The Science-Based Target Network's Freshwater Quantity Target

Supporting documentation

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4TU DOI: 10.4121/089afa18-bbd5-493e-8a6c-39e1ca7b2a59

Summary

This data product provides the Freshwater Quantity Target of the Science Based Targets Network (SBTN). Freshwater Quantity Targets are expressed as the percentage by which current collective water use levels must be reduced to stay within ecologically sustainable limits. The Targets are developed at the sub-catchment scale, as delineated by the HydroBASINS database level 05, with global coverage except Antarctica. For each sub-catchment, twelve monthly and one annual percentage reduction values are provided. Freshwater Quantity Target contained in this data product can also be accessed through a user friendly webapplication (https://www.acc.waterfootprintassessmenttool.org/?b=sbtn) which allows retrieval of (bulk) site-specific reduction targets.

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Background

The SBTN is a collaboration of over 80 leading global organizations that collectively co-develop scientifically rigorous methodologies for setting science-based targets (https://sciencebasedtargetsnetwork.org/). To add to their existing science-based targets for climate, the SBTN is developing targets for nature. Aiming to offer a robust methodology that companies can use to set validatable targets addressing their pressures on freshwater, land and biodiversity, the first science-based target for nature was recently released (Science Based Targets Network 2023). The targets are defined as measurable, actionable, and time-bound objectives based on the best available science. The Freshwater Quantity Target specifically refers to what the latest hydrological science says is necessary to meet local thresholds and allow actors to align with Earth's limits and societal sustainability goals. Where the Technical Guidance of the SBTN lays out the broader framework and application of the science-based target for Freshwater (Science Based Targets Network 2023), this description provides the technical documentation on how the Freshwater Quantity Target, as contained in this data product, was developed.

Method

This data product contains Freshwater Quantity Targets that are expressed as the percentage by which current collective water use levels must be reduced to stay within ecologically sustainable limits. The Targets are developed at the sub-catchment scale, as delineated by the HydroBASINS database level 05 (Lehner and Grill 2013), with global coverage except Antarctica. For each sub-catchment, twelve monthly and one annual percentage reduction values are provided as attributes to the vectorized sub-catchments. The general line of thought that underlies the development of these Targets largely follows the method proposed by Hogeboom et al. (2020). In short, Freshwater Quantity Targets consider the degree of reduction that is required to reverse current overshoot of total water consumption with respect to locally available water availability levels, thus bringing the sub-catchment back to an ecologically sustainable state. The Target only concerns use of blue water resources, i.e., water used from surface water and groundwater resources (Hoekstra et al. 2011). To determine the amount of locally available water, environment flow requirements in support of ecosystem functioning are estimated. Moreover and in addition to the method used by Hogeboom et al. (2020), an allocation procedure is applied that adds potential inflow from upstream sub-catchments to the water balance of downstream sub-catchments, thus making any excess water availability upstream available for downstream use. Each of the variables and their methods and data requirements needed to arrive at these Freshwater Quantity Targets, i.e., i) blue water runoff; ii) environmental flow requirements; iii) blue water footprints; iv) blue water availability; v) blue water footprint caps; vi) and the translation of all relevant variables into the final Freshwater Quantity Targets, are described below.

Blue Water Runoff (BWR)

First, an estimate is made of gross water availability levels in each sub-catchment. Hereto, monthly fields of blue water runoff (BWR, unit: m^3/month) are obtained by taking daily total runoff (i.e., locally generated surface and subsurface runoff assuming no human abstractions/impact) at 30 × 30 arcmin resolution over the period 1971—2010 as estimated by three Global Hydrology Models (GHMs): PCR-GLOBWB (Sutanudjaja et al. 2018); H08 (Hanasaki et al. 2008); and WaterGAP2-2C (Müller Schmied et al. 2016) and aggregating the resulting daily gridded data to monthly fields at HydroBASINS level 05. In some cases, a HydroBASINS polygon overlapped with a part of a gridcell. In such cases, we distributed the gridcell values according to the share in the areal overlap. In aggregating from daily to monthly values, a 360-day year calendar was applied in which each month was assigned 30 days. The median of the three total runoff estimates, i.e., of the model ensemble, is taken as BWR.

Daily gridded total runoff from the three GHMs was taken from ESGF-DKRZ (https://esgf-data.dkrz.de/search/esgf-dkrz/) and ISIMIP data repositories (https://data.isimip.org/search/sector/water_global/). Runs were selected that were forced with the WATCH-WFDEI climate forcing under a ‘no human impact’ scenario. Appendix A lists the full overview of datasets used from these repositories.

Environmental Flow Requirements (EFR)

Next, an estimate is made of how much water should be reserved to support environmental needs in each sub-catchment. Hereto, monthly fields of environmental flow requirements (EFR, unit: m^3/month) are obtained by taking three EFR methods, i.e., Richter et al. (2012), Smakhtin et al. (2004), and Pastor et al. (2014) and applying these to the BWR monthly fields as obtained earlier. The three methods estimate EFR as follows.

- Richter et al. (2012):

$$EFR = 0.8 * runoff$$

- Smakhtin et al. (2004):

$$EFR = \begin{cases} Q_{90}, MMF \leq MAF \\ Q_{90}, MMF > MAF \text{ } and \text{ } Q_{90} > 0.3MAF \\ Q_{90} + 0.07MAF, MMF > MAF \text{ } and \text{ } 0.3MAF \geq Q_{90} > 0.2MAF \\ Q_{90} + 0.15MAF, MMF > MAF \text{ } and \text{ } 0.2MAF \geq Q_{90} > 0.1MAF \\ Q_{90} + 0.2MAF, MMF > MAF \text{ } and \text{ } Q_{90} \leq 0.1MAF \end{cases}$$

- Pastor et al. (2014):

$$EFR = \begin{cases} 0.6MMF, MMF \leq 0.4MAF \\ 0.45MMF, 0.8MAF \geq MMF > 0.4MAF \\ 0.3MMF, MMF > 0.8MAF \end{cases}$$

Where MAF is the mean annual runoff (unit: m^3), MMF mean monthly runoff (unit: m^3), and Q_{90} the runoff that is exceeded 90% of the time (unit: m^3). MAF and MMF were calculated directly from BWR (over the 1971—2010 period, at HydoBASINs level 05). Q_{90} is first calculated at the 30 × 30 arcmin grid level using the daily total runoff data and subsequently aggregated to HydroBASINs level 05. Due to the high computational intensity, Q_{90} was calculated in blocks of 10 year intervals that were then averaged over the entire 1971—2010 period. The median of the nine resulting EFR estimates (i.e., 3 GHMs with 3 EFR methods each yields 9 combinations), is taken as EFR. As BWR contained monthly fields over the 1971—2010 period, so does EFR.

Blue Water Footprint (BWF)

Next, an estimate is made of the total blue water use in each sub-catchment. Estimates of water footprints (i.e., net or consumptive water use) serve two purposes. First, water footprints will be used in the allocation procedure that prescribes how unused water in upstream sub-catchments is added to the water balance of sub-catchments more downstream (see next section). Second and for each sub-catchment, water footprints will be compared to blue water availability (BWA) to assess if and by how much current consumption levels exceed ecological sustainability thresholds. To estimate total blue water footprints in each sub-catchment, monthly fields of blue water footprints (BWF, unit: m^3/month) are obtained by taking monthly gridded domestic water supply, industrial water consumption, potential irrigation consumption, and livestock water consumption estimates over the 1971—2010 period from PCR-GLOBWB (Sutanudjaja et al. 2018) and aggregating these to the HydroBASINS level 05. In some cases, a HydroBASINS polygon overlapped with a part of a gridcell. In such cases, we distributed the gridcell values according to the share in the areal overlap. Any water consumption in a gridcell that was partly covered by sea was assigned in full to the overlapping HydroBASINS polygon. Note that potential irrigation water consumption assumes that the required crop water supply is unlimited. While this may not always be the case in practice, literature typically reports potential over actual consumption (Wada et al. 2014). Water consumption for electricity is not included due to lack of available data.

Blue Water Availability (BWA)

The original method by Hogeboom et al. (2020) considered entire catchments as spatial units, which implies that to estimate (net) blue water availability (i.e., the sustainable water use threshold within which water that can be consumed by human activities without harming ecosystems) could be obtained by subtracting EFR from BWR in each catchment. However, since the current approach considers sub-catchments rather than catchments in their entirety, an upstream-downstream dynamic is introduced. Given this dynamic, unused blue water resources in upstream sub-catchments may be assigned to the water balance of sub-catchments located more downstream, such that the water availability in these more downstream sub-catchments can be increased. Allocating unused water from upstream to downstream sub-catchments is done on the basis of historical water consumption patterns, as proposed and applied by Zhuo et al. (2019). To represent recent historical water consumption patterns, the monthly average BWF over the 1990—2010 period is taken (H-BWF, unit: m^3/month), i.e., considering the most recent 20 years of the 1971—2010 timeseries for which BWF was calculated. Note that since H-BWF refers to a time-averaged statistic, H-BWF contains twelve monthly values for each sub-catchment.

To estimate the threshold for sustainable blue water consumption in each sub-catchment, monthly fields of blue water availability (BWA, unit: m^3/month) are calculated. Hereto, first the upstream-downstream sequence of sub-basins is retrieved from the HydroBASINS data product (Lehner and Grill 2013). In this data product, sub-catchment without upstream connections are labelled with a sequence number 0, while sub-catchments that do feature upstream connections are labelled with a sequence number that corresponds to the number of levels up from the given sub-catchment.

BWA in sub-basins with sequence 0 is comprised of locally generated runoff only, and is calculated by subtracting EFR from BWR. If EFR exceeds BWR, BWA is set to 0. For all other sub-catchments, i.e., those that feature one or more upstream sub-catchments, BWA is calculated from two components. The first is locally generated BWA, which is calculated by subtracting EFR from BWR (analogous to upstream sub-catchments with sequence number 0). The second is a potential inflow of unused water from connected upstream sub-catchments. This unused potential is calculated as the difference between BWA and H-BWF in each of the sub-catchments along the upstream sequence: any part of BWA in excess of H-BWF is added to the BWA of the next downstream sub-catchment. A BWA below H-BWF indicates that all sustainably available water within the sub-catchment is already being used, and no additional influx from upstream is available for more downstream sub-catchments. In other words, in sub-catchments downstream of already overdrafted upstream sub-catchments, BWA consists solely of locally generated BWA. Note that an important implication of this routing procedure is that overuse in upstream sub-catchments is *not* being compensated for by downstream sub-catchments. As all input variables contain monthly fields over the 1971—2010 period, so does BWA.

Blue Water Footprint Caps (BWFC)

The BWA variable can be understood as providing thresholds (i.e., upper limits) to sustainable blue water consumption at the sub-catchment scale for each month during the 1971—2010 period. These can be understood as backward looking thresholds. To arrive at a more forward looking threshold, a blue water footprint cap (BWFC, unit: m^3/month) is proposed at the 25th percentile of monthly BWA over the period 1971—2010. A BWFC set at the 25th percentile implies that monthly water consumption in a sub-catchment should be limited to the BWA value that is being met in 75% of the occurring months (e.g., three out of ever four months of January within the 1971—2010 period). Conversely, a BWFC at this percentile allows one in every four occurrences of a month to still violate EFR, assuming the full operating space for water use below the cap is being utilized. Setting the cap at the 25th percentile was suggested by Hogeboom et al. (2020) as a level that balances ambitious reduction goals with the realization that a certain amount of freshwater must be made available for human productive use. Note that for certain smaller sub-catchments (often unsequenced island or coastal catchments) high runoff variance may lead to EFR values that can exceed BWA in relatively dry month, potentially resulting in a BWFC of 0.

The median of the nine resulting BWA estimates (i.e., emerging from each GHM—EFR method comination), is taken as the BWA from which the 25th percentile gives the BWFC. Note that since BWFC refers to a time-averaged statistic, BWFC contains twelve monthly fields for each sub-catchment.

Freshwater Quantity Target

Finally, the Freshwater Quantity Target was computed. Technically, the Target reflects the percentage by which recent historical water consumption should be reduced in order to eliminate that part of historic water consumption that is in excess of sustainable water use levels. The Target is calculated by relating the excess of H-BWF over BWFC to H-BWF. If H-BWF is below BWFC, the Freshwater Quantity Target is 0%; in all other cases a reduction effort will be required, as indicated by positive Freshwater Quantity Target values. Note that as both H-BWF and BWFC contain twelve monthly fields, so does the Freshwater Quantity Target. However, as the SBTN Technical Guidance allows for setting targets at either the monthly or the annual level (Science Based Targets Network 2023), an annual Freshwater Quantity Target is calculated by dividing the sum of monthly exceedences of H-BWF over BWFC by the sum of monthly H-BWF, and expressing the result as a percentage. The final data product thus contains the twelve monthly and the annual value of the Freshwater Quantity Target for each sub-catchment.

How to apply the Freshwater Quantity Target

According to the SBTN Guidance (Science Based Targets Network 2023), certain pathways require companies to work with the Freshwater Quantity Targets as presented in this data product. Hereto, they must first retrieve Target values of those sub-catchments in which they have a presence. They can do so from the current data product, but also by through a dedicated and more user friendly webapplication that was developed to this end (https://www.acc.waterfootprintassessmenttool.org/?b=sbtn). This webapplication includes a functionality to upload multiple site locations and export (bulk) Target values for associated sub-catchments.

Where the Freshwater Quantity Target in essence describes a collective reduction requirement, the SBTN Guidance insists that companies also formulate individual, company-specific targets. Setting a company-specific target requires a decision on how the reduction burden will be shared among water users with a given sub-catchment. The SBTN Guidance follows the so-called "equal contraction of efforts" approach, which dictates that all water users in the basin must reduce their use by the same percentage. Companies can therefore take the Freshwater Quantity Target as presented in this data product and multiply the required sub-catchment level reduction percentage with the company's present-day level of water consumption (in the same units of volume per time).

Companies may use monthly or annual time periods for their Targets, depending on their baselining and the company type. If company baselines were calculated with annual values, their targets must be expressed as annual reductions. If company baselines were calculated with monthly values, the targets should be expressed using monthly reduction values. However, as a matter of reporting convenience for the monthly baseline case (which is potentially desirable when the variation between monthly targets is small), the required reduction for monthly targets may also be set equal to most stringent target across all individual months. For example, if the required reductions are 50% for certain months of the year and zero for other months, a company could set targets on an annual basis requiring a blanket 50% reduction across the entire year.

To balance the urgent need for progress on freshwater quantity in line with global goals while still providing companies sufficient time to implement actions to reduce their pressures, companies submit their targets with a target year of five years. Hence, when setting annual targets, the target will be stated as: "Company X will reduce its water withdrawal in the ____ basin to ____ ML/ year by the year ____." When setting monthly targets, the target will be stated as: "Company X will reduce its water withdrawal in the ____ basin to ____ ML/ month for each of the following months. The reductions will occur by the year ____." For more detailed guidance on how to use the Freshwater Quantity Target, see Science Based Targets Network (2023).

Appendix A: List of output from Global Hydrological Models used in this project

Impact model	Varia ble	Temporal resolution	Social-economic scenario	File name	Source
H08	qtot	Daily	nosoc	h08_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1971_1980.nc	ESGF-DKRZ
H08	qtot	Daily	nosoc	h08_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1981_1990.nc	ESGF-DKRZ
H08	qtot	Daily	nosoc	h08_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1991_2000.nc	ESGF-DKRZ
H08	qtot	Daily	nosoc	h08_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_2001_2010.nc	ESGF-DKRZ
PCR-GLOBWB	qtot	Daily	nosoc	pcr-globwb_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1971_1980.nc	ESGF-DKRZ
PCR-GLOBWB	qtot	Daily	nosoc	pcr-globwb_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1981_1990.nc	ESGF-DKRZ
PCR-GLOBWB	qtot	Daily	nosoc	pcr-globwb_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1991_2000.nc	ESGF-DKRZ
PCR-GLOBWB	qtot	Daily	nosoc	pcr-globwb_wfdei_nobc_hist_nosoc_co2_qtot_global_daily_2001_2010.nc	ESGF-DKRZ
WaterGAP2-2c	qtot	Daily	nosoc	watergap2-2c_watch-wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1971_1980.nc4	ISIMIP
WaterGAP2-2c	qtot	Daily	nosoc	watergap2-2c_watch-wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1981_1990.nc4	ISIMIP
WaterGAP2-2c	qtot	Daily	nosoc	watergap2-2c_watch-wfdei_nobc_hist_nosoc_co2_qtot_global_daily_1991_2000.nc4	ISIMIP
WaterGAP2-2c	qtot	Daily	nosoc	watergap2-2c_watch-wfdei_nobc_hist_nosoc_co2_qtot_global_daily_2001_2010.nc4	ISIMIP
PCR-GLOBWB	adomuse	Monthly	varsoc	pcr-globwb_watch-wfdei_nobc_hist_varsoc_co2_adomuse_global_monthly_1971_2010.nc4	ISIMIP
PCR-GLOBWB	ainduse	Monthly	varsoc	pcr-globwb_watch-wfdei_nobc_hist_varsoc_co2_ainduse_global_monthly_1971_2010.nc4	ISIMIP
PCR-GLOBWB	aliveuse	Monthly	varsoc	pcr-globwb_watch-wfdei_nobc_hist_varsoc_co2_aliveuse_global_monthly_1971_2010.nc4	ISIMIP
PCR-GLOBWB	pirruse	Monthly	varsoc	pcr-globwb_watch-wfdei_nobc_hist_varsoc_co2_pirruse_global_monthly_1971_2010.nc4	ISIMIP

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