Deliverable 2.4 v2.0 - User technical guide and metadata document

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Issue	Version	Date	Comments
1	1.0	13/09/2024	First version of the deliverable for internal submission
1	2.0	16/09/2024	Internal edits approved

Purpose of this document

This is a metadata guide describing the SDG 6.3.2 EO-based indicator for the target audience of SDG focal points. Together with D2.3 (a developers technical guide) are the final documents of Activity 2 as part of the UNEP WWQA 'EO pathway for SDG indicator 6.3.2' - Lake Tanganyika pilot. This intentionally short document includes a description of the input water quality parameters, the indicator methodology and results for the case studies and a summary of the limitations or validation.

EO data disclaimer

Copernicus Land Monitoring Service (CLMS) Lake Water Quality (LWQ) early release *(Calimnos v2.1 L3 test dataset (July 2024)* of Lake Tanganyika produced by Plymouth Marine Laboratory within the Copernicus Land Monitoring Service) and Lake Surface Water Temperature (LSWT).

Technical document for a satellite Earth Observation indicator for SDG Indicator 6.3.2 Level 2

This document presents the methodology for a satellite-based Earth Observation indicator, developed for level 2 reporting on Sustainable Development Goal Indicator 6.3.2 ('Proportion of bodies of water with good ambient water quality'). The indicator provides a snapshot of water quality by comparison to baseline conditions or national target values, and allows progress towards SDG Target 6.3 (improve water quality) to be tracked over time. This EO approach benefits from the increased spatial and temporal coverage compared with traditional monitoring programmes.

The EO indicator is a “proof-of-concept” and has been piloted for Lake Tanganyika over one reporting period. The EO indicator was co-designed with SDG 6.3.2 focal points from Burundi, Democratic Republic of Congo, Tanzania and Zambia. Further work is planned for testing the indicator for global applicability.

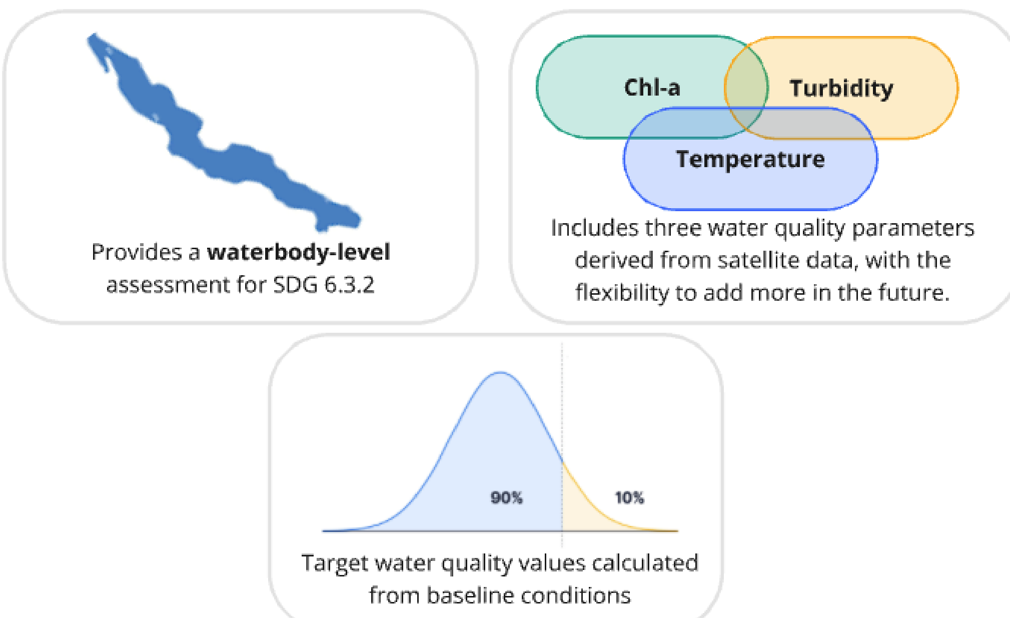


Figure 1. Quick summary of the Earth Observation Indicator for SDG 6.3.2.

Water Quality Parameters

Overall water quality is estimated based on an index which incorporates data on three parameters derived from operational satellite-based Earth Observation products. The indicator has three input products which are either currently, or soon to be, operationally provided by the Copernicus Land Monitoring Service. The selected products are free and open-access, available for around 4000 medium and large lakes globally. A detailed assessment of available products for the EO indicator is presented in deliverable 2.1. As new EO products, such as cyanobacterial blooms and coloured dissolved organic matter, become available, they can be added as input water quality parameters.

Table 1. Summary of input satellite-based Earth Observation products within the EO indicator for SDG 6.3.2.

Parameter	Description	Product
Chlorophyll-a	A proxy for phytoplankton biomass, often driven by high nutrient levels or pollution. Algal blooms reduce light and oxygen in deeper water, but chlorophyll-a maps don't specify species or toxins.	Copernicus Lake Water Quality 2002 to 2012 2016 to present (see disclaimer)
Turbidity	Measures cloudiness from suspended particles, affecting water clarity. High turbidity reduces light, impacting aquatic life, water chemistry, and accelerating lake sedimentation.	Copernicus Lake Water Quality 2002 to 2012 2016 to present (see disclaimer)
Water temperature	Influences oxygen levels and nutrient availability, impacting aquatic ecosystems and fish health. Rising due to climate change, it affects biological activity and chemical reactions, with indirect impacts on water quality.	Copernicus Lake Surface Water Temperature 2002 to 2012 2016 to present

Methodology

This EO-based methodology is conceptually similar to the Level 1 approach that uses *in situ* parameter-level data that are combined to create an composite index. **Step 1** is to define the target water quality for each water quality parameter. The user has the options of defining the target water quality by either: A) a dynamic per-pixel target using the monthly 90th percentile for the baseline period (the default option), or B) input national target values for each water quality parameter. The 90th percentile describes the conditions under which 90% of values occurred during the baseline period, while accounting for seasonality, and the part of the lake. Hence conditions which exceed the 90th percentile are extreme cases.

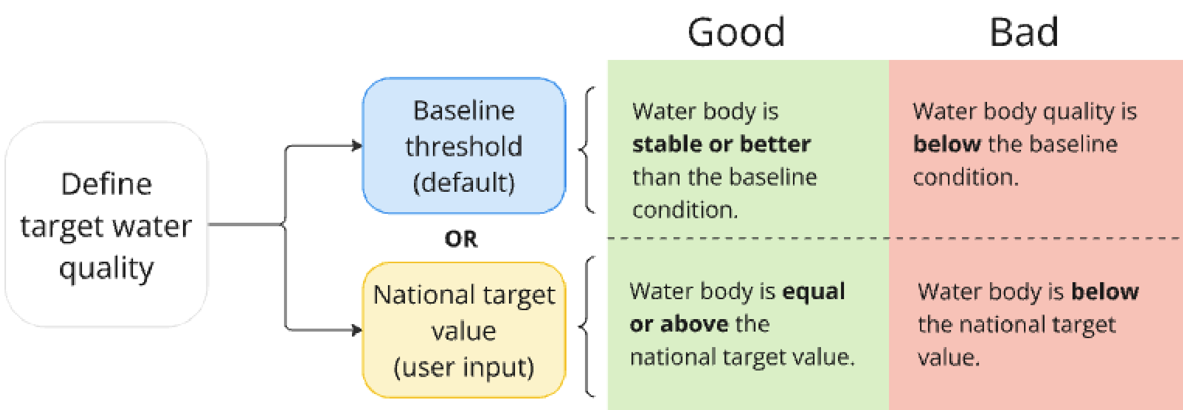


Figure 2. Options for defining the target water quality and for the EO-based SDG 6.3.2 indicator.

Step 2 is to then calculate the number of measurements per pixel which met the water quality target value during the reporting period, for each water quality parameter. The multi-parameter indicator is then calculated in **step 3** by combining the number of measurements which meet the target value for all water quality parameters. Finally, in **step 4** the water body can be classified as “good” or “bad” water quality, depending on whether the majority of the water body is within the target water quality range over the reporting period. A more detailed description of the method is provided in deliverable 2.3.

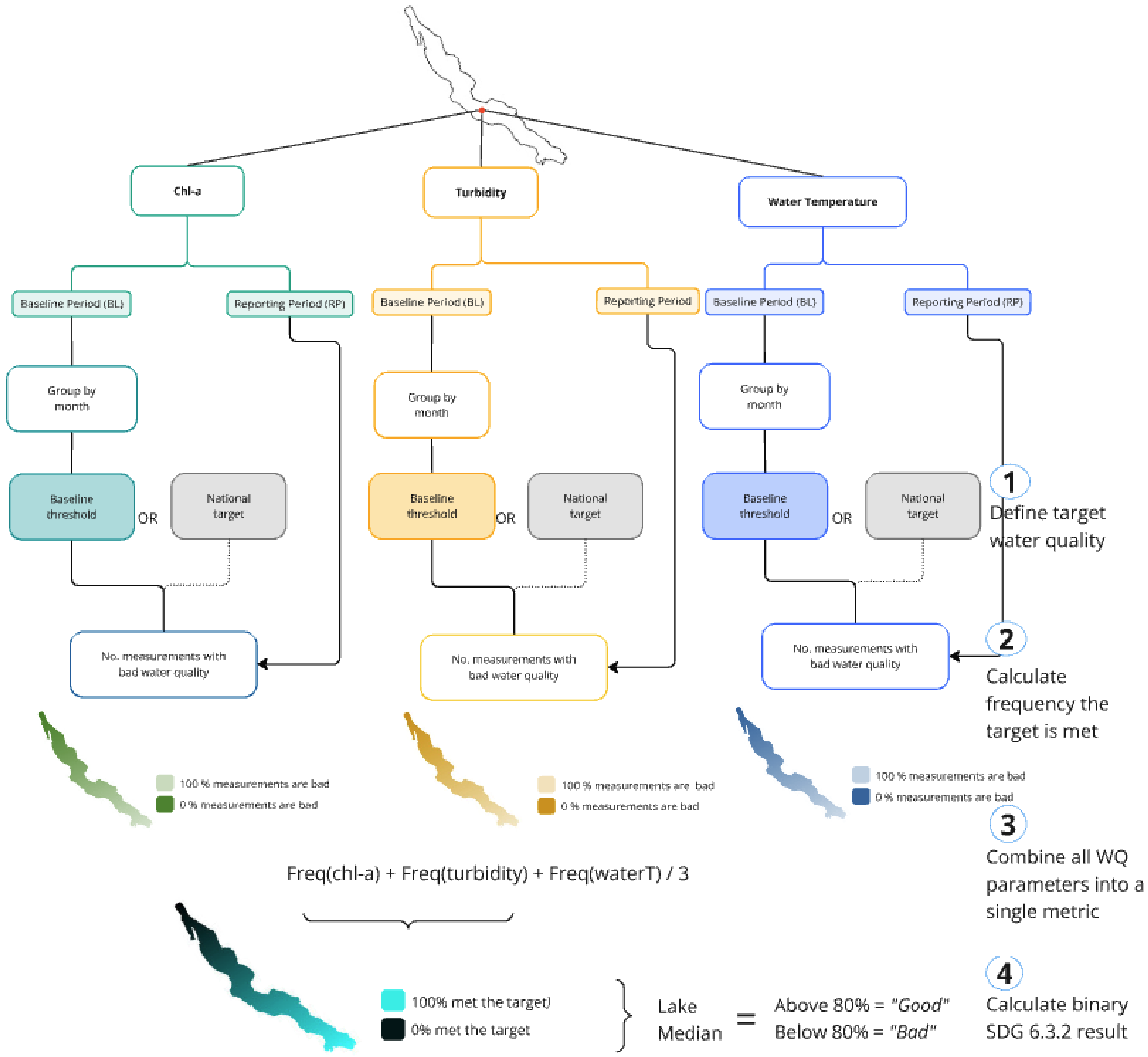


Figure 3. Schematic showing steps 1 to 4 for calculating the EO indicator for SDG 6.3.2.

Indicator Demonstration

Lake Tanganyika is a freshwater, oligotrophic, transboundary lake in Africa with significant social, economic, and environmental importance. Lake Tanganyika is transboundary and spread out in Democratic Republic of Congo (45%), Tanzania (41), Burundi (8%) and Zambia (6%). The lake water quality is challenged by various pressures, including pollution, changes in basin land use, and climate change[1]. Currently, water quality data from Lake Tanganyika are not used for SDG Indicator 6.3.2 reporting, so this approach helps to fill an important information gap.

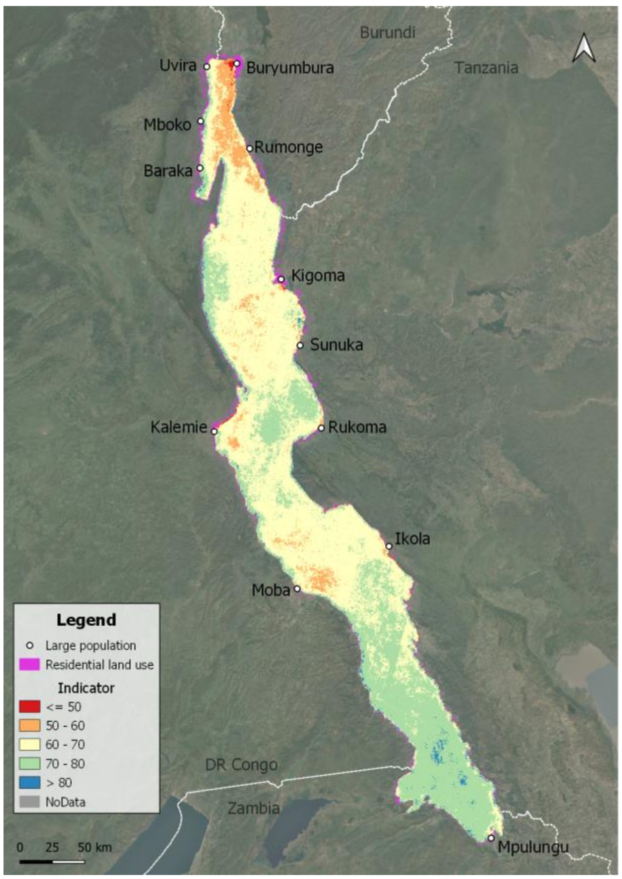
The EO indicator describes the number of water quality observations (chl-a, turbidity and water quality in this case) that meet their target values during the reporting period. The EO indicator is normalised for a scale between 0 and 100, where higher values indicate better water quality. The EO indicator value for SDG reporting period 2 (2017 to 2019) for Lake Tanganyika was 67.9 (Box 1.). This means that, between 2017 and 2019, an average of 67% of the water quality measurements from Lake Tanganyika met the target water quality conditions. The target water quality is dynamically calculated for each pixel and month and is determined using the baseline threshold for each of the water quality parameters. (Box 2). This lake average is below the 80% compliance requirement for "good" ambient water quality classification, and therefore water quality during this period is considered "not good" ambient water quality.

The EO indicator also offers spatial information about the lakes water quality during the reporting period. For example, it is apparent that water quality is lower around some fo the populated regions and most notably in the northern part of the lake by Buryumbura.

[1] Phiri et al,. 2023

Box 1. Result Reporting Period for 2017 to 2019

SDG reporting period 2017 to 2019

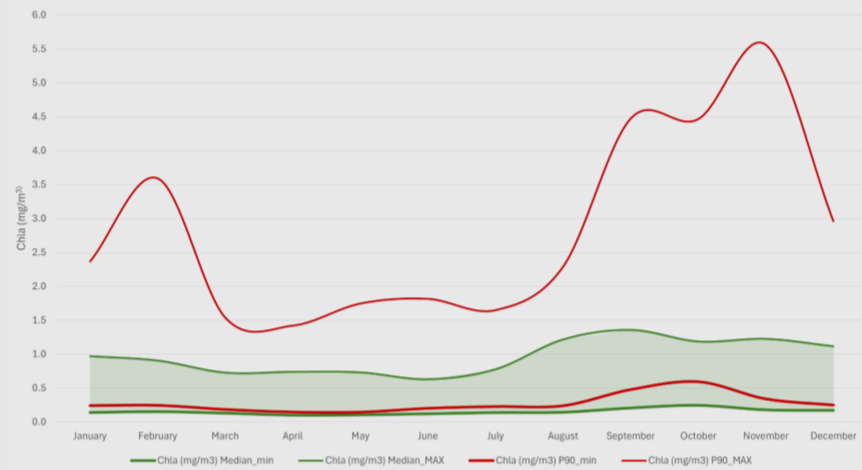
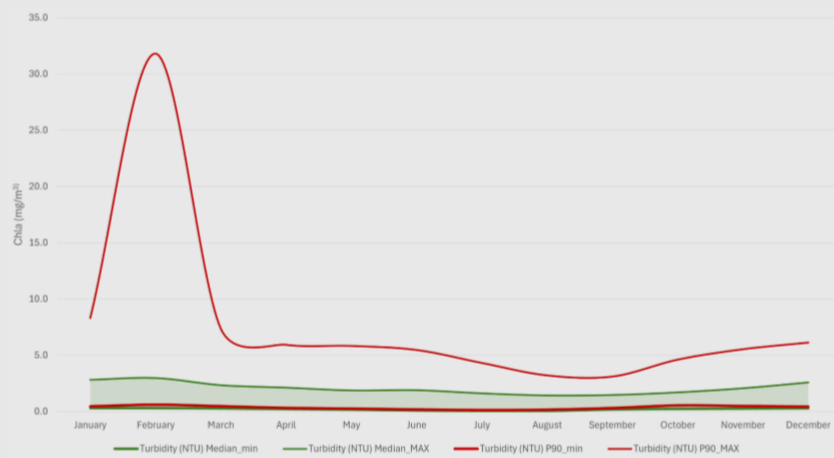
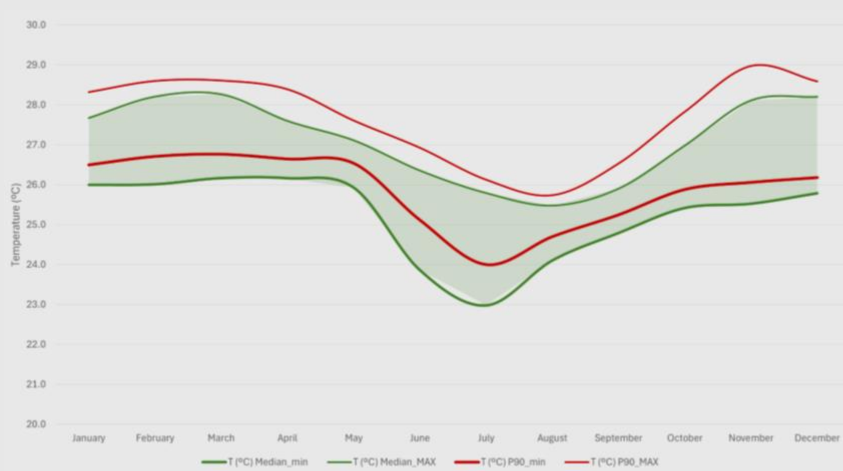


Overall Result: 67 *("not good" ambient WQ)*

Between 2017 and 2019, 67% of the satellite-derived water quality measurements met target values. This is below the 80% compliance requirement for "good" water quality classification. Water quality is lowest at the northern point of the lake (red) and highest in the southern point of the lake (blue).

Value (%)	Description	Proportion of lake
90 - 100	Conditions exceed or very close to the baseline state.	<1%
80 - 90	Conditions rarely depart from the baseline state.	1%
60 - 80	Conditions sometimes depart from the baseline state.	92%
40 - 60	Conditions often depart from the baseline data.	7%
0 - 40	Conditions usually depart from the baseline state.	<1%

Box 2. Baseline conditions (2002-2012) showing min and max values of all the pixels in the lake for the median (green) and the 90th percentile (red) for each water quality parameter.

Chlorophyll-a	
Turbidity	
Water temperature	

Limitations & Future Global scalability

Below are summarised the key advantages and limitations of the EO SDG 6.3.2 indicator, which are important to understand when interpreting the results or considering the indicator for global application:

Limitations & Cautions:

- The indicator has not been validated against in situ data (although the input EO products have been validated and are delivered with uncertainty measurements).
- Baseline conditions (in this case 2002-2012) might not be the original state of the lake.
- Water quality describes surface trends only, while many water quality phenomena, such as deep chlorophyll maxima, occur below the surface.
- Currently, each parameter is unweighted in the index calculation.
- It is not currently possible to disaggregate by basins, which might be appropriate for very large water bodies with distinct lake basins.
- Requires some understanding of EO still and could be complex to fully comprehend.
- The 90th percentile approach is supported by scientific literature for chl-a and wate temperature but might not be appropriate for all wate quality parameters.

- The approach is limited to water bodies included in the Copernicus Lake Water Quality and Lake Surface Temperature products (i.e. 4000 medium-large lakes).
- The final SDG 6.3.2 result ("good" or "bad") is based on the lake median value, treating all pixels equally, though some pixels may have significantly less data than others.
- There is currently no inclusion of uncertainty, which could be calculated for each pixel based on the number of observations per pixel during the reporting period and the uncertainty of each input water quality product. Using multiple water quality parameters can compounding effects on uncertainty, which has not been explored yet.
- Input products have biases, for example, satellite EO-derived products for chlorophyll-a are more accurate for eutrophic lakes than oligotrophic lakes[2].

[2] Carrea et al., (2023)

Advantages:

- The indicator can be applied globally.
- It increases spatial coverage and temporal consistency compared to level 1 reporting.
- Provides water quality conditions for different parts of the lake.
- It can be used in the absence of in situ data.
- Input products are validated across a range of lakes.
- It can incorporate additional water quality parameters as EO matures and more products become operational.
- Input products are operational, with extensive quality checks and uncertainty data.
- It offers an alternative to national target inputs for defining target values, with targets dynamically defined based on the lake and season.
- Results can be compared to in situ-derived level 1 SDG 6.3.2 reporting.
- Individual water quality parameters can be assessed, and their own contribution can be understood. The user has the control to exclude water quality parameters from the EO indicator calculation.
- There is no minimum or maximum requirement for water quality parameters.
- New water quality parameters can be easily incorporated as they become available.

Bibliography

[1] EPA. (2024) Available at: https://www.epa.gov/national-aquatic-resource-surveys/indicators-chlorophyll#:~:text=What%20can%20chlorophyll%20a%20tell,the%20concentration%20of%20chlorophyll%20a. (Accessed: 14 September 2024).

[2] Mantzouki, E., Lürling, M., Fastner, J., de Senerpont Domis, L., Wilk-Woźniak, E., Koreivienė, J., Seelen, L., Teurlincx, S., Verstijnen, Y., Krztoń, W. and Walusiak, E., 2018. Temperature effects explain continental scale distribution of cyanobacterial toxins. *Toxins*, *10*(4), p.156.

[3] Phiri, H., Mushagalusa, D., Katongo, C., Sibomana, C., Ajode, M.Z., Muderhwa, N., Smith, S., Ntakimazi, G., De Keyzer, E.L., Nahimana, D. and Mulungula, P.M., 2023. Lake Tanganyika: Status, challenges, and opportunities for research collaborations. *Journal of Great Lakes Research*.

[4] Carrea, L., Crétaux, J.F., Liu, X., Wu, Y., Calmettes, B., Duguay, C.R., Merchant, C.J., Selmes, N., Simis, S.G., Warren, M. and Yesou, H., 2023. Satellite-derived multivariate world-wide lake physical variable timeseries for climate studies. *Scientific Data*, *10*(1), p.30.

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