European Environment Agency

8th Environment Action Programme

Water scarcity conditions in Europe (Water exploitation index plus)

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European Environment Agency

Water scarcity conditions in Europe (Water exploitation index plus)

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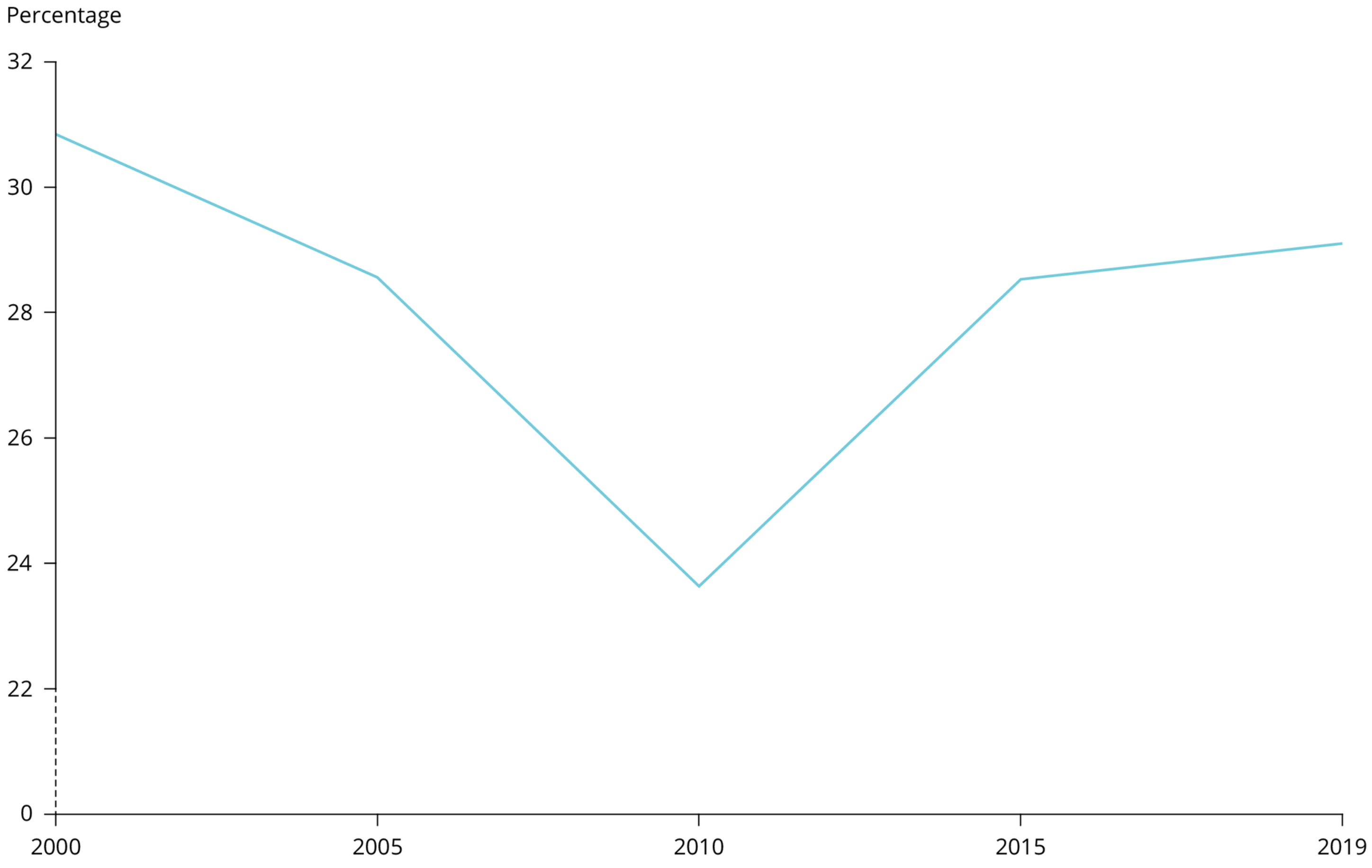
Water scarcity affected 29% of the EU territory during at least one season in 2019. Despite water abstraction declining by 15% in the EU between 2000 and 2019, there has been no overall reduction in the area affected by water scarcity conditions. In fact, since 2010 there has been a worsening of the situation. This, compounded with the fact that climate change is expected to further increase the frequency, intensity and impacts of drought events, makes it somewhat unlikely that water scarcity will reduce by 2030. Additional effort is needed to ensure sustainable water use

Figure 1. Area affected during at least one quarter of the year by water scarcity conditions in the EU, measured by the water exploitation index plus



.**Source:** EEA/Eurostat/OECD/Joint Research Centre/Ecrins

Freshwater resources are essential for human health, nature and the functioning of economies and societies. However, across the EU, these resources are threatened by multiple pressures. To address this, the Water Framework Directive requires Member States to promote the sustainable use of water resources and to protect the available water resources [1].

Water scarcity is determined primarily by (1) water demand and consumption, which largely depend on population and type of socio-economic activities; (2) climatic conditions, which control water availability and seasonality of supply; and (3) landscape and geological characteristics of the basins. Assessing water scarcity conditions across Europe at river basin level and by season is more informative, compared to aggregated annual estimates at European or even country level, which masks the extent or intensity of the problem for certain areas or seasons. The water exploitation index plus (WEI+) does that by measuring water consumption as a percentage of the renewable freshwater resources available at river sub-basin level and by each of the four quarters of the year (3 consecutive months). WEI+ values above 20% indicate that water resources are under stress and therefore water scarcity conditions prevail; values above 40% indicate that stress is severe and freshwater use is unsustainable [2][3].

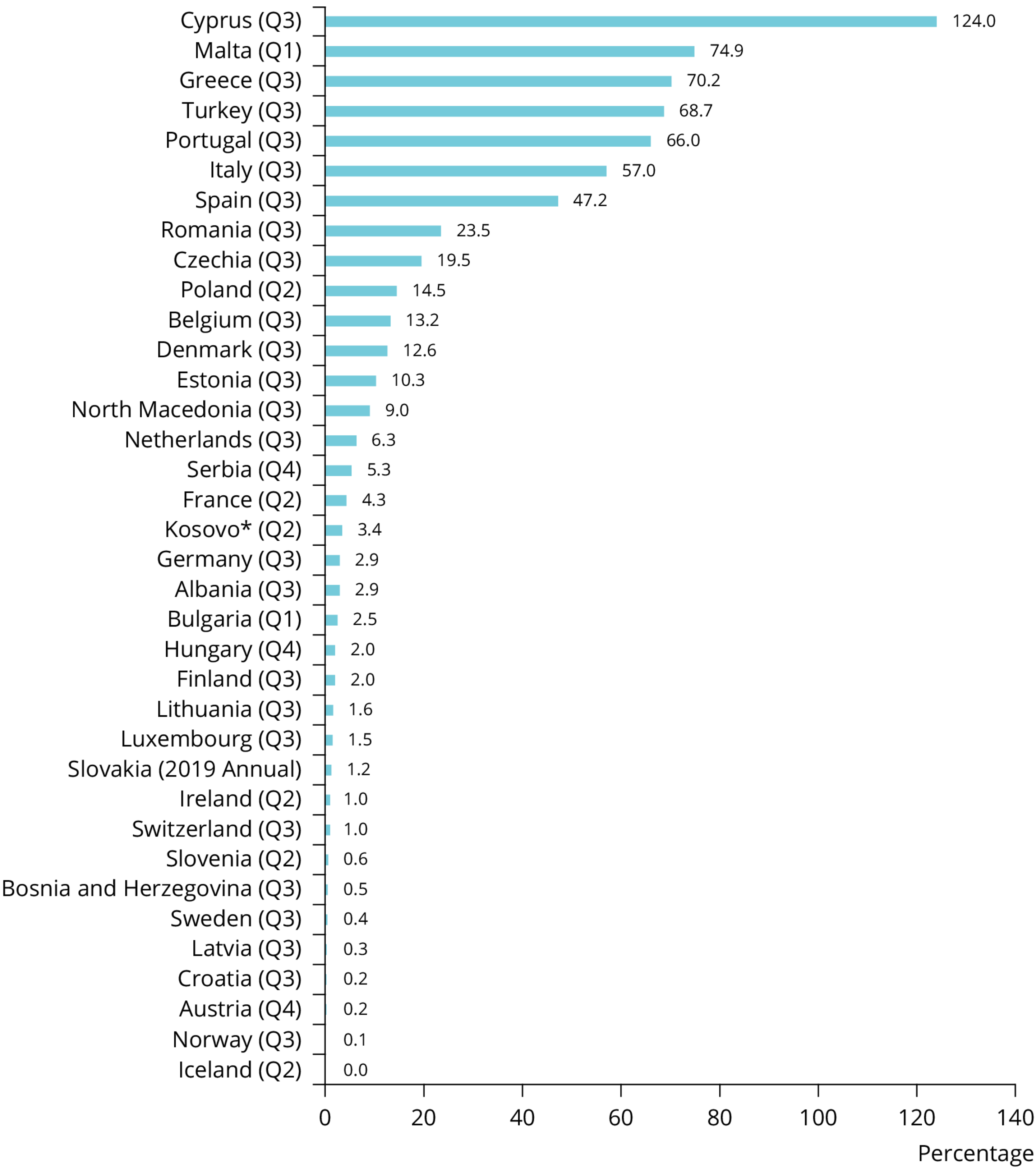
Figure 1 shows the percentage of the EU territory that has been affected in at least one of the four quarters of the year by WEI+ values of above 20% per year. It shows that 29% of the EU-27 territory, excluding Italy, was affected by water scarcity conditions in 2019. Despite total water abstraction declining by about 15% in the EU between 2000 and 2019, the area affected by water scarcity conditions was relatively stable over the period, albeit there has been an increase since 2010.

In general, water scarcity is more common in southern Europe, where approximately 30 % of its population living in areas with permanent water stress and up to 70 % of its population living in areas with seasonal water stress during summer[4]. Water abstractions for agriculture, public water supply and tourism are the most significant pressures on freshwater [5]

However, water scarcity is not limited to southern Europe. It extends to river basins across the EU, particularly in western Europe, where water scarcity is caused primarily by high population density in urban areas, combined with high levels of abstraction for public water supply, energy and industry[5]. During the last decade, drought events have also become more frequent and severe in these areas, with impacts on seasonal water availability[6].

Climate change threatens to reduce further the availability of freshwater resources mostly in southern, western and eastern Europe and to exacerbate the natural fluctuations in seasonal water availability. As a result, it is expected that the frequency, intensity and impacts of drought events will be increasing[7]. Based on this and the fact that the overall past trend does not show any improvement — rather a deterioration since 2010 — it seems unlikely that water scarcity will reduce by 2030 (Figure 1).

Figure 2. Worst seasonal water scarcity conditions for European countries in 2019, measured by the water exploitation index plus (WEI+)



Source: EEA/Eurostat/OECD/Joint Research Centre.

In 2019, Cyprus, Malta, Greece, Portugal, Italy and Spain faced the most significant water scarcity conditions in the EU-27 on the seasonal scale (seasonal WEI+ >40%). Malta is experiencing the permanent water scarcity conditions partly due to its natural hydro-climatic conditions. Romania displays water scarcity challenges as well (seasonal WEI+ >20%) (Figure 2). Among the non-EU European countries for which data are available, Turkey is the most severely challenged.

In general, water scarcity conditions intensify between July and September in the majority of countries. This is a combination of dry weather, reduced flows and increased abstractions for irrigated agriculture, tourism and recreational activities, and other socio-economic activities during that period of the year.

Certain river sub-basins, which were affected by seasonal water scarcity in 2019, are located in Belgium, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Malta, Poland, Portugal, Romania, Sweden, Spain and Romania (seasonal WEI+ >20%; see further River sub-basin seasonal WEI+ results).

Supporting information

Definition

The WEI+ provides a measure of total water consumption as a percentage of the renewable freshwater resources available for a given territory and period. The WEI+ is an advanced geo-referenced version of the WEI. It quantifies how much water is abstracted monthly or seasonally and how much water is returned before or after use to the environment via river basins (e.g. leakages, discharges by economic sectors). The difference between water abstractions and water returns is regarded as 'water consumption'.

Methodology

In 2011, a technical working group, developed under the Water Framework Directive Common Implementation Strategy, proposed the implementation of a regional 'WEI+'. This differed from the previous approach, as the WEI+ was able to depict more seasonal and regional aspects of water stress conditions across Europe (see the EEA's updated conceptual model of WEI+ computation). This proposal was approved by the Water Directors in 2012 as one of the awareness-raising indicators[8].

The regional WEI+ is calculated according to the following formula:

WEI+=(abstractions-returns)/renewable freshwater resources.

Renewable freshwater resources are calculated as 'ExIn+P-Eta±ΔS' for natural and semi-natural areas, and as 'outflow+(abstraction-return)±ΔS' for densely populated areas

where:

ExIn=external inflow

P=precipitation

Eta=actual evapotranspiration

ΔS=change in storage (lakes and reservoirs)

Outflow=outflow to downstream/sea.

It is assumed that there are no pristine or semi-natural river basin districts or sub-basins in Europe. Therefore, the formula 'outflow+(abstraction-return)±ΔS' is used to estimate renewable water resources.

Climate data and streamflow data have been integrated from Waterbase — Water Quantity database and the Joint Research Centre (JRC) Lisflood model[9]. The JRC Lisflood data cover hydro-climatic variables for Europe in a homogeneous way for the years 2000-2019 on a monthly scale.

Once the data series are complete, the flow linearisation calculation is implemented, followed by a water asset accounts calculation, which is done to fill the gaps in the data for the parameters requested for the estimation of renewable water resources. The computations are implemented at different scales independently, from sub-basin scale to river basin scale or to country level.

Overall, annually reported data are available for water abstraction by source (surface water and groundwater) and water abstraction by sector with temporal and spatial gaps. Gap-filling methods are applied to obtain harmonised time series.

No sufficient data are available at the European scale on 'return'. To fill gaps in data on return, urban wastewater treatment plant data, the European Pollutant Release and Transfer Register (E-PRTR) database[10], JRC data on the crop coefficient of water consumption and satellite-observed phenology data have been used as proxies to quantify water demand and water use by different economic sectors. Eurostat tourism data[11] and data on industry in production have been used to estimate the actual water abstraction and return on a monthly scale. Where available, Waterbase — Water Quantity database[12] and Eurostat data[13] on water availability and water use have also been used at aggregated scales for further validation purposes.

Once water asset accounts have been implemented according to the United Nations System of Environmental-Economic Accounting for Water[14], the necessary parameters for calculating water use and renewable freshwater resources are harvested.

Following this, bar and pie charts are produced, together with static and dynamic maps.

Methodology for gap filling

For each parameter of water abstraction, return and renewable freshwater resources, primarily data from the Waterbase — Water Quantity database have been used[12]. Eurostat, OECD and Aquastat (FAO) databases have also been used to fill the gaps in the data sets. Furthermore, the statistical office websites[13] of all European countries have each been visited several times to get the most up-to-date data from these national open sources. Despite this, some gaps still needed to be filled by applying certain statistical or geospatial methodologies (see EEA (undated), Table 1 - Reference data sources for gap filling and modulation coefficients).

Lisflood data from the JRC have been used to gap fill the streamflow data set (see EEA (undated), Table 1 - Reference data sources for gap filling and modulation coefficients). The spatial reference data for the WEI+ are the European Catchments and Rivers Network System (Ecrins) data (250-m vector resolution). Ecrins is a vector spatial data set, while Lisflood data are in 5-km raster format. To fill the gaps in the streamflow data, centroids of the Lisflood raster have been identified as fictitious (virtual) stations. The topological definition of the drainage network in Ecrins has been used to match the most relevant and nearest fictitious Lisflood stations with EEA-Eionet stations and the Ecrins river network. After this, the locations of stations between Eionet and Lisflood stations were compared and overlapping stations were selected for gap filling. For the remaining stations, the following criteria were adhered to: fictitious stations had to be located within the same catchment as the Eionet station and have the same main river segment; in addition, both stations had to show a strong correlation.

A substantial amount of gap filling has been performed on the data on water abstraction for irrigation. First, a mean factor between utilised agricultural areas and irrigated areas has been used to fill the gaps in the data on irrigated areas. Then, a multiannual mean factor of water density (m^3/ha) in irrigated areas per country has been used to fill the gaps in the data on water abstraction for irrigation.

The gaps in the data on water abstraction for manufacturing and construction have been filled using Eurostat data on production in industry (Eurostat [sts_inpr_a]) and the E-PRTR database, with the methodologies in the best available techniques reference document (BREF) being used to convert the production level into the volume of water.

Uncertainties

Methodology uncertainty

Reported data on water abstraction and water use do not have sufficient spatial or temporal coverage. Therefore, estimates based on country coefficients are required to assess water use. First, water abstraction values are calculated and, second, these values are compared with the production level in industry and in relation to tourist movements to approximate actual water use for a given time resolution. This approach cannot be used to assess the variations (i.e. the resource efficiency) in water use within the time series.

Spatial data on lakes and reservoirs are incomplete. However, as reference volumes for reservoirs, lakes and groundwater aquifers are not available, the water balance can be quantified as only a relative change, and not the actual volume of water. This masks the actual volume of water stored in, and abstracted from, reservoirs. Thus, the impact of the residence time, between water storage and use, in reservoirs is unknown.

The sectoral use of water does not always reflect the relative importance of the sectors to the economy of a given country. It is, rather, an indicator that describes which sectors environmental measures should focus on in order to enhance the protection of the environment. A number of iterative computations based on identified proxies are applied to different data sets, i.e. urban wastewater treatment plant data, E-PRTR data, JRC data on the crop coefficient of water consumption and satellite-observed phenology data have been used as proxies to quantify water demand and water use by different economic sectors. This creates a high level of uncertainty in the quantification of water return from economic sectors, thus also leading to uncertainty with regard to the 'water use' component.

The calculation of the EU percentage area affected by water scarcity includes the whole of the sub-river basins, which are shared with non-EU neighbouring countries as it has not been possible to distinguish the data between EU and non-EU countries in such locations. Nevertheless, most of the sub-basins identified as having water scarcity fall in EU territory.

ISPRA, in collaboration with Istat, provided provisional annual WEI+ values for Italy for the years 2015-2019 by following the WEI+ formula that is also implemented by the EEA. In the annual WEI+ computation for Italy (2015-2019), the term ΔS (change in water storage) is considered to be negligible by these institutions, and it has therefore been set equal to zero by ISPRA. In the seasonal WEI+ estimation, provided by Italy for 2019, the term ΔS (change in water storage) has been considered instead. The datasets used for WEI+ evaluation are not homogeneous in terms of sources over the entire time-period. Therefore, there is no use in assessing trends, as they would not be statistically significant.

Policy/environmental relevance

Justification for indicator selection

The WEI+ is a water scarcity indicator that provides information on the level of pressure exerted by human activities on the natural water resources of a territory. This helps to identify the areas that are prone to water stress problems [8]. The WEI+ values on the country and annual scales are provided in line with the directions of UN SDG indicator 6.4.2 ('Level of water stress'), which is used to track progress towards target 6.4, addressing water scarcity and resource efficiency[15] (however, ecological flows are not yet included in the WEI+). Furthermore, computing and assessing the WEI+ at finer spatial scale (e.g. river basin districts) and finer temporal scale (e.g. seasonal), compared to the country-scale annual averages, helps to improve the monitoring and assessment of water scarcity issues occurring regionally/locally and seasonally. Finally, computation and assessment of the WEI+ at the European level, would hide the large regional and local differences that exist across the continent. Therefore, it would be misleading. Instead, the computation and assessment of the proportional area being affected by water scarcity conditions (either seasonally or throughout an entire year) better capture the significance of water scarcity conditions on the continental scale.

Policy context and targets

Context description

The WEI is part of the set of water indicators published by several international organisations, such as the Food and Agricultural Organization of the United Nations (FAO), the Organisation for Economic Co-operation and Development (OECD), Eurostat and the Mediterranean Blue Plan. An indicator similar to WEI is also used to measure progress towards UN SDG target 6.4.2 at the global level[15]. Therefore, the WEI is an internationally accepted indicator for assessing the pressure of the economy on water resources, i.e. water scarcity.

This indicator is a headline indicator for monitoring progress towards the 8th Environment Action Programme (8th EAP). It contributes mainly to monitoring aspects of the 8th EAP Article 2.1. that requires that ‘by 2050 at the latest, people live well, within the planetary boundaries in a well-being economy where nothing is wasted, growth is regenerative, climate neutrality in the Union has been achieved and inequalities have been significantly reduced. A healthy environment underpins the well-being of all people and is an environment in which biodiversity is conserved, ecosystems thrive, and nature is protected and restored, leading to increased resilience to climate change, weather- and climate-related disasters and other environmental risks. The Union sets the pace for ensuring the prosperity of present and future generations globally, guided by intergenerational responsibility’[16]. The European Commission 8th EAP monitoring communication specifies that this indicator should monitor whether there is a reduction in water scarcity[17].

The new Water Reuse Regulation[18], which entered into force in 2020, explicitly addresses water stress and water scarcity, respectively, and includes provisions for improving resource efficiency in the context of managing water resources.

Targets

There are no specific quantitative targets directly related to this indicator. However, the Water Framework Directive (Directive 2000/60/EC)[19] requires Member States to promote the sustainable use of water resources based on the long-term protection of available water resources, and to ensure a balance between abstraction and the recharge of groundwater, with the aim of achieving good groundwater status and good ecological status or potential for surface waters.

Regarding WEI+ thresholds, it is important that agreement is reached on how to delineate non-stressed and stressed areas. Raskin et al. (1997)[2] suggested that a WEI value of more than 20% should be used to indicate water scarcity, whereas a value of more than 40% would indicate severe water scarcity. These thresholds are commonly used in scientific studies[20]. Smakhtin et al. (2004)[21] suggested that a 60% reduction in annual total run-off would cause environmental water stress. The FAO uses a water abstraction value of above 25% to indicate water stress and of above 75% to indicate serious water scarcity[22]. Since no formally agreed thresholds are available for assessing water stress conditions across Europe, in the current assessment, the 20% WEI+ threshold is considered to distinguish stressed from non-stressed areas, while a value of 40% is used as the highest threshold for mapping purposes. The previous thresholds were proposed by Raskin at al. (1997) [2]originally for the WEI.

Accuracy and uncertainties

Methodology uncertainty

Reported data on water abstraction and water use do not have sufficient spatial or temporal coverage. Therefore, estimates based on country coefficients are required to assess water use. First, water abstraction values are calculated and, second, these values are compared with the production level in industry and in relation to tourist movements to approximate actual water use for a given time resolution. This approach cannot be used to assess the variations (i.e. the resource efficiency) in water use within the time series.

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Data set uncertainty

Data are very sparse for some parameters of the WEI+. For instance, current streamflow data reported by the EEA member countries to the WISE SoE — Water Quantity database[12] do not have sufficient temporal or spatial coverage to provide a strong enough basis for estimating renewable water resources for all of Europe. Such data are not available elsewhere at the European level. Therefore, JRC Lisflood data are used intensively as surrogates[23], 'Availability on streamflow data').

Data on water abstraction by economic sector have better spatial and temporal coverage. However, the representativeness of data for some sectors is also poor, such as the data on water abstraction for mining. In addition to the WISE SoE — Water Quantity database, intensive efforts to compile data from open data sources such as Eurostat, OECD, Aquastat (FAO) and national statistical offices have also been made (see EEA (undated), 'Share of surrogate data versus reported data on water abstraction by all economic sectors (total volume)').

Quantifying water exchanges between the environment and the economy is, conceptually, very complex. A complete quantification of the water flows from the environment to the economy and, at a later stage, back to the environment, requires detailed data collection and processing, which have not been done at the European level. Thus, reported data have to be used in combination with modelling to obtain data that can be used to quantify such water exchanges, with the purpose of developing a good approximation of 'ground truth'. However, the most challenging issue is related to water abstraction and water use data, as the water flow within the economy is quite difficult to monitor and assess given the current lack of data availability. Therefore, several interpolation, aggregation or disaggregation procedures have to be implemented at finer scales, with both reported and modelled data. The main consequences of data set uncertainty are that the water accounts and WEI+ results have been implemented in the EEA member and western Balkan countries. However, regional data availability was an issue for some river basins (e.g. in Italian and Turkish river basins), which had to be removed from the assessment.

Rationale uncertainty

Because of the aggregation procedure used, slight differences exist between sub-basin and country levels for total renewable water resources and water use.

Data sources and providers

- Groundwater depletion - Lisflood- EPIC model, Joint Research Centre (JRC)
- Population on 1 January by age and sex (DEMO_PJAN), Statistical Office of the European Union (Eurostat)

- Freshwater abstractions (OECD), Organisation for Economic Co-operation and Development (OECD)
- Annual freshwater abstraction by source and sector [env_wat_abs], Statistical Office of the European Union (Eurostat)
- Waterbase - Water Quantity, European Environment Agency (EEA)
- European catchments and Rivers network system (Ecrins), European Environment Agency (EEA)

Metadata

DPSIR

Pressure

Topics

 # Water **# Climate change adaptation** **# Extreme weather**

Tags

 # Surface water **# 8th EAP** **# Water abstraction** **# Groundwater** **# WAT001**

Temporal coverage

2000-2019

Geographic coverage

Albania
Austria
Belgium
Bosnia and Herzegovina
Bulgaria
Croatia
Cyprus
Czechia
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Kosovo (UNSCR 1244/99)
Latvia
Lithuania
Luxembourg
Malta
Netherlands
North Macedonia
Norway
Poland
Portugal

Romania
Serbia
Slovakia
Slovenia
Spain
Sweden
Switzerland
Turkey

Typology

Descriptive indicator (Type A - What is happening to the environment and to humans?)

UN SDGs

Clean water and sanitation

Unit of measure

WEI+ values are given as percentages, i.e. water use as a percentage of renewable water resources.

Frequency of dissemination

Every 2 years

Contact

info@eea.europa.eu

References and footnotes

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