Measuring changes in reservoir surface area

Why measure reservoir surface area?

Reservoirs are artificial (human-made) bodies of freshwater, as opposed to lakes which are naturally occurring. Reservoirs are included as a type of water-related ecosystem within the SDG indicator 6.6.1 methodology for two reasons. Firstly because of the contribution they make in providing water services to large numbers of people, including domestic water supply; irrigation; hydroelectric power generation; flood control; and recreation. Secondly, so that changes in one dataset do not mask changes in the another, it is useful to separate naturally occurring surface water from reservoir water. Hence a separate dataset on reservoir dynamics has been produced. In the context of SDG target 6.6 which seeks to protect and restore water-related ecosystems, it is important to stress that while reservoirs provide valuable water services to people, it is also widely recognized that reservoirs adversely impact the connectivity of naturally occurring freshwater systems and are directly attributed to causing significant loss of freshwater biodiversity.

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) extent 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.

Figure 1 Global Map of all reservoirs

Each reservoir is documented as separate object with a unique ID assigned. For instance, Figure 2 illustrates a reservoir in Sardinia, Italy, with a true colour, cloud free composite of Sentinel-2 imagery as background.

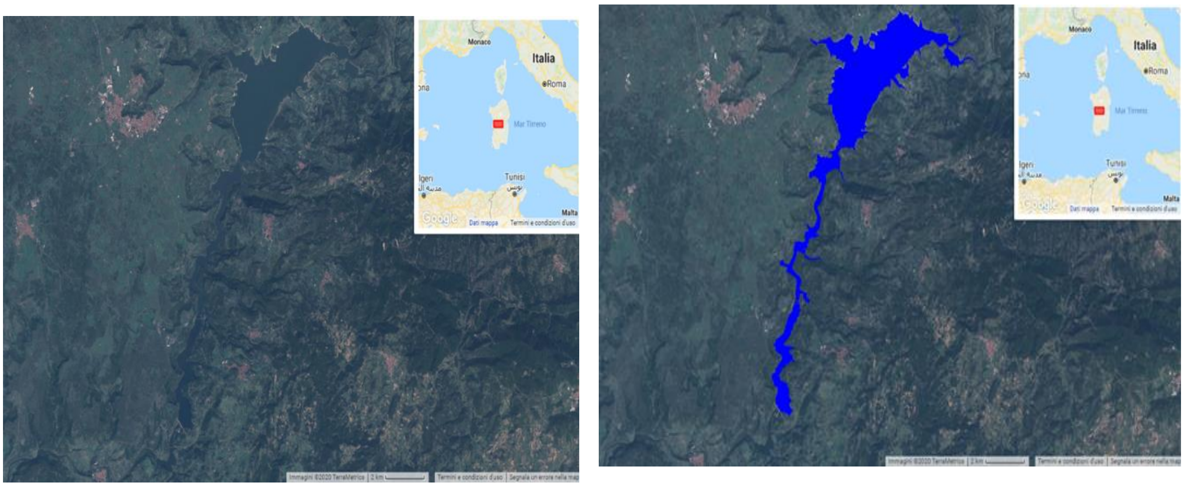

Figure 2 Visualisation of a reservoir in Sardinia, Italy (left image); also shown as maximum water extent for the same reservoir shown with a blue mask (right image)

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 area dynamics are available for a 36 year period, from 1984-2019. 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 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. Averaging all earth observations annually and over a five year period the baseline is then compared a subsequent 5 year target period 2015-2019. 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=$((\beta-\gamma))/\beta\times100$