European Commission

DOPA Digital Observatory for Protected Areas

Inland surface water

Indicator name

Inland Seasonal and Permanent Surface Water and Change statistics

Indicator unit

Areas of inland permanent and seasonal surface water and their changes over time (1985 - 2015) are expressed in km^2 and percentages. We provide for here for each protected areas of size ≥ 25 km^2 the following statistics and associated maps:

- Area (km^2) of permanent surface water (2015)
- Area (km^2) of seasonal inland water (2015)

- Net change (km^2) of permanent surface water (1985 - 2015)
- Net change (km^2) of seasonal inland water

- Net change (%) of permanent surface water (1985 - 2015)
- Net change (%) in surface area of seasonal inland water

We further provide maps of water occurrence, water occurrence change intensity and water transitions.

Area of interest

Surfaces of inland surface water and change statistics have been computed at the country level and for all protected areas of size ≥ 50 km^2.

Related targets

Sustainable Development Goal 15 on life on land

Aichi Biodiversity Target 5 on natural habitats

Aichi Biodiversity Target 11 on protected areas

Aichi Biodiversity Target 12 on species

Policy question

How well are we protecting freshwater ecosystems and how strong are anthropogenic changes affecting surface water in a given area? Human pressures are constantly increasing and it is important to monitor the consequences of the associated changes on the environment, in particular inside and around protected areas, to ensure that natural ecosystems and their associated species and ecosystem functions (e.g. goods and services) are preserved. By comparing surface water maps over time at the country and protected area level, changes in water regimes can be identified.

Use and interpretation

Many surface waters and wetlands are unique and species-rich ecosystems upon which numerous plant and animal species depend, and can provide key ecosystem services such as nutrient cycling, primary production, water provisioning, water purification and recreation (Dudgeon *et al.* 2006; Dodds *et al.* 2013). Surface waters may be more at risk than other land habitat resources due to multiple pressures such as unsustainable consumption, wetland drainage, land use intensification, stream diversion and climate change, a situation that is particularly worrying in dry areas where water scarcity is already becoming a major limiting factor for wildlife and for humans (Vörösmarty *et al.* 2010; Carpenter *et al.*, 2011; Dodds *et al.* 2013). For these reasons, the risk of extinction for freshwater species was already found to be higher than for their terrestrial counterparts (Collen *et al.*, 2013).

Here, we quantify surface water in protected areas using the global surface water product mapped by Pekel *et al.* (2016). By further assessing temporal changes using the full 32-year history of Landsat data one can distinguish between permanent and seasonal water, and assess the net change of water inside areas that are currently protected.

Hence, we provide for each protected area as large as 50 km^2 summary statistics about permanent and seasonal surface water for two time periods, 1985 and 2015. Figure 1 below display such statistics for the Okavango Delta World Heritage Site (Botswana) as computed in DOPA Explorer 3.0.

Figure 1. Area of inland permanent and seasonal surface water in the Okavango Delta World Heritage Site (Botswana) and 30 years change statistics for the time period 1985–2015.

We further provide three different maps that are documenting water occurrences and changes an over time.

The Water Occurrence map shows the water presence frequency (expressed as a percentage of the available observations over the period 1984-2015 time actually identified as water). The provided occurrence accommodates for variations in data acquisition over time (i.e. temporal deepness and frequency density of the satellite observations) in order to provide a consistent characterization of the water dynamic over time. Water that is permanent over the 30 years is displayed in dark blue, lowest frequency in surface water is white (see e.g. Figure 2).

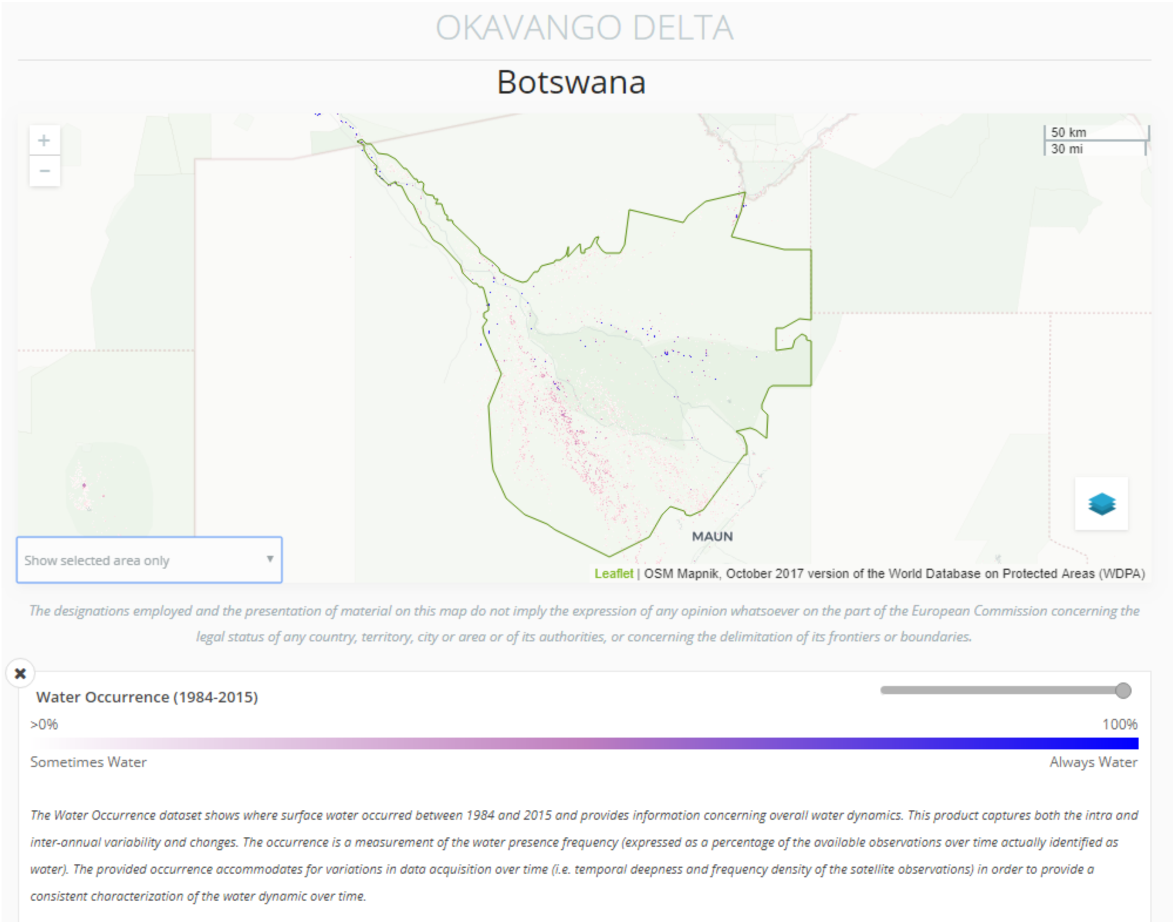

Figure 2. Water occurrence in the Okavango Delta World Heritage Site (Botswana) over 30 years (1984-2015).

The Water Occurrence Change Intensity product shows where surface water occurrence increased, decreased or remained invariant between 1984 - 1999 and 2000 - 2015 (Figure 3). Both the direction of change (i.e. increase, decrease or no change) and its intensity are documented. The occurrence change accommodates for variations in data acquisition over time (i.e. temporal deepness and frequency density of the satellite observations) in order to provide a consistent occurrence change measurement.

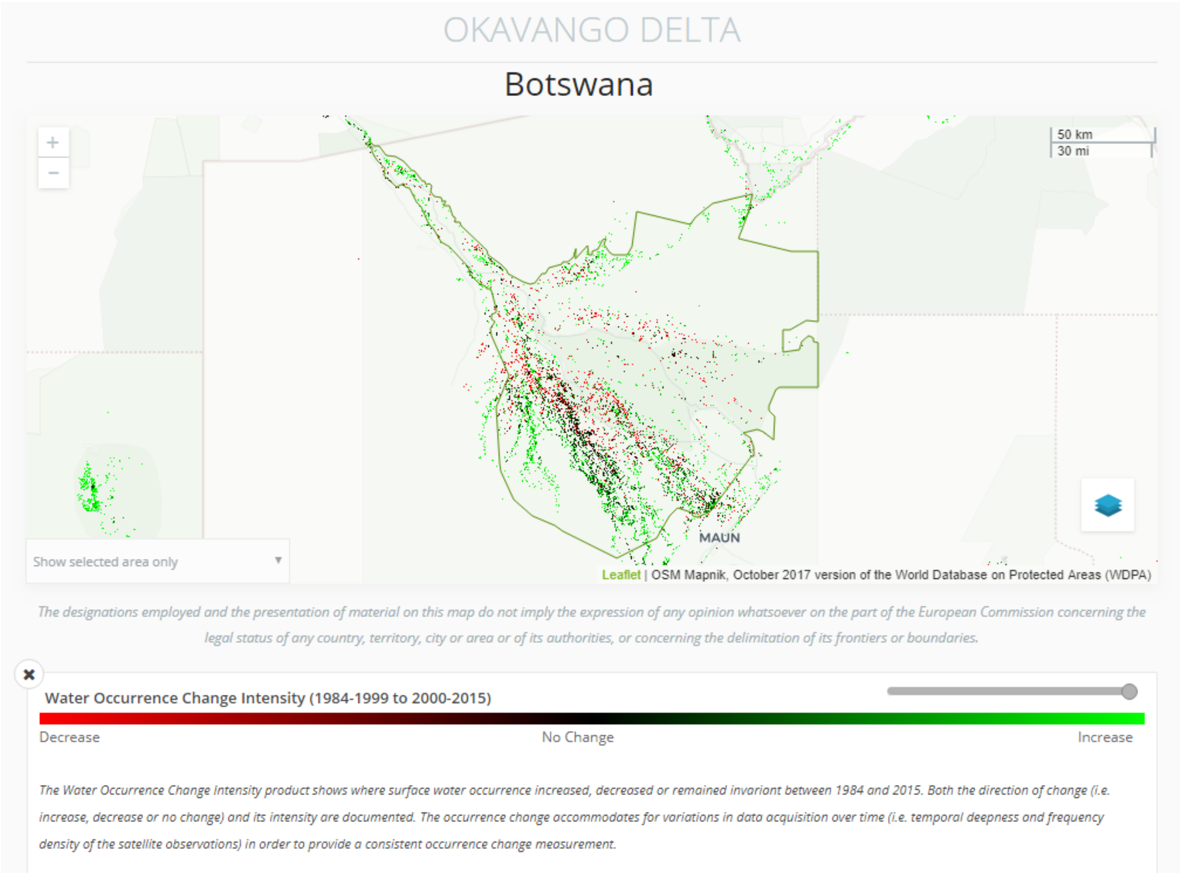

Figure 3. Water occurrence change intensity in the Okavango Delta World Heritage Site (Botswana) over 30 years (1985-2015). Increase in water occurrence is shown in green, decrease in red and no change in black.

The Water Transitions map documents changes in water state between the first year and the last year of observation. In particular we can map

- New permanent water surfaces (i.e. conversion of a no water place into a permanent water place.)
- Unchanging permanent water surfaces
- Lost permanent water surfaces (i.e. conversion of a permanent water place into a no water place)
- New seasonal water surfaces (i.e. conversion of a no water place into a seasonal water place)
- Unchanging seasonal water surfaces
- Lost seasonal water surfaces (i.e. conversion of a seasonal water place into a no water place)
- Conversion of permanent water into seasonal water
- Conversion of seasonal water into permanent water
- Ephemeral permanent water (i.e. no water places replaced by permanent water that subsequently disappeared within the observation period)
- Ephemeral seasonal water (i.e. no water places replaced by seasonal water that subsequently disappeared within the observation period)

An example of such transition map is shown below (Figure 4).

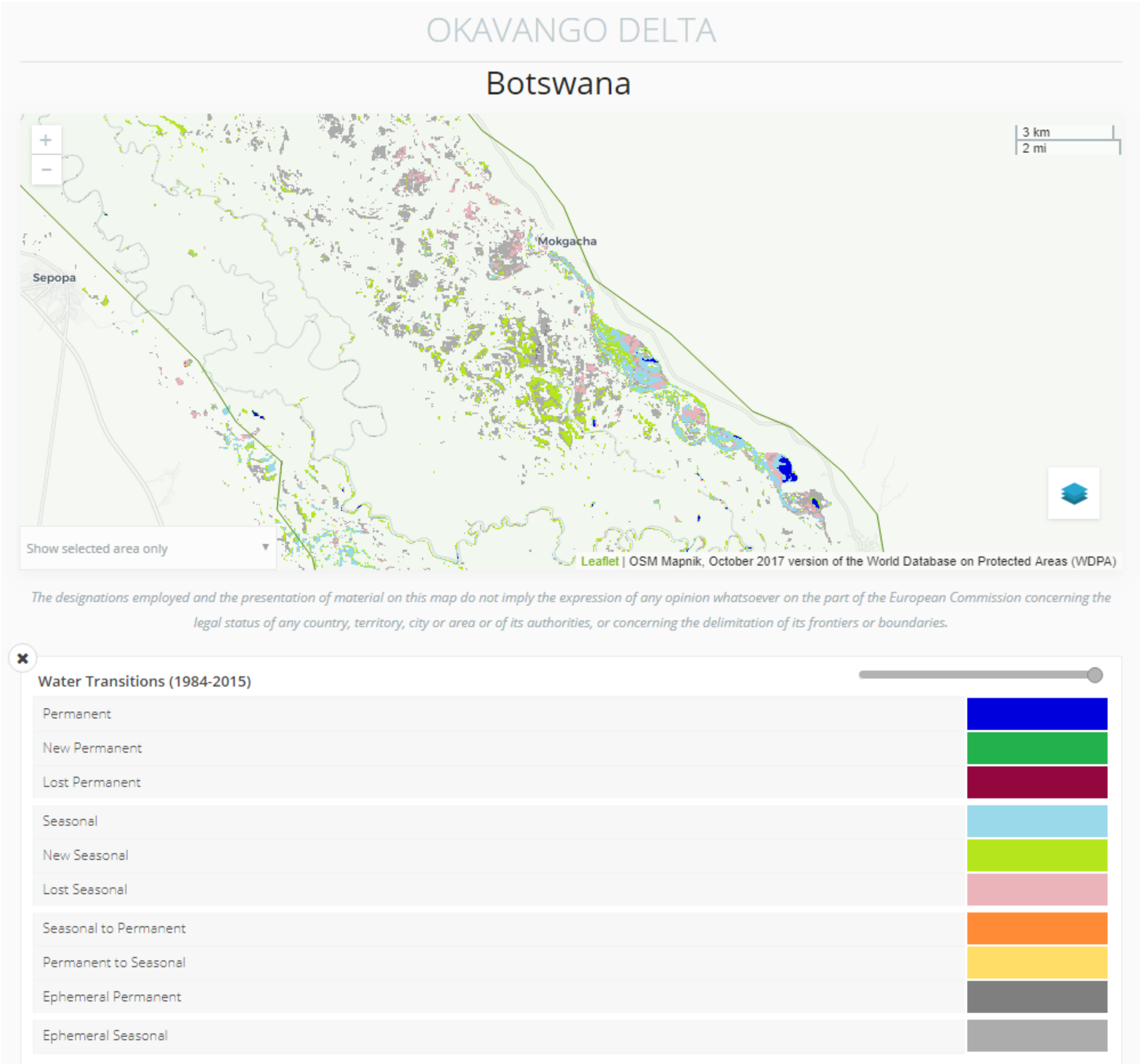

Figure 4. Water transitions classes in an area of the Okavango Delta World Heritage Site (Botswana) over 30 years (1985-2015).

Key caveats

There are some important caveats to our study. Our analysis has treated current boundaries of protected areas as constant over the whole time period 1985 – 2015 as the World Database on Protected Areas does not provide yet means to track changes in boundaries.

A number of water bodies are not reported in the global surface water product: for example, water under forest canopy remains undetected, and the current 30-metre resolution is still too coarse for detection of small rivers, streams and ponds. For some regions, valid image acquisitions of the Landsat archive are restricted by cloud or for other reasons (see Pekel *et al.* 2016 for a full discussion) so that transitions were only detected between the first and last years of available reliable data.

The water transitions are based on two time intervals only. In areas with inter-annual variability this can lead to spurious or not relevant (perhaps misleading) change information, if the initial year considered was simply a dry year in general and the last one a wet one (this can very well happen in Mediterranean areas or in places of South and Central America affected by El Nino).

Finally, it is worth noting that a number of the countries of the world are islands or have highly-dynamic coastlines. This fact, combined with currently-designated protected areas in coastal areas, can mean that ‘loss’ and ‘gain’ actually captures coastal erosion and deposition – i.e., actual habitat change - over the 32 years of the water history.

Uncertainties in the boundaries of the protected areas can also exist and lead to false descriptions.

Indicator status Country and protected areas statistics are documented in a manuscripts submitted to PNAS (Bastin *et al.*, 2018).

Available data and resources

Data available The surface water statistics can be obtained for each protected area at least as large as 25 km^2 from the DOPA Explorer 3.0 website available at http://dopa-explorer.jrc.ec.europa.eu/

Data updates Planned annually.

Codes The codes used to generate the statistics are not yet public domain although some information can be found in our Technical Documentation. See http://dopa.jrc.ec.europa.eu/en/technicaldocumentation

Methodology

Methodology The global surface water was mapped at 30 m resolution using the full 32-year history of Landsat data between 1984 and 2015 (Pekel *et al.* 2016). The long temporal extent of the product allowed to distinguish between permanent and seasonal water, and to assess the net change of water inside and outside areas that are currently protected. Note however that water under vegetation cover, such as swamp forests, is not detectable from optical remote sensing and hence is not included in this assessment.

We used the July 2018 version of the World Database on Protected Areas (WDPA) (IUCN & UNEP-WCMC 2016) to compute the surface water statistics. As recommended by UNEP-WCMC, the data was filtered to remove all features with a status of "not reported" or "proposed", and all features designated as UNESCO Man and the Biosphere (MAB) Reserves.

The polygon PAs were converted to a binary raster with a cell size of 3 arc seconds (representing a resolution of c. 31 m at the equator). The resulting raster was used as an asset in Google Earth Engine to mask the transition layer of the global surface water product and identify protected and unprotected water of different types.

We summarized the water transitions over a 32 year period (1984-2015) based on the procedure described in Pekel *et al.* (2016). Permanent water surface and its uncertainty were computed for each year, from which the trend was derived for each country. This allowed seasonal, permanent and ephemeral water to be distinguished, and transitions between the classes to be mapped. Years for which unobserved data exceeded 5% were excluded from the trend analysis. Note that transitions are detected based on the first and last available and reliable year of data, and that for some regions of the world, the available data history is shorter than 32 years. For a full description, see Pekel *et al.* (2016).

Net gain or loss includes changes between water body categories: for example, areas which transitioned from permanent to seasonal water are counted in the net loss of permanent water and in the net gain of seasonal water.

Input datasets

The inland surface water statistics were obtained using the following input datasets

Protected Areas

- WDPA of July 2018 (UNEP-WCMC & IUCN, 2018).
    - Latest version available from: www.protectedplanet.net

Surface water

- Global Surface Water and long-term change maps accessed directly from the Global Surface Water Explorer (Pekel, J.F. *et al.*, 2016). Quantitative assessments of changes in protected areas done in Google Earth Engine with support from J.-F Pekel & N. Gorelick.
    - Latest version available from: https://global-surface-water.appspot.com/

References

Bastin, L. *et al.* (2018) Inland surface waters in protected areas globally: current coverage and 30-year trends. PlosONE (*Submitted*)

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

Collen, B., *et al.* (2013). Global patterns of freshwater species diversity, threat and endemism. *Global Ecology and Biogeography,* 23: 40-51. https://dx.doi.org/10.1111/geb.12096

Dixon, M. J. R., *et al.* (2016). Tracking global change in ecosystem area: The Wetland Extent Trends index. *Biological Conservation*, 193: 27-35. https://doi.org/10.1016/j.biocon.2015.10.023

Dodds, W. K., Perkin, J. S. & Gerken, J.E. (2013). Human impact on freshwater ecosystem services: a global perspective. *Environmental Science & Technology*, 47: 9061-9068. https://dx.doi.org/10.1021/es4021052

Dubois, G., *et al.* (2016). Integrating multiple spatial datasets to assess protected areas: Lessons learnt from the Digital Observatory for Protected Area (DOPA). *International Journal of Geo-Information* 5(12): 242. http://dx.doi.org/10.3390/ijgi5120242

Dudgeon, D., *et al.* (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, 81, 2: 163-182. https://dx.doi.org/10.1017/S1464793105006950

Pekel, J. -F., Cottam, A., Gorelick, N. & Belward, A. S. (2016). High-resolution mapping of global surface water and its long-term changes. *Nature*, 540: 418-422. https://dx.doi.org/10.1038/nature20584

UNEP-WCMC & IUCN (2018). Protected Planet: The World Database on Protected Areas (WDPA) [On-line], [July/2018], Cambridge, UK: UNEP-WCMC and IUCN. www.protectedplanet.net

Vörösmarty, C. J., *et al.* (2010). Global threats to human water security and river biodiversity. *Nature,* 467: 555 561. https://dx.doi.org/10.1038/nature09440

Weatherall, P., *et al.* (2014). A new digital bathymetric model of the world's oceans. *Earth and Space Science*, 2, https://doi.org/10.1002/2015EA000107

Contact Please contact us at: JRC-DOPA@ec.europa.eu

Factsheet last updated November 13, 2018

@EU_DOPA