water that is the most accessible and affects many aspects of our world. It affects the exchange of heat, gas and water vapour between the planet's surface and atmosphere. Water is the engine behind the distribution, movement and migration of Earth's plant and animal life and is just as essential for humans. It affects our capacity to grow crops and manage animal grazing lands, to run our industrial processes, to manufacture goods, it influences the movement of disease-vectors, toxins and pollutants, it generates energy directly (hydroelectric) and indirectly (thermoelectric), it is an essential part of our transport network, and forms part of our recreational, cultural and sporting world.

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, 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 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. For the purpose of producing national statistics to monitor indicator 6.6.1, annual data starting from year 2000 has been used and includes all annual data up to the present day.

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. Averaging all earth observations annually and over a five-year period the baseline is then compared a subsequent 5-year target period. From the baseline and target period, percentage change of spatial extent is calculated using the following formula:

Where β = the average national spatial extent from 2000-2004
Where γ = the average national spatial extent of any other subsequent 5 year period
Percentage Change in Spatial Extent$=((\beta-\gamma))/\beta\times100$

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.