Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

6 CLEAN WATER AND SANITATION

SDG 6.4 MONITORING SUSTAINABLE USE OF WATER RESOURCES PAPERS

A disaggregation of indicator 6.4.2 “Level of water stress: freshwater withdrawal as a proportion of available freshwater resources” at river basin district level in Italy

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

Istat
Istituto Nazionale di Statistica

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Foreword

The Food and Agriculture Organization of the United Nations (FAO) is supporting the 2030 Agenda for Sustainable Development through the transformation to more efficient, inclusive, resilient and sustainable agrifood systems for better production, better nutrition, a better environment, and a better life. The transformation of agrifood systems is at the heart of FAO's mandate.

Water is the essence of life and is central to agrifood systems. The path to reducing water stress passes through sustainable agrifood systems. To ensure the sustainable management of water resources for all, it is essential to look at the water cycle in its entirety, including all its uses and users.

FAO is the custodian agency responsible for monitoring Sustainable Development Goal (SDG) target 6.4 that addresses water use and scarcity to "S*ubstantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity by 2030*". In FAO, the data collection, management and reporting of target 6.4 indicators at the global level takes place through the FAO Global Information System on Water Resources (AQUASTAT).

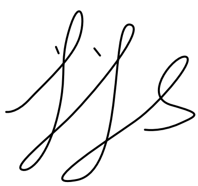
In 2015 FAO joined the Integrated Monitoring Initiative for SDG6 coordinated by UN-Water. The Initiative aims at accelerating the achievement of the SDG targets on sustainable water and sanitation through the establishment of a coherent monitoring framework for water and sanitation and by supporting countries to achieve progress through well-informed decision-making on water. Such a framework will help countries achieve progress, based on harmonized, comprehensive, timely and accurate information.

Assessing the water cycle and potential situations of water stress at both national and subnational scales used for the management of water resources is essential to provide users and decision-makers with the information needed to inform the planning process.

This report presents the methodology to spatially disaggregate the computation of SDG indicator 6.4.2 on the level of water stress: *freshwater withdrawal as a proportion of available freshwater resources* from the national to the subnational scale in Italy. The analysis was performed by the Italian Institute for Environmental Protection and Research (ISPRA) and the Italian National Institute of Statistics (Istat) considering the available freshwater resources during the different 30-year periods within the reference period 1951–2020 and the water withdrawal for the period 2015–2019.

Compared to the national assessment, which results in a low level of water stress in the country (about 30–40 percent, depending on the reference period), the spatial disaggregation of the indicator by hydrological unit highlighted the presence of one river basin district (RBD) affected by a water stress exceeding 60 percent (namely, the district of the Po river basin in northern Italy). RBDs, defined according to the EU Water Framework Directive 2000/60/EC, have been chosen as hydrological units for this disaggregation assessment since they are both hydrographically consistent and represent units of management of water resources and of evaluation of flood and drought risks.

In coordination and collaboration with other stakeholders, FAO will continue supporting its Member Nations to achieve this objective by providing scientific and technical assistance.



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Acknowledgements

This document is the outcome of an agreement between the Food and Agriculture Organization of the United Nations (FAO) and the Italian Institute for Environmental Protection and Research (ISPRA), designed to co-produce a map of Italy corresponding to Sustainable Development Goals (SDGS) indicator 6.4.2 *"Level of water stress: freshwater withdrawal as a proportion of available freshwater resources"* disaggregated at river basin district level.

This document was prepared by Giovanni Braca, Martina Bussettini Barbara Lastoria, Stefano Mariani and Francesca Piva, researchers in the fields of hydrology, hydromorphology, freshwater ecology, department of environmental protection, monitoring and biodiversity conservation at ISPRA, Rome, Italy.

Stefano Tersigni and Simona Ramberti, researchers at the Italian National Institute of Statistics (Istat), Rome, co-authored chapter 6 concerning water withdrawal data for different uses.

We would like to thank also Riccardo Biancalani, coordinator of the Integrated Monitoring Initiative for SDG 6 (IMI-SDG6), and Michela Marinelli, environmental analyst and responsible of the disaggregation of SDG 6.4.2 in the framework of the IMI-SDG6 project, for the coordination of this activity, and would also like to extend thanks to Cristina Peretto and Jim Morgan of the FAO Land and Water Division for the design and layout.

Abbreviations and acronyms

AH	agricultural holding
AWS	available water storage
BIGBANG	Bilancio Idrologico Gis Based a scala Nazionale su Griglia regolare (Nationwide GIS-based regular gridded hydrological water budget)
Eurostat	European Statistical Office
EEA	European Environmental Agency
EFR	environmental flow requirements
ERWR	external renewable water resources
EU	European Union
EU-27	27 European Union Member Nations
FAO	Food and Agriculture Organization of the United Nations
GEFIS	Global Environmental Flow Information System
GIS	geographic information system
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale (Italian Institute for Environmental Protection and Research)
HH	holding headquarters
Istat	Istituto Nazionale di Statistica (Italian National Institute of Statistics)
IWMI	International Water Management Institute
IRWR	internal renewable water resources
LAEA	Lambert Azimuthal Equal Area
LMAs	labour market areas
LTAA	long-term annual average

OECD	Organization for Economic Co-operation and Development
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne (Statistical Classification of Economic Activities in the European Community)
NAR	natural annual runoff
NUTS	Nomenclature des Unités Territoriales Statistiques (Nomenclature of Territorial Units for Statistics)
RBDs	River basin districts
SDGs	Sustainable Development Goals
TFWW	total freshwater withdrawal
TRWR	total renewable water resources
WFD	Water Framework Directive
WISE	Water Information System for Europe
WS	water storage

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Introduction

In September 2020, the Italian Institute for Environmental Protection and Research (ISPRA) and the Food and Agriculture Organization of the United Nations (FAO) signed an implementation agreement to cooperate in the evaluation of Sustainable Development Goal (SDG) 6.4.2 indicator, “Level of water stress: freshwater withdrawal as a proportion of available freshwater resources” for Italy, disaggregated at subnational level. A thorough description of this implementation, carried out as part of the Integrated Monitoring Initiative for SDG 6, “Clear water and sanitation”, is detailed in the following sections.

SDG Target 6.4 “Water use and scarcity” addresses the reduction of water scarcity. Its aim is to ensure sufficient water to meet the needs of the population, economy and environment by increasing water-use efficiency across all sectors of society. To monitor progress towards this target, two indicators were set up: indicator 6.4.1 measures the change in water-use efficiency over time, whereas indicator 6.4.2 measures the level of water stress, defined as follows:

$$\textit{Water Stress (percentage)} = \frac{TFWW}{TRWR - EFR} \times 100 \qquad \textit{eq. 1.1}$$

where TFWW is the annual volume of total freshwater withdrawal, TRWR are the total renewable water resources, and EFR are the environmental flow requirements.

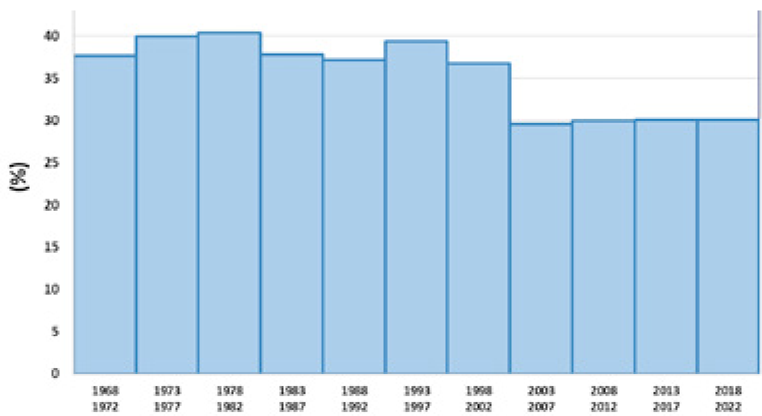
The term TFWW includes withdrawals from both surface water and groundwater, while TRWR includes both internal and external renewable freshwater resources (Sood *et al.,* 2017). Internal resources are generated by endogenous precipitation, whereas external resources are generated outside but made available within the country.

Following the structure of eq. 1.1, this report is organized as follows:

- identification of the territorial units of disaggregation;
- selection of the water budget model for estimating internal renewable water resources (IRWR);
- estimation of external renewable water resources (ERWR);
- calculation of TRWR;
- assessment of environmental flow requirements (EFR);
- data collection and estimation of water withdrawals (TFWW); and
- calculation of the water stress indicator.

To set the scene, Figure 1.1 depicts the level of water stress for Italy over five-year periods since 1968, as estimated by FAO's AQUASTAT.

Figure 1.1 – Level of water stress for Italy estimated in AQUASTAT since 1968



Source: FAO AQUASTAT. 2022. https://www.fao.org/aquastat/en

Meanwhile, water resources in Italy, as estimated and reported in the AQUASTAT database, are illustrated in Table 1.1.

Table 1.1 – Most recent main water resource statistics for Italy reported in AQUASTAT (www.fao.org/aquastat/en/databases/maindatabase/ accessed November 2022)

Food and Agriculture Organization of the United Nations

AQUASTAT

Country	Variable	2019
Italy	Long-term average annual precipitation in depth (mm/year)	832,00 I
Italy	Surface water produced internally (10^9 m3/year)	170,50 I
Italy	Total internal renewable water resources (IRWR) (10^9 m3/year)	182,50 I
Italy	Total internal renewable water resources per capita (m3/inhab/year)	3.014,03 E
Italy	Total renewable water resources (10^9 m3/year)	191,30 I
Italy	Total renewable water resources per capita (m3/inhab/year)	3.159,37 E
Italy	Water resources: total external renewable (10^9 m3/year)	8,80 I

Source: FAO AQUASTAT. 2022. https://www.fao.org/aquastat/en/

The following sections illustrate the approach applied to estimate water stress indicators at national and subnational level, based on available official national data. The results are then compared with those derived from AQUASTAT to assess consistency and identify any discrepancies across the two different approaches.

Units of disaggregation: the river basin districts

Disaggregation of SDG indicator 6.4.2, at subnational level, is carried out at river basin district (hereafter RBD) level. RBD territories are defined and prescribed by European Directive 2000/60/EC (Water Framework Directive – WFD) and identified by Italian Law n. 221/2015.

A RBD is defined as an area of land and sea made up of one or more neighbouring river basins, together with their associated groundwater and coastal waters, and identified under Article 3(1) as the main unit for the management of river basins (WFD art. 2.15)

Italy is divided into the following seven RBDs, each identified by a univocal code in the Water Information System for Europe (WISE) (Table 2.1, Figure 2.1):

1. Eastern Alps
2. Po River
3. Northern Apennines
4. Central Apennines
5. Southern Apennines
6. Sardinia
7. Sicily

Table 2.1 – Characteristics of Italian river basin districts

River Basin District	WISE CODE	Area	RBDs/Italy	Population(*)	RDB/Italy
		km^2	%	10^6 inhab.	%
Eastern Alps	ITA	34 805	11.5	6.96	11.7
Po River	ITB	82 977	27.5	19.8	33.2
Northern Apennines	ITC	24 340	8.1	4.95	8.3
Central Apennines	ITE	42 373	14.0	7.89	13.2
Southern Apennines	ITF	67 646	22.4	13.4	22.5
Sardinia	ITG	24 100	8.0	1.61	2.7
Sicily	ITH	25 832	8.6	5.07	8.5
ITALY	IT	302 073	100.0	59.7	100.0

(*) RBD population data are sourced from the River Basin Management Plan. The Italian population is derived as a sum of the RBD population

Italy covers a total area of 302 073 km^2, as officially stated by Istat (www.istat.it/it/archivio/137001) referring to the national territory. This value differs from the total reported by AQUASTAT, which is equal to 301 340 km^2. Such a difference, even if it only approximates to 0.25 percent, nevertheless affects the estimate of the total volume of water resources.

Given that Istat provides the official boundaries and areas only for the administrative units of Italy and its regions, the total area of RBD territories was inferred from geographic information system (GIS) data and then adjusted for the sake of consistency.

RBDs were chosen as units for disaggregating the SDGs 6.4.2 indicator for the following reasons:

1) RBDs are not only hydrographically consistent but represent units of management of water resources and are governed by a specific administrative authority (the River Basin District Authority), in charge

of developing water management plans (including flood and drought risk evaluation and management). Available water resources data are therefore usually aggregated at RBD level.

2) RBDs are suitable units to perform surface water balance because they are calculated as an aggregation of river basins. There are therefore no natural water surface exchanges among conterminous territories.

3) RBDs are extensive enough to discount neglect groundwater exchanges within conterminous territories, but at the same time small enough to be considered relatively homogeneous from a climatic point of view.

4) RBDs were delimited, as far as possible, in such a way that there are no water relocations between them.

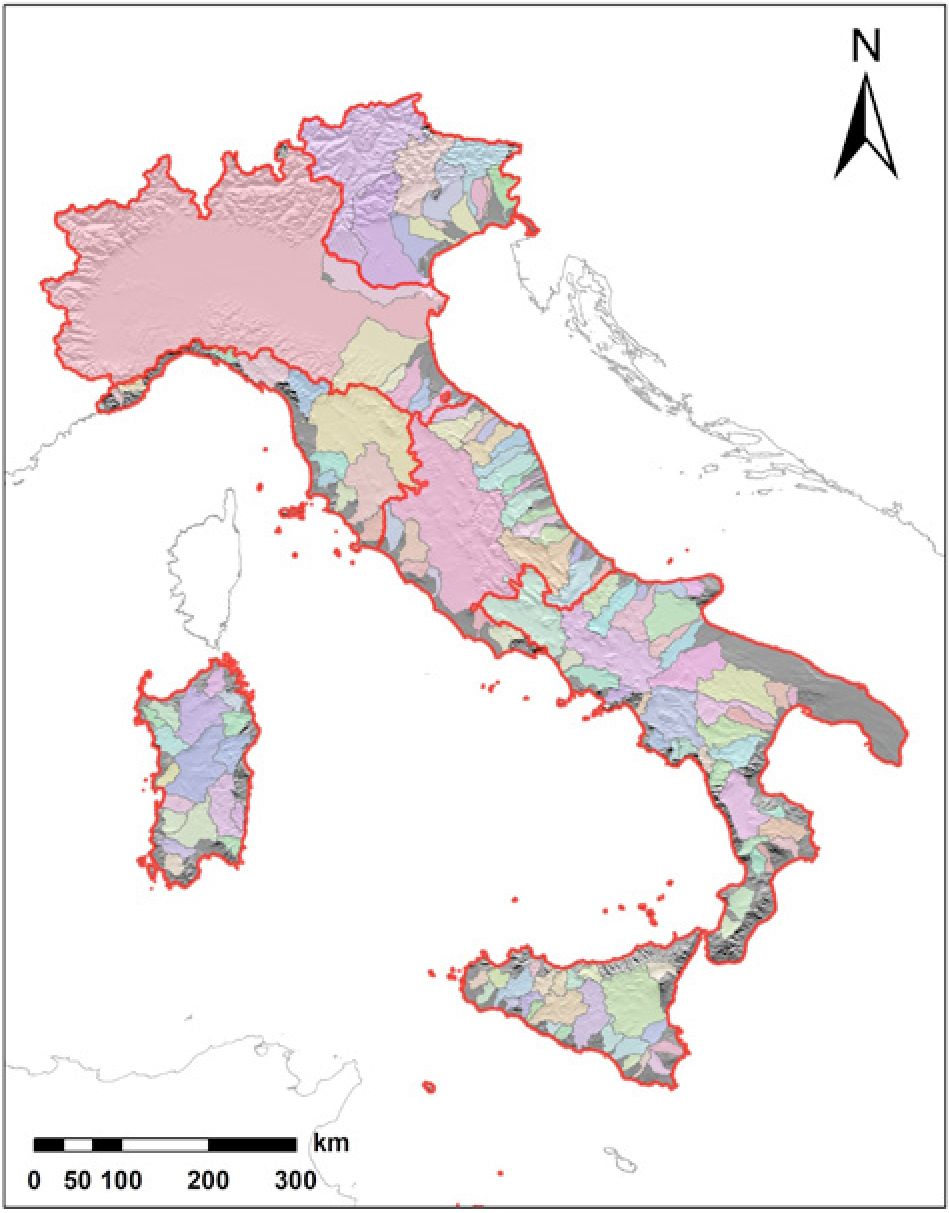
5) RBDs have a comparable extension, as reported in Table 2.1.

6) Owing to its peculiar orographic structure, Italy is characterized by a very dense hydrographic network and a high number of small river basins, as shown in Figure 2.2. Disaggregating the 6.4.2 indicator at a smaller level than RBDs would therefore have been excessively cumbersome. Moreover, water data are not always homogeneously available at a higher spatial resolution.

Figure 2.1 – Italian RBDs after Italian Law n. 221/2015

Source: Ministry of Environment of Italy. 2018. https://www.isprambiente.gov.it/pre_meteo/idro/UoM_CA.html

Figure 2.2 – Main Italian river basins depicted in different colours



Source: ISPRA. 2022. http://www.sinanet.isprambiente.it/

Hydrological model for evaluating water balance components

To evaluate the water balance components, ISPRA developed a hydrological model named BIGBANG[1] (Braca *et al.*, 2019, 2021, 2022; Braca and Ducci, 2018). The model is implemented on a monthly timescale and adopts a spatially distributed approach, based on the European Environmental Agency (EEA) 1-km reference grid, cropped over Italy. The EEA grid, within the European Terrestrial Reference System 1989 Datum, uses the Lambert Azimuthal Equal Area (LAEA) projection. Such a GIS-based approach enables the analysis of hydrological budget components over different areas, including regions, RBDs, river basins, and every subterritory in the country.

For each month and for each grid cell, the BIGBANG model calculates the following well-known balance equation:

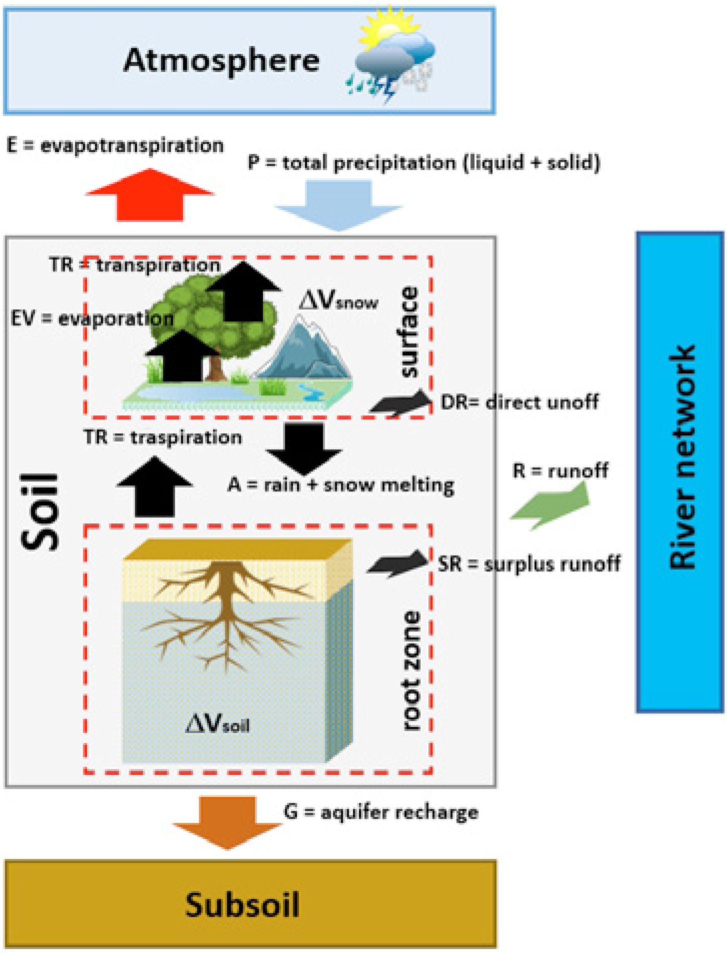
$$P - E = R + G + \Delta V_{soil} + \Delta V_{snow} \qquad \textit{eq. 3.1}$$

where P is the total precipitation, E is the actual evapotranspiration, G is the aquifer or groundwater recharge and R is the surface runoff. ΔV_{soil} and ΔV_{snow} are net volume variations, which are stored in the soil and in the snow cover respectively in the same month (Figure 3.1).

1 Italian acronym of “Bilancio Idrologico GIS BAsed a scala Nazionale su Griglia regolare” meaning “Nationwide GIS-based hydrological budget on a regular grid”.

According to the definition provided by FAO in the AQUASTAT glossary and by other international organizations[2] (OECD, Eurostat, EEA, UNEP, UNECE, etc.), Internal renewable water resources (IRWR) are equal to the long-term annual average of the term (P - E) or, similarly, of the term (R+G), because the long annual average of volume variations on the right hand side of equation (eq. 3.1) is virtually zero for all practical applications. Taking into account the term (P - E) or (R+G) also avoids the overlap of surface water and groundwater resources.

Figure 3.1 – Water budget scheme in the BIGBANG model

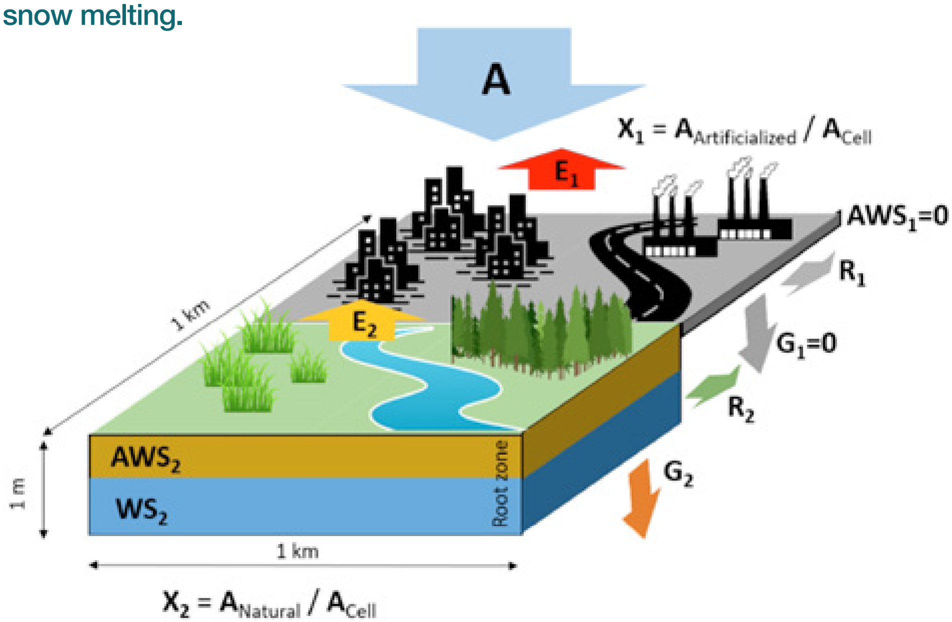


Source: Braca *et al.*, 2021, (translated into English).

2 Internal flow definition: long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. The internal flow is equal to precipitation less actual evapotranspiration.

The BIGBANG model also takes into account, within each cell, the status of the land cover, obtained by ISPRA at national level from the impervious layers made available by the EU Copernicus Land Monitoring Service. Each cell is characterized by a soil-sealing rate, defined as a percentage of artificialized territory. Water balance therefore considers two different land cover levels, indicated in Figure 3.2 with index 1 for *artificial* and index 2 for *natural* land cover. Moreover, water balance is applied for each 1-km grid cell without any consideration of the horizontal motion of water on the ground surface, or in the soil. As a reservoir, the BIGBANG model schematizes a volume of soil of 1-km grid for 1-m depth, whose maximum capacity is defined in terms of available water storage (AWS) depending on soil texture. The variable representing the soil moisture at the end of the month is the water storage (WS).

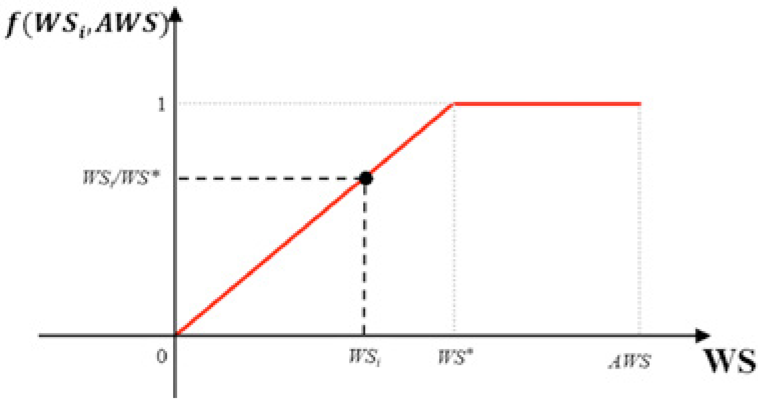
Figure 3.2 – Water budget scheme over each cell (according to the two different land cover classes) in BIGBANG model where A is rain plus snow melting.



Source: Braca *et al.*, 2021, (translated into English).

The soil scheme adopted in the BIGBANG model is similar to the one in Allen *et al.* (1998); the actual evapotranspiration is calculated as potential evapotranspiration multiplied by a coefficient, variable between 0 and 1, depending on soil WS (or content) and the maximum AWS – that is, the water content between the field capacity and the wilting point of the soil (Figure 3.3).

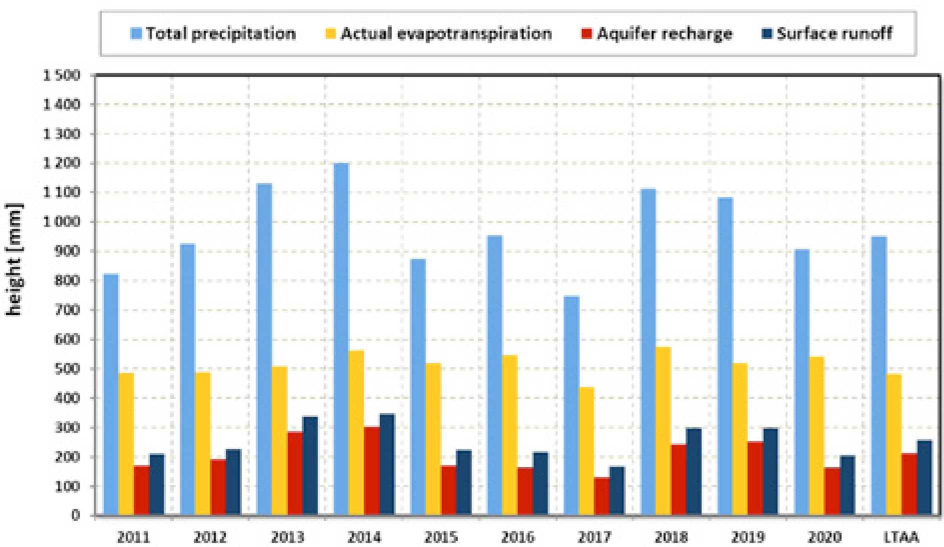
Figure 3.3 – Coefficient used for calculating actual evapotranspiration in BIGBANG model



Source: ibid

Using the currently operational version 5.0 of the BIGBANG model (hereafter BIGBANG 5.0), the water budget components were estimated at monthly intervals, from 1951 to 2020 (Figure 3.4). BIGBANG 5.0 estimates a current LTAA evapotranspiration of 482.6 mm for Italy.

Figure 3.4 – Annual water balance main components in Italy for the ten-year period 2011–2020 and for the long-term annual average (LTAA) following the 1951–2020 baseline, as estimated by BIGBANG 5.0.



Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

An analysis was also conducted applying the GlobWAT water balance model (Hoogeveen *et al.*, 2015), which was used by FAO to disaggregate the SDG 6.4.2 by major river basin on a global scale. The aim was to compare and contrast the results modelled by FAO with the BIGBANG estimations over Italy. GlobWAT was used to calculate annual mean values from 1961 to 1990 using the same rainfall data as in BIGBANG for input.

As shown in Table 3.3, it appears that BIGBANG overestimates the groundwater recharge in respect of GlobWAT. By contrast, GlobWAT runoff estimations are higher than the BIGBANG ones. If the two components of runoff (drainage) and aquifer recharge (groundwater) are considered together, the differences between the two models represent an average of 30 mm in all RBDs except for Sicily, where the difference is greater and equal to 74.0 mm.

Table 3.1 – GlobWAT annual average results referred to the thirty-year period 1961–1990

GlobWAT annual average results referred to the thirty-year period 1961–1990												
River Basin District	Total precipitation		Actual evapo-transpiration		Aquifer recharge (Groundwa-ter)		Runoff (Drain-age)		Aquifer recharge + Runoff	
	mm	km³	mm	km³	mm	km³	mm	km³	mm	km³
Eastern Alps	1 138.2	39.6	467.7	16.3	238.4	8.3	434.1	15.1	672.6	23.4
Po River	999.8	83.0	453.8	37.7	179.3	14.9	370.2	30.7	549.6	45.6
Northern Apennines	1 011.7	24.6	450.0	11.0	160.2	3.9	405.4	9.9	565.6	13.8
Central Apennines	964.3	40.9	481.8	20.4	176.0	7.5	309.1	13.1	485.1	20.6
Southern Apennines	902.6	61.1	419.0	28.3	131.8	8.9	355.5	24.0	487.3	33.0
Sardinia	719.3	17.3	384.2	9.3	86.8	2.1	250.3	6.0	337.1	8.1
Sicily	647.7	16.7	341.6	8.8	57.8	1.5	252.0	6.5	309.8	8.0
ITALY	937.5	283.2	436.1	131.7	155.7	47.0	348.9	105.4	504.6	152.4

Source: Authors' own elaboration.

Table 3.2 – BIGBANG 5.0 annual average results referred to the thirty-year-period 1961–1990

BIGBANG 5.0 annual average results referred to the thirty-year period 1961–1990										
River Basin District	Total precipitation		Actual evapotranspiration		Aquifer recharge (Groundwater)		Runoff (Drainage)		Aquifer recharge + Runoff	
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3
Eastern Alps	1 156.2	40.2	506.3	17.6	370.4	12.9	284.8	9.9	651.2	22.7
Po River	1 003.8	83.3	477.6	39.6	209.3	17.4	317.9	26.4	527.1	43.7
Northern Apennines	1 031.5	25.1	501.3	12.2	205.4	5.0	324.6	7.9	530.1	12.9
Central Apennines	957.8	40.6	506.5	21.5	219.8	9.3	231.1	9.8	450.8	19.1
Southern Apennines	902.3	61.0	452.7	30.6	213.0	14.4	236.3	16.0	449.5	30.4
Sardinia	710.4	17.1	405.1	9.8	119.5	2.9	185.8	4.5	305.3	7.4
Sicily	623.1	16.1	387.9	10.0	94.7	2.4	141.4	3.7	235.8	6.1
ITALY	938.4	283.5	467.9	141.3	212.8	64.3	258.5	78.1	470.9	142.2

Source: ISPRA. 2022. www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

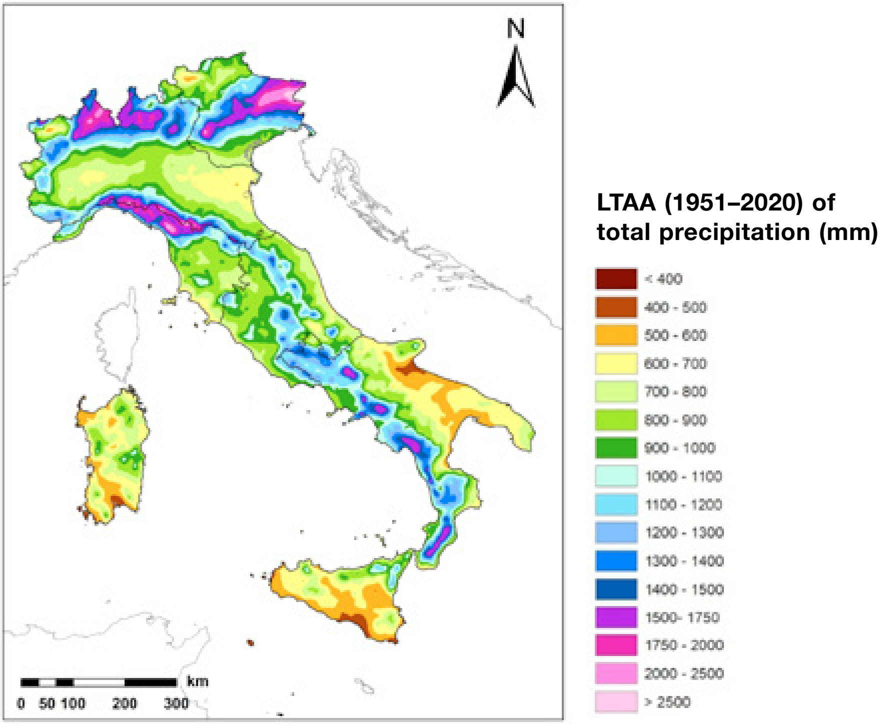
Table 3.3 – Difference between GlobWAT and BIGBANG 5.0 annual average results, referred to the thirty-year period 1961–1990

Difference between GlobWAT and BIGBANG 5.0 annual average results referred to the thirty-year period 1961–1990										
River Basin District	Total precipitation		Actual evapotranspiration		Aquifer recharge (Groundwater)		Runoff (Drainage)		Aquifer recharge + Runoff	
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3
Eastern Alps	-18.0	-0.6	-38.6	-1.3	-132.0	-4.6	149.3	5.2	21.4	0.7
Po River	-4.0	-0.3	-23.8	-1.9	-30.0	-2.5	52.3	4.3	22.5	1.9
Northern Apennines	-19.8	-0.5	-51.3	-1.2	-45.2	-1.1	80.8	2.0	35.5	0.9
Central Apennines	6.5	0.3	-24.7	-1.1	-43.8	-1.8	78.0	3.3	34.3	1.5
Southern Apennines	0.3	0.1	-33.7	-2.3	-81.2	-5.5	119.2	8.0	37.8	2.6
Sardinia	8.9	0.2	-20.9	-0.5	-32.7	-0.8	64.5	1.5	31.8	0.7
Sicily	24.6	0.6	-46.3	-1.2	-36.9	-0.9	110.6	2.8	74.0	1.9
ITALY	-0.9	-0.3	-31.8	-9.6	-57.1	-17.3	90.4	27.3	33.7	10.2

Source: Authors' own elaboration.

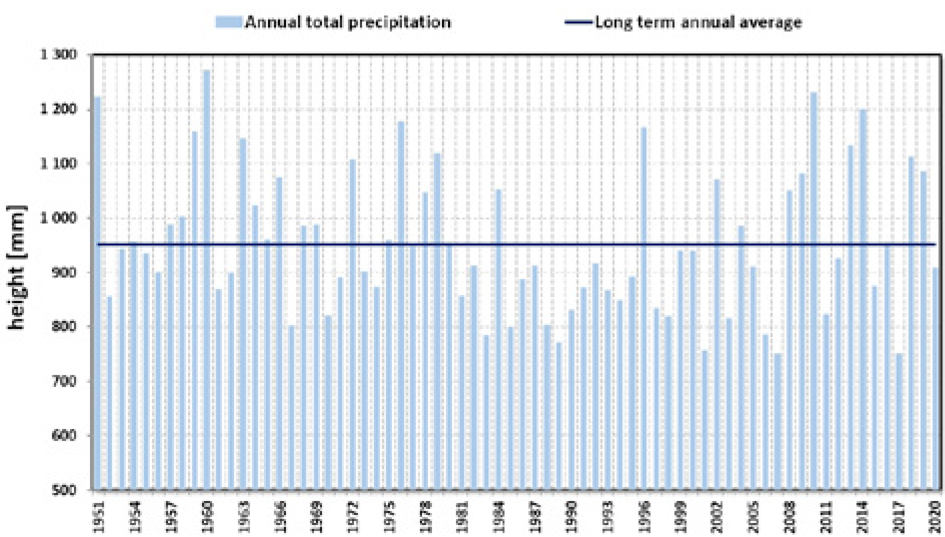
The following figures illustrate LTAA and time series from 1951 to 2020 for the main water balance components: precipitation in Figure 3.5 and Figure 3.6; actual evapotranspiration in Figure 3.7 and Figure 3.8; surface runoff in Figure 3.9 and Figure 3.10; and aquifer recharge in Figure 3.11 and Figure 3.12. It should be noted that in the AQUASTAT database, the current value of mean annual precipitation in Italy is reported as 832 mm whereas BIGBANG 5.0 estimates a long-term annual average of 952.6 mm. This latter value is in line with national assessments over the years, based on observed rain gauge data, and was confirmed by a recent study of the Italian climate by Crespi *et al.*, (2018).

Figure 3.5 – LTAA (1951–2020) of total precipitation in Italy estimated using the BIGBANG 5.0 water budget model



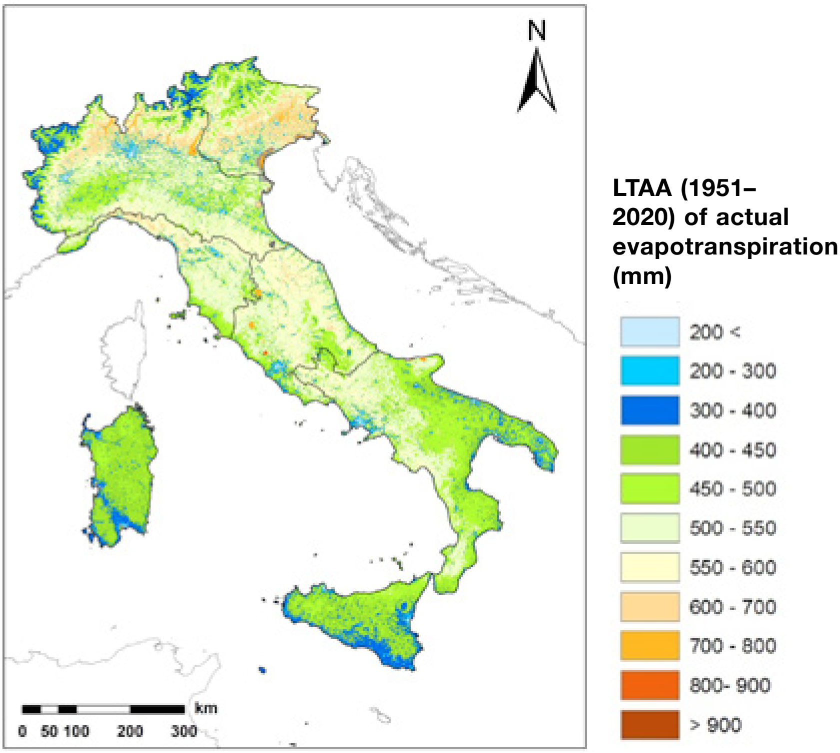
ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.6 – Annual total precipitation from 1951 to 2020 in Italy estimated using the BIGBANG 5.0 water budget model



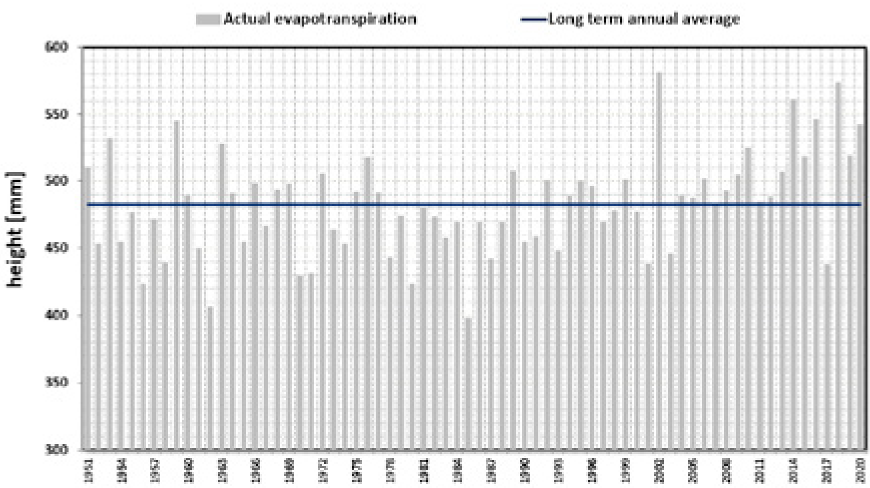
ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.7 – LTAA (1951–2020) of actual evapotranspiration in Italy estimated using the BIGBANG 5.0 water budget model



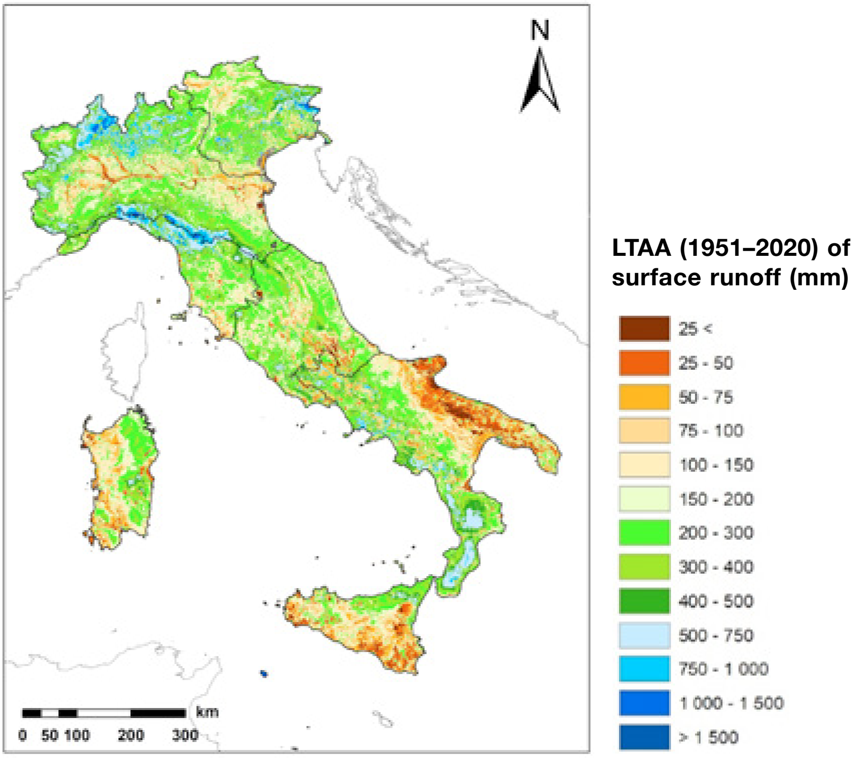
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.8 – Annual actual evapotranspiration from 1951 to 2020 in Italy estimated using the BIGBANG 5.0 water budget model



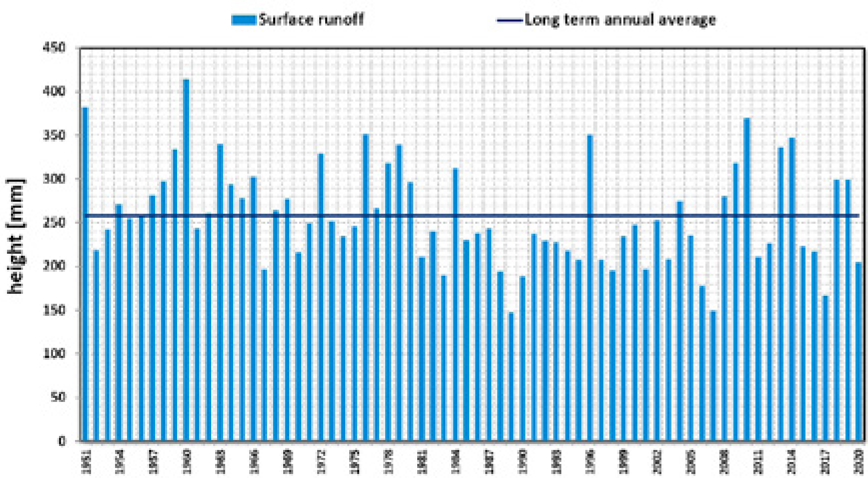
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.9 – LTAA (1951–2020) of surface runoff in Italy estimated using the BIGBANG 5.0 water budget model



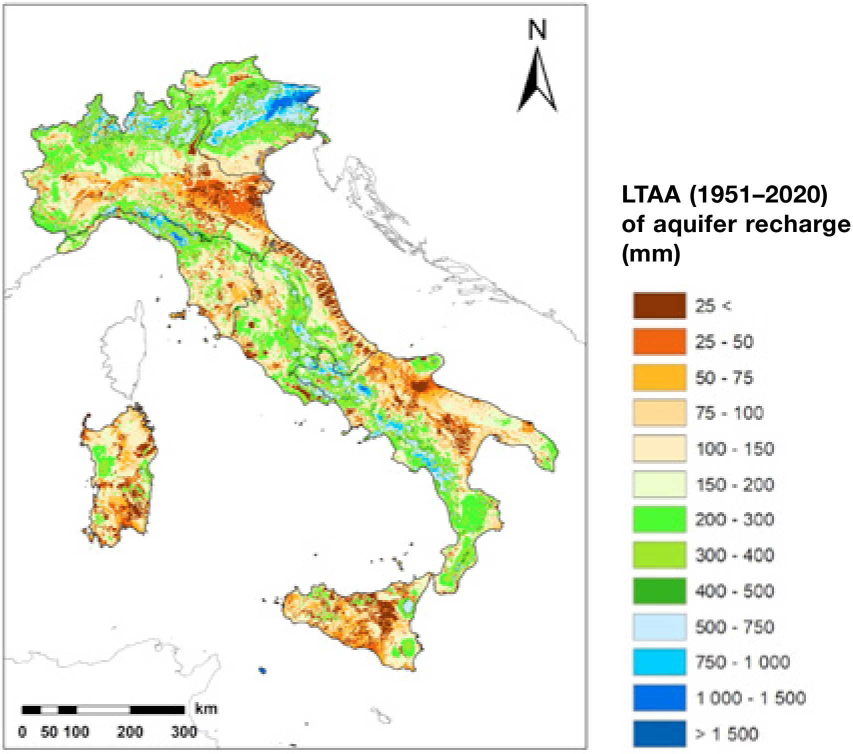
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.10 – Annual surface runoff from 1951 to 2020 in Italy estimated using the BIGBANG 5.0 water budget model



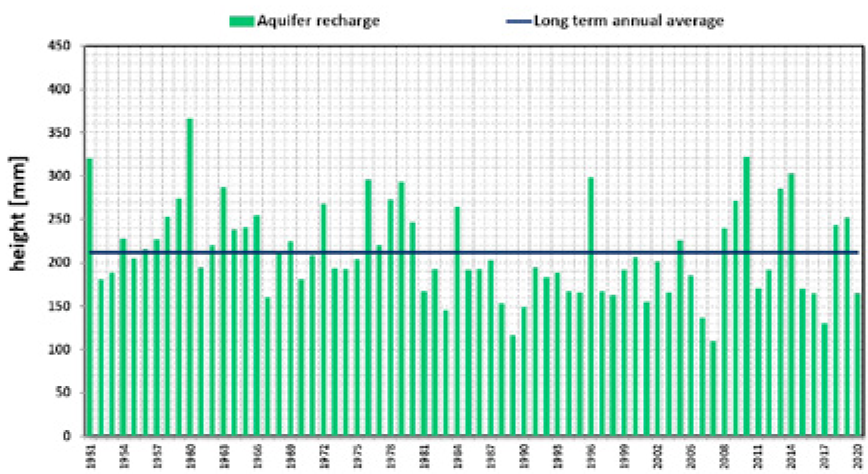
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.11 – LTAA (1951–2020) of aquifer recharge in Italy estimated using the BIGBANG 5.0 water budget model



Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 3.12 – Annual aquifer recharge from 1951 to 2020 in Italy estimated using the BIGBANG 5.0 water budget model



Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Total renewable water resources

In the AQUASTAT Glossary (FAO, 2019), total renewable water resources (TRWR) are defined as *"The sum of internal renewable water resources (IRWR) and external renewable water resources (ERWR). It corresponds to the maximum theoretical yearly amount of water available for a country at a given moment"*, and are calculated using the following equation:

[Total renewable water resources] = [Total renewable surface water] + [Total renewable groundwater] – [Overlap between surface water and groundwater], *eq. 4.1*

expressed in terms of billions of cubic metres per year (10^9 m^3/year).

However, in this report TRWR are calculated without any differentiation between surface water and groundwater, but only as the sum of IRWR and ERWR:

[Total renewable water resources] = [Internal renewable water resources] + [External renewable water resources]. *eq. 4.2*

Internal renewable water resources (IRWR)

In the AQUASTAT Glossary (FAO, 2019), IRWR are defined as the:

> *"long-term average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. Double counting of surface water and groundwater resources is avoided by deducting the overlap from the sum of the surface water and groundwater resources".*

The calculation uses the following equation:

[Total IRWR] = [Groundwater produced internally] + [Surface water produced internally] – [Overlap between surface water and groundwater]. *eq. 4.3*

As mentioned above, the calculations in the present report were made without any distinction between surface water and groundwater, so that IRWR were calculated using the formula:

$$IRWR = P - E'' \qquad \textit{eq. 4.4}$$

where P is the LTAA for annual total precipitation and E is the LTAA for annual actual evapotranspiration in the territory.

The term P-E in the hydrological LTAA water balance (eq. 3.1) represents exactly the average of the sum of annual river flow and of annual aquifer recharge generated only by endogenous precipitation. The same expression is also termed as *Internal Flow* by Eurostat and OECD (2018). So it is restated that IRWR can be expressed interchangeably by term (P-E) or term (G+R).

In Table 4.1 the IRWR estimations achieved by BIGBANG 5.0 for the Italian RBD territories and for the entire Italian territory are shown. Because IRWR are required as LTAA, monthly values were aggregated on a yearly scale and then averaged.

In calculating long term, either the entire available period 1951–2020 or various thirty-year periods inferable from it were used.

In Table 4.1 the average results of water balance for the entire available period 1951–2020 are shown, while in Table 4.2, Table 4.3, Table 4.4 and Table 4.5 the water budget components and the IRWR averaged over the climatological thirty-year periods 1951–1980, 1961–1990, 1971–2000 and 1981–2010 are reported respectively. Finally, Table 4.6 presents the average results of water balance for the most recent climatological 30-year period available, that is, 1991–2020, used in the calculation of the water stress indicator.

Figure 4.1 summarizes and illustrates the change over time in IRWR for RBDs. It should be noted that there is a clear decreasing trend in the first four periods, which is however not confirmed by the last 30 years, in which the trend has been reversed. In any case, it remains below the long-term average. In fact, in this recent 30-year time period 1991–2020, the IRWR in Italy are estimated in about 135 billion cubic metres (km^3) per years, less than the LTAA calculated for the entire available period 1951–2020, is estimated at about 142 billion cubic metres (km^3) per year. Similarly, per capita water resources were reduced compared to the LTAA (Table 4.7).

Figure 4.2 and Figure 4.3 illustrate the LTAA map for Italy and the period from 1951 to 2020 of IRWR.

Table 4.1 – LTAA (1951–2020) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

LTAA (1951–2020) for water balance components and IRWR estimated through the BIGBANG 5.0 model											
River basin district	Total precipitation		Actual evapotranspiration		Aquifer recharge		Runoff		IRWR		
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3
Eastern Alps	1 197.6	41.7	525.4	18.3	382.5	13.3	292.6	10.2	670.9	23.4
Po River	1 021.3	84.7	496.3	41.2	207.7	17.2	317.3	26.3	524.9	43.6
Northern Apennines	1 040.4	25.3	508.8	12.4	206.5	5.0	325.0	7.9	531.6	12.9
Central Apennines	947.9	40.2	513.8	21.8	209.7	8.9	224.4	9.5	434.1	18.4

Southern Apennines	911.6	61.7	466.7	31.6	210.6	14.2	234.4	15.9	444.8	30.1
Sardinia	701.3	16.9	417.6	10.1	110.0	2.7	173.7	4.2	283.7	6.8
Sicily	668.8	17.3	406.7	10.5	108.6	2.8	154.7	4.0	262.6	6.8
ITALY	952.6	287.8	482.6	145.8	212.3	64.1	258.1	78.0	469.8	141.9

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.2 – Thirty-year average (1951–1980) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

Thirty-year average (1951–1980) for water balance components and IRWR estimated through the BIGBANG 5.0 model										
River basin district	**Total precipitation**		**Actual evapotranspiration**		**Aquifer recharge**		**Runoff**		**IRWR**	
	mm	**km^3**	**mm**	**km^3**	**mm**	**km^3**	**mm**	**km^3**	**mm**	**km^3**
Eastern Alps	1 199.1	41.7	500.8	17.4	399.5	13.9	302.0	10.5	697.3	24.3
Po River	1 058.1	87.8	483.8	40.1	229.1	19.0	345.0	28.6	573.7	47.6
Northern Apennines	1 088.7	26.5	505.5	12.3	227.9	5.5	355.2	8.6	583.1	14.2
Central Apennines	1 003.7	42.5	508.0	21.5	241.0	10.2	254.5	10.8	495.5	21.0
Southern Apennines	966.2	65.4	464.3	31.4	239.4	16.2	262.8	17.8	501.9	33.9
Sardinia	762.0	18.4	413.5	10.0	135.8	3.3	212.8	5.1	348.5	8.4
Sicily	680.2	17.6	398.5	10.3	117.4	3.0	166.3	4.3	282.3	7.3
ITALY	992.7	299.9	473.7	143.1	235.5	71.1	283.9	85.8	518.7	156.7

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.3 – Thirty-year average (1961–1990) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

Thirty-year average (1961–1990) for water balance components and IRWR estimated through the BIGBANG 5.0 model											
River basin district	Total precipitation		Actual evapotranspiration		Aquifer recharge		Runoff		IRWR		
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3
Eastern Alps	1 156.2	40.2	506.3	17.6	370.4	12.9	284.8	9.9	651.2	22.7
Po River	1 003.8	83.3	477.6	39.6	209.3	17.4	317.9	26.4	527.1	43.7
Northern Apennines	1 031.5	25.1	501.3	12.2	205.4	5.0	324.6	7.9	530.1	12.9
Central Apennines	957.8	40.6	506.5	21.5	219.8	9.3	231.1	9.8	450.8	19.1
Southern Apennines	902.3	61.0	452.7	30.6	213.0	14.4	236.3	16.0	449.5	30.4
Sardinia	710.4	17.1	405.1	9.8	119.5	2.9	185.8	4.5	305.3	7.4
Sicily	623.1	16.1	387.9	10.0	94.7	2.4	141.4	3.7	235.8	6.1
ITALY	938.4	283.5	467.9	141.3	212.8	64.3	258.5	78.1	470.9	142.2

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.4 – Thirty-year average (1971–2000) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

Thirty-year average (1971–2000) for water balance components and IRWR estimated through the BIGBANG 5.0 model										
River basin district	Total precipitation		Actual evapotranspiration		Aquifer recharge		Runoff		IRWR	
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3
Eastern Alps	1 143.4	39.8	513.2	17.9	356.5	12.4	276.4	9.6	629.3	21.9
Po River	1 016.9	84.4	488.1	40.5	210.0	17.4	318.1	26.4	528.3	43.8
Northern Apennines	998.7	24.3	501.6	12.2	191.8	4.7	305.3	7.4	497.2	12.1
Central Apennines	926.0	39.2	504.4	21.4	204.8	8.7	216.6	9.2	421.7	17.9
Southern Apennines	866.5	58.6	447.0	30.2	198.7	13.4	221.0	14.9	419.5	28.4
Sardinia	670.9	16.2	416.7	10.0	97.9	2.4	155.8	3.8	254.1	6.1
Sicily	626.2	16.2	392.3	10.1	95.1	2.5	138.9	3.6	234.4	6.1
ITALY	922.6	278.7	471.3	142.4	203.3	61.4	248.0	74.9	451.0	136.2

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.5 – Thirty-year average (1981–2010) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

Thirty-year average (1981–2010) of water balance components and IRWR estimated through the BIGBANG 5.0 model											
River basin district	Total precipitation		Actual evapotranspiration		Aquifer recharge		Runoff		IRWR		
	mm	km^3	mm	km^3	mm	km^3	mm	km^3	mm	km^3	
Eastern Alps	1 156.9	40.3	532.9	18.5	351.7	12.2	273.9	9.5	621.9	21.6	
Po River	980.4	81.4	498.1	41.3	189.1	15.7	292.1	24.2	481.3	39.9	
Northern Apennines	979.5	23.8	502.9	12.2	183.3	4.5	293.0	7.1	476.4	11.6	
Central Apennines	894.7	37.9	506.6	21.5	187.4	7.9	200.9	8.5	388.2	16.4	
Southern Apennines	850.8	57.6	455.0	30.8	186.4	12.6	209.3	14.2	395.9	26.8	
Sardinia	649.6	15.7	416.7	10.0	89.4	2.2	143.5	3.5	232.9	5.6	
Sicily	643.8	16.6	406.4	10.5	97.5	2.5	141.2	3.6	237.8	6.1	
ITALY	904.4	273.2	479.7	144.9	190.6	57.6	233.9	70.7	424.2	128.1	

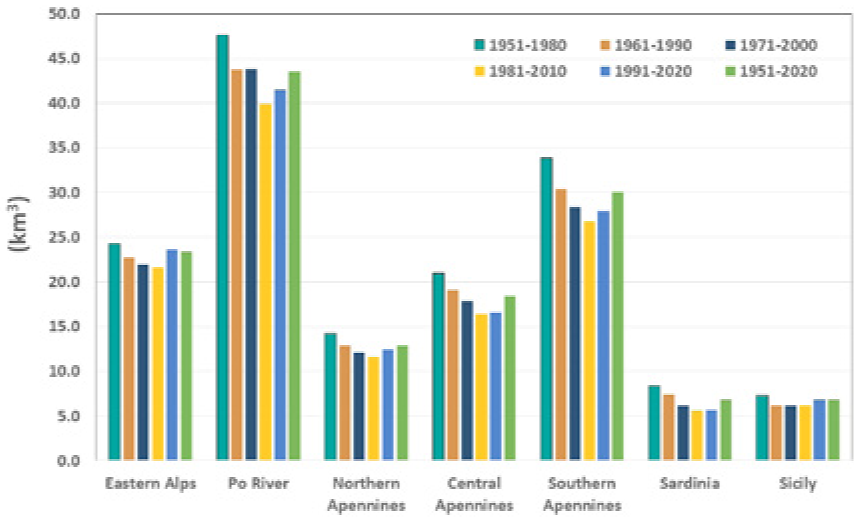
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.6 – Thirty-year average (1991–2020) for water balance components and IRWR for Italian RBDs (based on BIGBANG 5.0)

Thirty-year average (1991–2020) of water balance components and IRWR estimated through the BIGBANG 5.0 model										
River basin district	Total precipitation		Actual evapotranspiration		Aquifer recharge		Runoff		IRWR	
	mm	km³	mm	km³	mm	km³	mm	km³	mm	km³
Eastern Alps	1 228.7	42.8	551.1	19.2	385.8	13.4	295.6	10.3	677.2	23.6
Po River	1 014.4	84.2	515.5	42.8	196.1	16.3	303.7	25.2	499.7	41.5
Northern Apennines	1 028.2	25.0	517.9	12.6	197.9	4.8	312.5	7.6	510.5	12.4
Central Apennines	915.8	38.8	524.0	22.2	187.8	8.0	204.6	8.7	392.4	16.6
Southern Apennines	892.7	60.4	480.4	32.5	194.3	13.1	218.2	14.8	412.4	27.9
Sardinia	663.6	16.0	426.2	10.3	91.1	2.2	146.3	3.5	237.4	5.7
Sicily	687.7	17.8	424.9	11.0	109.6	2.8	154.3	4.0	263.3	6.8
ITALY	943.2	284.9	498.3	150.5	200.6	60.6	245.0	74.0	445.2	134.5

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 4.1 – IRWR averaged over different climatological 30-year periods and LTAA for Italian RBDs



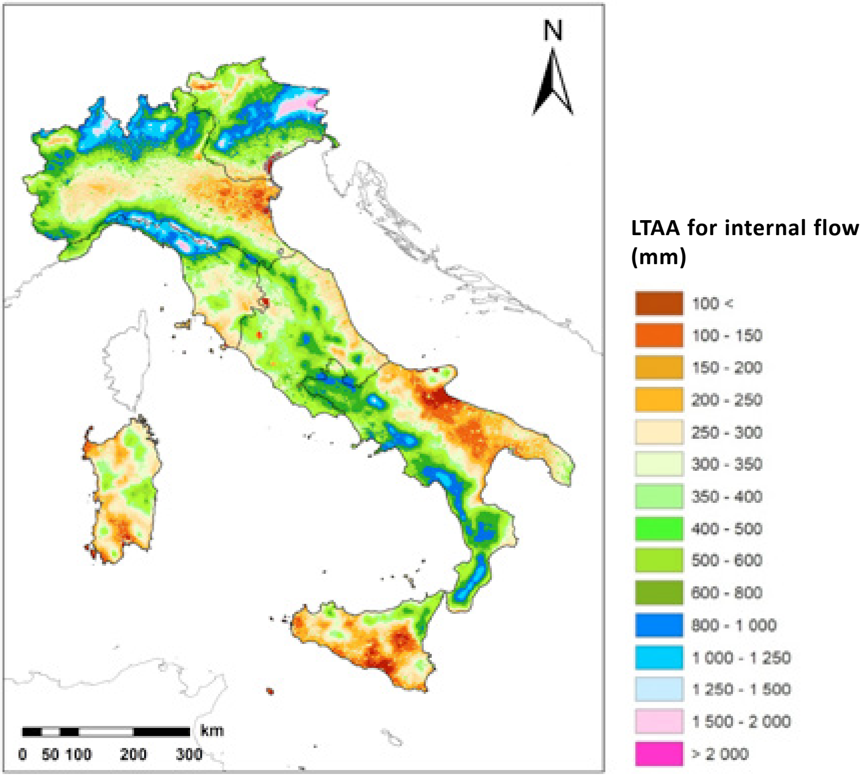
Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table 4.7 – IRWR for Italian RBDs per capita

River basin district	Population	IRWR per capita (m^3/inhab)	
	Million inhab	1951–2020	1991–2020
Eastern Alps	6.96	3 355	3 386
Po River	19.8	2 200	2 094
Northern Apennines	4.95	2 614	2 510
Central Apennines	7.89	2 331	2 107
Southern Apennines	13.4	2 246	2 082
Sardinia	1.61	4 246	3 554
Sicily	5.07	1 338	1 342
ITALY	59.7	2 377	2 253

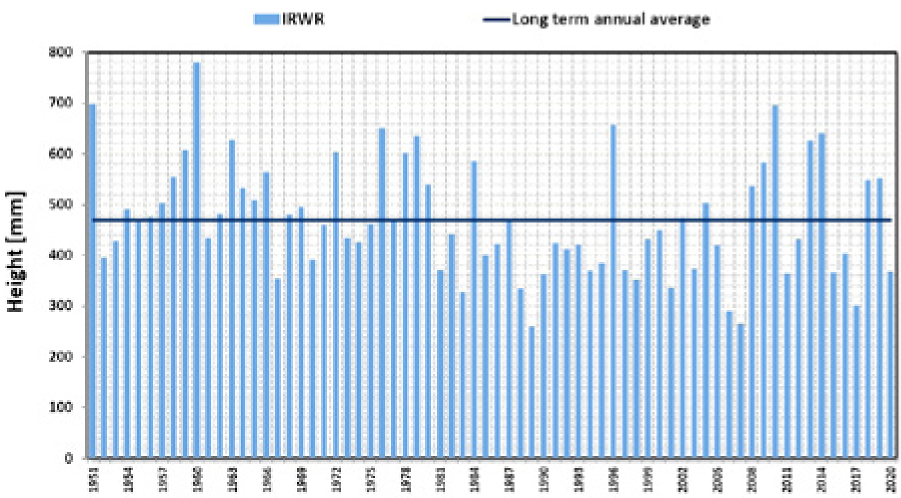
Source: River Basin Management Plan. ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html.

Figure 4.2 – LTAA (1951–2020) for IRWR in Italy estimated using the BIGBANG 5.0 water budget model



Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 4.3 – IRWR (1951– 2020) in Italy estimated using the BIGBANG 5.0 water budget model



Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

External renewable water resources

As mentioned in the AQUASTAT Glossary (FAO, 2019), ERWR are defined as:

> *"That part of the country's long-term average annual renewable water resources which are not generated in the country. It includes inflows from upstream countries (groundwater and surface water), and part of the water of border lakes and/or rivers. The ERWR take into account the quantity of flow reserved by upstream (incoming flow) and/or downstream (outflow) countries through formal or informal agreements or treaties. Therefore, it may vary with time. In extreme cases, it may be negative when the flow reserved to downstream countries is more than the incoming flow"*.

External renewable water resources from conterminous districts

There are no water surface fluxes among RBDs along their boundaries, as they are made up of one or more neighbouring river basins. As is well known, a river basin, referred to as a river cross section, is defined as the portion of territory that drains all precipitations falling on its surface net to hydrological losses, so that no water can be transferred to the conterminous territories through the surface.

On the other hand, it is not possible to estimate groundwater fluxes within internal boundaries. We therefore consider the contribution of groundwater fluxes among RBDs as negligible with respect to the IRWR totals.

External renewable water resources from foreign conterminous countries

Italy shares with foreign conterminous countries some portions of river basins, which drain both from and towards external territories. The Italian RBDs which share river basin portions are the Eastern Alps, River Po and Northern Apennines (Figure 4.5).

In particular, for the purposes of the present report, it is necessary to estimate the water surface fluxes that mostly reach Italy from conterminous countries. Few parts of the Italian territory drain to external foreign territories. For each RBD and for each country, the incoming water average flows were estimated first, followed by the outgoing ones.

Surface water entering Italy

In the following section, only the estimates of the surface water resources coming from the conterminous countries are reported for each RBD. The interchange of groundwater resources was omitted.

In detail, moving from East to West (Figure 4.4):

- The Eastern Alps RBD shares the river basins of the following rivers or streams with Slovenia:
  - Timavo (*Timav* or *Reka* in Slovenian, *Timava* in Croatian);
  - Ospo (*Osapska* in Slovenian) and Rosandra (*Glinščica* in Slovenian) which flows into the Adriatic Sea;
  - Vipacco (in Slovenian *Vipava*);
  - Isonzo (*Soča* in Slovenian);
  - Piumizza (*Pevmica* in Slovenian);
  - Versa (*Birša* in Slovenian);
  - Oblino (*Oblent* in Slovenian);
  - Fidri (*Fedrih* in Slovenian);
  - Reca (*Reka* in Slovenian) which flows through the Italian territory into the Isonzo River;
  - Judrio (*Idrija* in Slovenian) which for half of its length forms the boundary between Italy and Slovenia; and
  - Natisone (*Nadiža* in Slovenian).
- The Eastern Alps RBD shares the river basins of the following rivers or streams with Switzerland:
  - Ram (in German *Rambach, Rom* in Romansh).
- The River Po RBD shares the river basins of the following rivers or streams with Switzerland:
  - Poschiavino, which flows into the Adda River;
  - Mera (*Maira* in Switzerland), which flows into Lake Como;
  - Breggia, which flows into Lake Como;
  - Ticino (*Tessin* in German), with Lake Maggiore;
  - Tresa, with Lake Lugano,of which it is the outlet;

  - Giona stream, which flows into Lake Maggiore; and
  - Diveria (*Krumm Bach* in German) which flows into the Toce River;
- The River Po RBD shares the river basins of the following rivers or streams with France:
  - Cenischia (in French *Cenise*), with Moncenisio (*Mont Cenis* in French) reservoir, which flows into the Dora Riparia River;
  - Rio di valle Stretta (*Ruisseau de la Vallée Étroite* in French) a little stream in the basin of the Dora di Bardonecchia River; and
  - Ripa stream, which rises in French territory near the Col de Montgenèvre;
- The Northern Apennines RBD shares the river basins of the following rivers or stream swith France:
  - Bevera (*Bévéra* in French) which is the main tributary of the Roya River in which it discharges downstream of the Italian border; and
  - Roja (*Roya* in French) which flows into the Ligurian Sea near Ventimiglia town.

The total area of external river basins that flow into Italy amounts to approximately 8 000 km^2, or around 2.5 percent of the Italian territory.

Table 4.8 illustrates the characteristics of the rivers entering Italy.

Figure 4.4 – Portions (in blue) of transnational river basins belonging to foreign countries that drain in the Italian territory.

Source: Authors' own elaboration.

Table 4.8 – Summary of the characteristics of the rivers entering Italy from conterminous countries. River basin areas are inferred based on GIS calculations. Therefore these figures do not exactly match the area extensions reported in other data sources

River or stream	Country of origin	Area of whole basin(1) km^2	Area of transnational basin km^2
Timavo	Slovenia	1 170	890
Ospo	Slovenia	39	23
Rosandra	Slovenia	52	29
Vipacco	Slovenia	606	587
Isonzo	Slovenia	1 602	1 572
Piumizza	Slovenia	14	10
Versa	Slovenia	69	11
Oblino	Slovenia	14	6
Fidri	Slovenia	10	4
Reca	Slovenia	37	34
Judrio	Slovenia	156	31
Natisone	Slovenia	344	69
Ram	Switzerland	183	130
Poschiavino	Switzerland	247	237
Mera	Switzerland	264	188
Ticino	Switzerland	2 990	2 782
Tresa	Switzerland	750	368
Giona	Switzerland	55	14
Breggia	Switzerland	84	62

River or stream	Country of origin	Area of whole basin(1) km^2	Area of transnational basin km^2
Diveria	**Switzerland**	320	173
Cenischia	**France**	146	82
Dora di Bardonecchia (Ruisseau de la Vallée Étroite)	**France**	241	46
Ripa	**France**	268	31
Roja	**France**	492	452
Bevera	**France**	160	130
TOTAL AREA			7 961

(1) Here, "river basin" refers to the main cross section, or a confluence section into a major river, or a section that flows into the sea immediately downstream of the country limits.

Source: Authors' own elaboration.

Surface water leaving the country

In the following section, for each RBD only the estimates of the surface water resources flowing towards conterminous countries are reported. The groundwater resource interchange was again omitted.

Moving from East to West (Figure 4.5):

- The Eastern Alps RBD shares the river basins of the following rivers or streams with Slovenia:
  - Legrada which flows into Slovenian reach of the Isonzo River, that returns downstream into Italy
  - Uccea, which flows into Slovenian reach of the Isonzo River, that returns downstream into Italy.
- The Eastern Alps RBD shares the river basins of the following rivers or streams with Austria:
  - Slizza (*Gailitz* in German, *Ziljica* in Slovenian) which flows into the Gail River, which is a tributary of the Drava River; and
  - Drava (*Drau* in German), which flows into the Danube River

  - Stillebach which flows into the Inn River, which is a tributary of the Danube River
- The River Po RBD shares the river basins of the following rivers or streams with Switzerland:
  - Uina stream which flows into the Inn River
  - Spöl (or Aqua Granda), which flows into the Inn River, which is a tributary of the Danube River; and
  - Reno di Lei, which flows into the Rhine River and is the only Italian river which flows into the North Sea.

The total of Italian zones which flow outside the country represents about 737 km^2, or around 0.2 percent of the whole territory.

The net water balance between Italy and conterminous foreign countries is clearly in favour of Italy, as the basin area entering Italy is much greater than the basin area leaving Italy (Table 4.10).

Due to the lack of more accurate data on the water resources entering Italy from neighbouring countries, this study was based on the estimates reported in AQUASTAT (Table 4.11).

Figure 4.5 – Portions (in red) of transnational river basins belonging to the Italian territory that drain towards conterminous countries

Source: Authors' own elaboration.

Table 4.9 – Summary of rivers and streams leaving Italy towards conterminous countries

River and streams	Country to which rivers are directed	Area of transnational basin in Italian territory km²
Legrada	Slovenia	45
Uccea	Slovenia	24
Slizza	Austria	192
Drava	Austria	160
Stillebach	Austria	13
Uina	Switzerland	4
Spöl	Switzerland	248
Reno di Lei	Switzerland	51
TOTAL		737

Source: Authors' own elaboration.

Table 4.10 – Summary of area of transnational basins entering or leaving the Italian territory listed by RBD

River Basin District	Area	Total Basin Area Entering	Total Basin Area Leaving
	km²	km²	km²
Eastern Alps	34 805	3 396	438
Po River	82 977	3 983	299
Northern Apennines	24 340	582	0
Central Apennines	42 373	0	0
Southern Apennines	67 646	0	0
Sardinia	24 100	0	0
Sicily	25 832	0	0
ITALY	302 073	7 961	737

Source: Authors' own elaboration.

Table 4.11 – Summary of the annual average volume of water exchange listed by foreign conterminous countries estimated in the AQUASTAT database

Country	Total Basin Area Entering from	Total Basin Area Leaving Italy toward	AQUASTAT Volume Entering from	AQUASTAT Volume Leaving Italy
	km^2	km^2	hm^3	hm^3
Slovenia	3 266	69	3 800	0
Austria	0	365	0	0
Switzerland	3 954	303	4 500	0
France	582	0	500	0
TOTAL	7 961	737	8 800	0

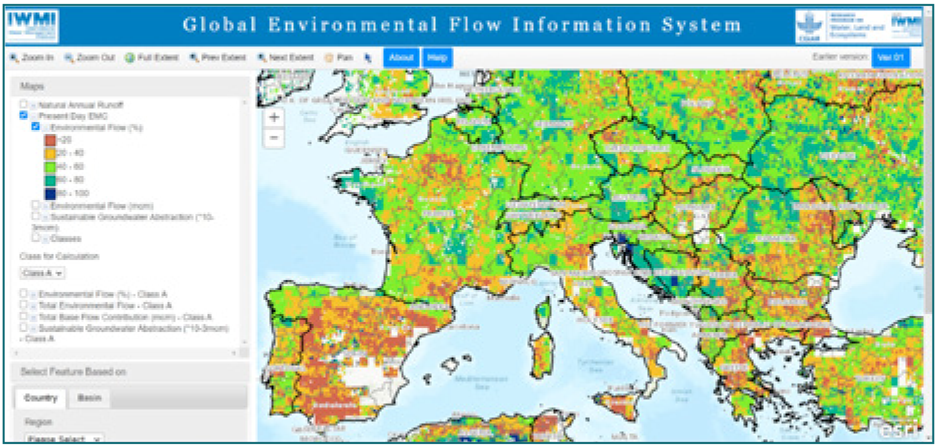
Source: Authors' own elaboration and FAO AQUASTAT. 2022. https://www.fao.org/aquastat/en/

Environmental flow requirements

Italy currently has no official methodology to estimate EFR as required in eq. 1.1. For this reason, in this report the assessment of EFR is based on the global estimates available on the online GEFIS-Global Environmental Flow Information System, version 01 (Figure 5.1), developed by the International Water Management Institute (IWMI) (Sood *et al.,* 2017; FAO, 2019).

Owing to the difference between the natural annual runoff (NAR) estimated for Italy in GEFIS and the runoff estimated using BIGBANG, the EFR data provided by GEFIS for Italy were not directly used. A different approach was applied to derive EFR from GEFIS estimates – applying current GEFIS EFR percentages to the TRWR estimated using the BIGBANG 5.0. The EFR percentages were calculated considering the ratio between the EFR and the NAR of GEFIS, both expressed in millions of cubic metres and aggregated by RBD. The resulting percentage of this ratio (the EFR percentage) was applied to the TRWR estimated by BIGBANG 5.0 (Figure 5.2, Figure 5.3, Figure 5.4).

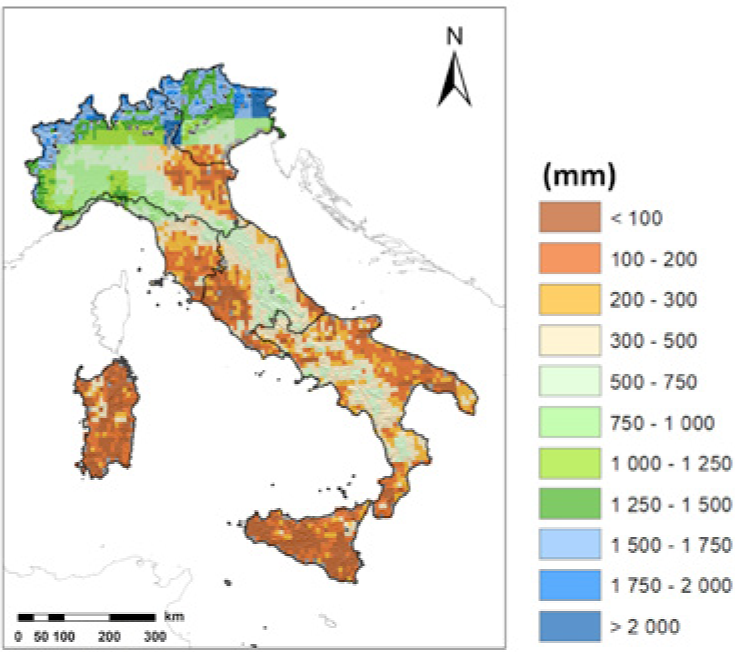
Figure 5.1 – GEFIS portal for EFR estimation



Source: GEFIS. 2022. https://eflows.iwmi.org/

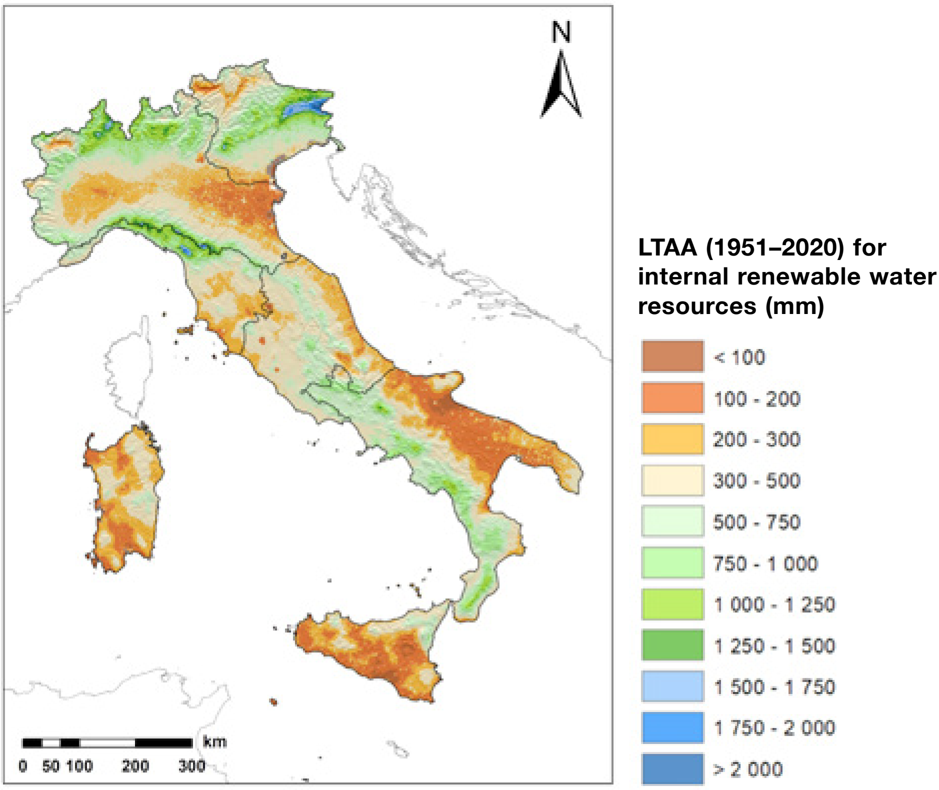
In order to be able to compare the evaluations of the BIGBANG model with those carried out in GEFIS, the latter were first transformed into unit values (expressed in mm) and then projected on the 1-km resolution grid as showed in Figure 5.2.

Figure 5.2 – NAR estimated in GEFIS, transformed into a LAEA projection on the EEA 1-km resolution grid and then expressed in mm



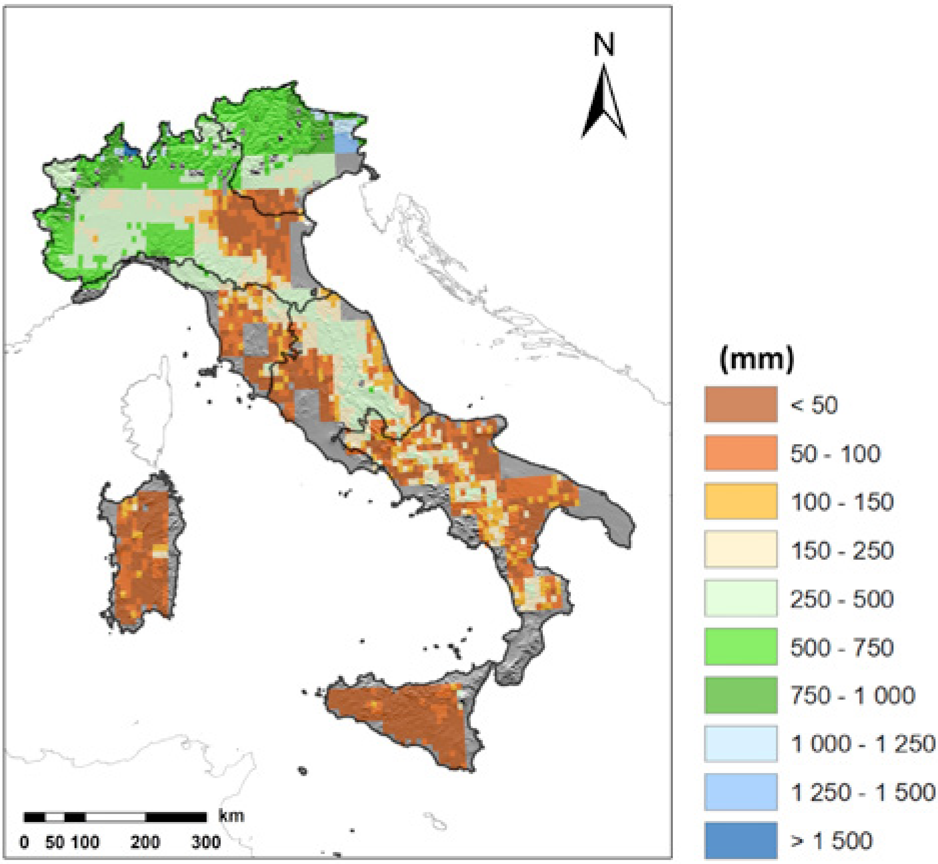
Source: Authors' own elaboration.

Figure 5.3 – LTAA (1951–2020) for IRWR in Italy estimated using the BIGBANG 5.0 model. For visual comparison, the same colour scale is used as in Figure 5.2



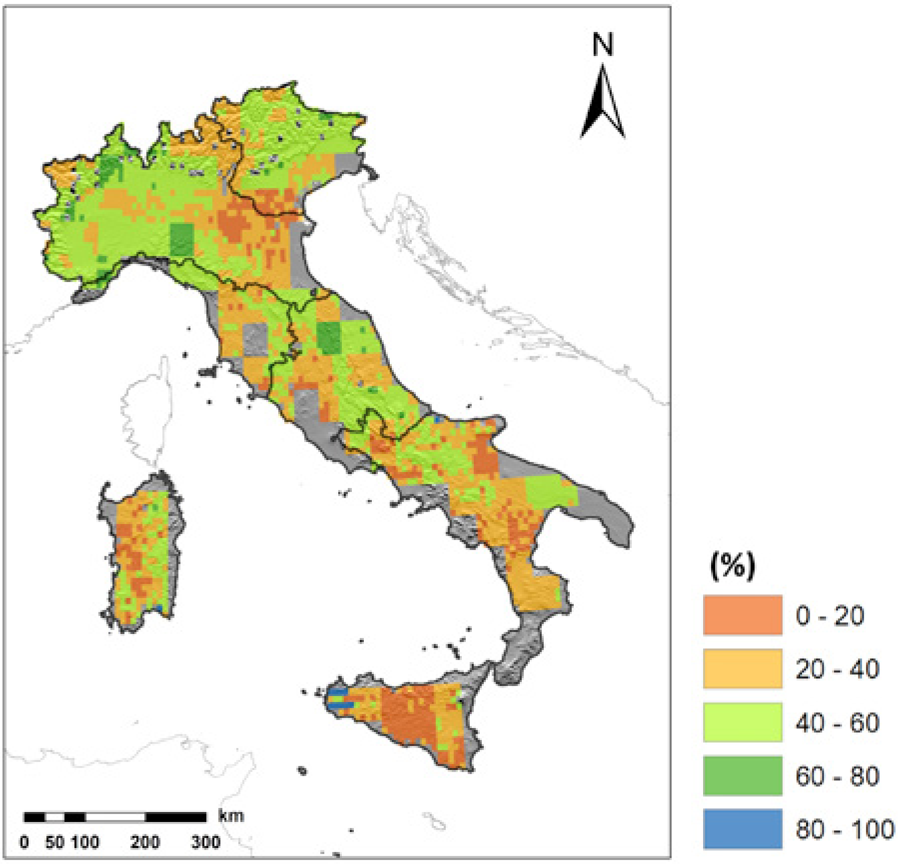
Source: Authors' own elaboration.

Figure 5.4 – Present-day EFR estimated in GEFIS, transformed into a LAEA projection on the EEA 1-km resolution grid and then expressed in mm



Source: Authors' own elaboration.

Figure 5.5 – Present-day EFR percentage with respect to natural runoff in GEFIS, transformed into a LAEA projection on the EEA 1-km resolution grid and then expressed in mm



Source: Authors' own elaboration.

Figure 5.6 – Environmental flow statistics for Italy provided by GEFIS

Type	Value (mcm - million cubic meters)
Class A Environmental Flow (mcm)	112 771.40
Class A Environmental Flow (%)	75.17
Base Flow (mcm)	44 796.83
Sustainable GW Abstraction (^10-3 mcm)	1 300.98
Present Day Enviornmental Flow (mcm)	65 845.96
Present Day Enviornmental Flow (%)	43,89
Present Day Sustainable GW Abstraction (^10-3 mcm)	2 807.31
Natural Annual Runoff (mcm)	150 012.16

Present day EMC classes

Type	Area (km^2)	Percentage (%)
Class A	0	0
Class B	159 100.00	28,28
Class C	286 400.00	50,9
Class D	4 500.00	0,8
No Data	112 674.60	20,02

Source: GEFIS. 2022. https://eflows.iwmi.org/

Table 5.1 – Summary of the values for present-day EFR and NAR estimated by GEFIS. Figures are listed by RBD and across Italy

River Basin District	Area	EFR_{GEFIS}	NAR_{GEFIS}	EFR_{GEFIS}/NAR_{GEFIS}
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	20 123	44 449	45.3
Po River	82 977	34 654	74 263	46.7
Northern Apennines	24 340	4 223	9 521	44.4
Central Apennines	42 373	7 877	15 451	51.0
Southern Apennines	67 646	7 089	19 303	36.7
Sardinia	24 100	1 036	2 911	35.6
Sicily	25 832	629	2 773	22.7
ITALY	302 073	75 631	168 670	44.8

Source: GEFIS. 2022. https://eflows.iwmi.org/

It should be noted that RBD areas where mean areal EFR_{GEFIS} is calculated are different from RBD areas where mean areal NAR_{GEFIS} is calculated – and both are different from actual areas of RBDs. Nevertheless, we assume that the mean areal values of NAR_{GEFIS} and EFR_{GEFIS} can also be extrapolated in those areas where they are not calculated.

The rates (EFR_{GEFIS}/NAR_{GEFIS}) calculated for each RBD from the GEFIS portal are then applied to TRWR estimated from BIGBANG and from the discharge data of foreign conterminous countries to obtain the $EFR_{BIGBANG}$ estimate, and thus the actual water availability.

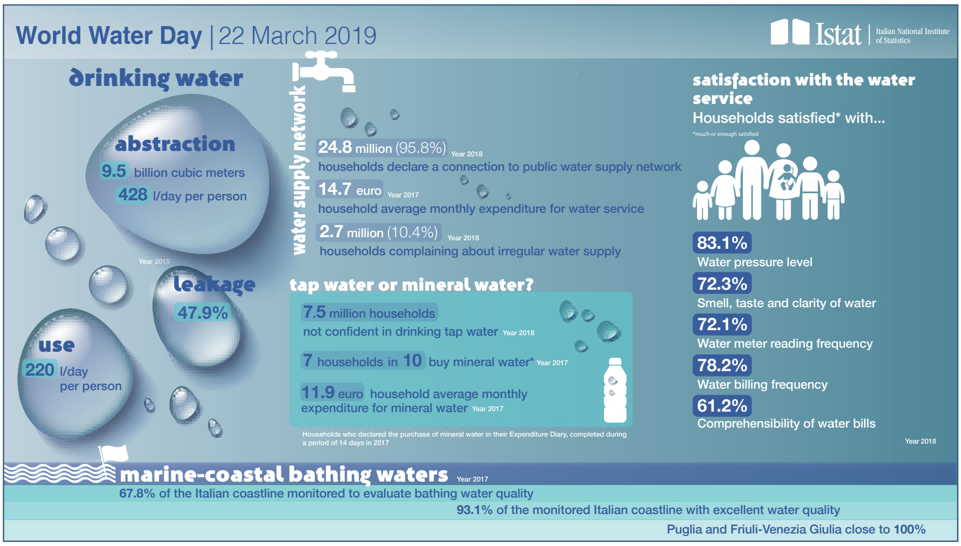
Water withdrawals

Water withdrawal data, used in the present report to calculate SDG 6.4.2 level of water stress indicators, are regularly collected and disseminated by Istat. In its institutional role, Istat calculates national official statistics about water resources and water use (Istat, 2019).

With the aim of increasing knowledge and devoting greater attention towards water resources, to mark the occasion of World Water Day, established by the United Nations and celebrated on March 22, Istat provides an annual summary of the main and most recently available water statistics in the form of reports and tables, downloadable from the institutional website.[3] Figure 6.1 offers an example of Istat communication on a combined set of indicators related to water. Some of these indicators are also periodically used to fill in international data collections (including Eurostat/OECD inland waters questionnaire; Eurostat regional water questionnaire; FAO AQUASTAT; SDG reporting).

[3] www.istat.it/en/archivio/268982

Figure 6.1 – Annual water abstraction and other statistics for public water supply in Italy, based on the 2015 Urban water census and other sources (Istat, Infographic published on the occasion of World Water Day 2019, at https://www.istat.it/en/archivio/228780)



Source: Istat, Water Statistics. 2019. https://www.istat.it/en/archivio/268982

Civil use

Data on public water supply, from water withdrawal for drinkable use to urban wastewater treatment, are regularly collected by Istat. Although its focus on water affairs began in the 1950s, it is only since 1999 that Istat has periodically collected information on water resources for civil use[4] with a dedicated Urban water census, in which the respondent units are water operators.[5] Since the 2018 edition, the survey frequency has changed and the census is now conducted every two years (in the past, data were collected every three years, until the 2015 edition). The content of the questionnaires is regularly reviewed with the twofold objective of guaranteeing comparable and homogenous time series and responding to new information needs.

4 That is, water uses in urban areas (domestic, public, commercial and productive).

5 In 2018 in Italy there were 2 552 water operators for urban water services, from abstraction for public water supply to urban wastewater treatment: in 17 percent of cases they were water utility companies (2 119) while 83 percent were municipalities and other local authorities (433).

Data collection takes place online on the Istat website at gino.istat.it/censacque. Questionnaires are organized in seven sections and some data are prefilled in order to maintain time series and reduce statistical load. Warnings and exceptions are present during the compilation with the aim of guaranteeing a deeper quality of data. Besides, a long list of checks is carried out both within the questionnaire and between different questionnaires and sections upon submission. Reading and verification in time series lie at the base of all the checks. In some cases, water operators are invited to re-check and correct data. At the end of this process, the data are validated and disseminated.

In the period June–November 2021 the Urban water census was posted online with reference to 2020 and the data checking and validation phase is still ongoing.[6] At present, some indicators in relation to provincial or metropolitan capital cities have already been disseminated in the final version,[7] but there has been no definitive release for all the variables and territorial levels of interest. For this reason the data used in this report refer to 2018 (disseminated in 2019).

As the information is very detailed, indicators are calculated with a high territorial level. Depending on the indicator analysed, the territorial levels of dissemination used may change for methodological or conceptual reasons.

With reference to water withdrawal for public water supply, data are collected for each abstraction point (more than 35 000 in Italy). For each point water operators must record the location, in terms of municipality and geographical coordinates, the name/code of the water body in WISE and the source (spring, well, river, natural lake, artificial basin, sea or brackish water). For this reason, indicators are elaborated on several territorial scales, including at RBD/NUTS2 level.

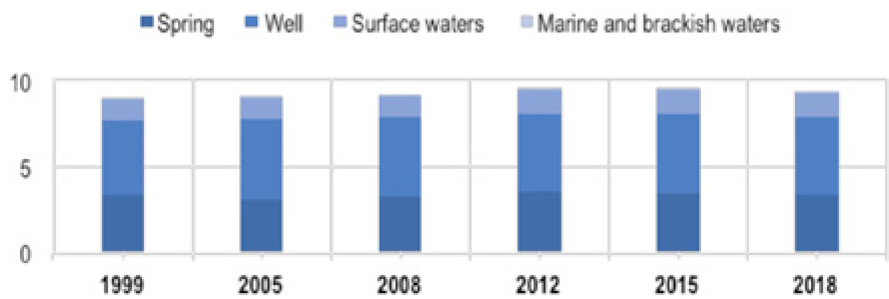
With reference to water use in public water supply, and in detail to volumes of water input into the network, water supplied and invoiced to final users, data are collected at the municipal level. Aggregating for different territorial levels it is possible to obtain the figures at RBD/NUTS2/Municipality/Metropolitan area level.

6 The next edition is scheduled for May 2023, and will cover 2022.

7 www.istat.it/en/archivio/268982

Census data show that the volume of water abstracted for public water supply is constantly high (Figure 6.2), even compared to the European context. Since 2008 the volume was set at values above 9 billion cubic metres, even if in 2018, for the first time in the last 20 years, there was a reduction in the volume of water abstracted for drinking use (-2.7 percent compared to 2015). In detail, in 2018 9.2 billion cubic metres were abstracted from water bodies, corresponding to about 419 litres per person per day.[8] Water operators withdrawn for drinking use 25 million cubic metres every day, or 419 litres per person per day. Groundwater provided about 84.8 percent of the volume abstracted, while surface sources accounted for 15.1 percent and marine and brackish waters the remaining 0.1 percent.[9]

Figure 6.2 – Annual water withdrawal for public water supply by source, 1999–2018, km^3 (Istat, Urban water census)



Source: Istat, Water Statistics. 2019. https://www.istat.it/en/archivio/268982

Italy ranks first in the 27 European Union Member Nations (EU-27) for freshwater withdrawal for public water supply. In 2018 Italy also had the highest volume of freshwater abstracted for public water supply in absolute terms. In per capita terms (Figure 6.3), the gap between Member Nations was wide and Italy took second place (153 cubic metres per inhabitant), immediately after Greece (157), with values far above the following countries in the ranking, Ireland (128), Bulgaria (119) and Croatia (111). By contrast, in Malta it was just 30 cubic metres per inhabitant.

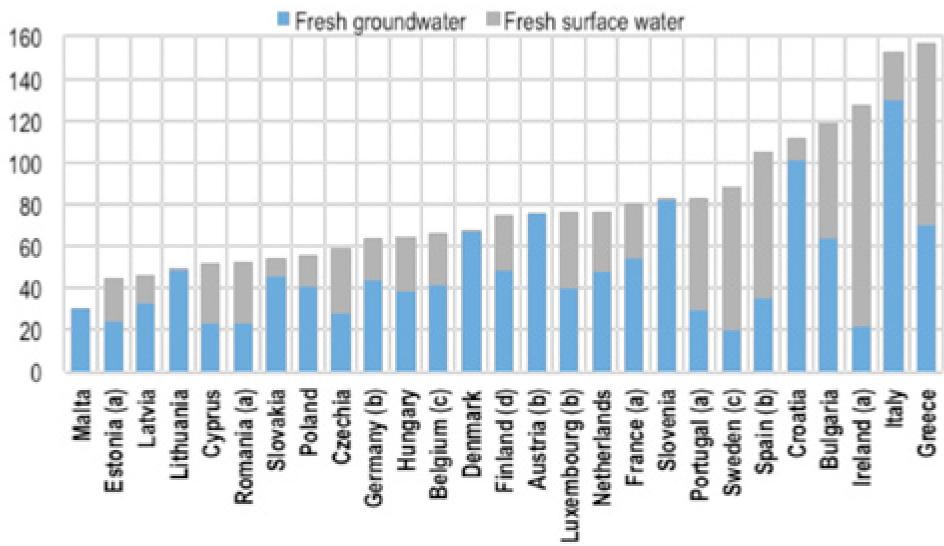
8 www.istat.it/en/archivio/252831

9 The component of non fresh water made available for use is not included in the calculation of indicator 6.4.2.

The great majority of EU Member Nations abstracted between 45 and 90 cubic metres of freshwater per person for public supply.

Of the EU-27 countries in the Mediterranean area, Italy was among those that exploited the biggest majority of groundwater, springs and wells, that is the largest and most precious freshwater resource for the Italian territory (84.8 percent of the total volume abstracted) – as deemed essential to satisfy drinkable uses.

Figure 6.3 – Freshwater withdrawal for the public water supply in the EU-27 countries. 2018 or last year available, cubic metres per inhabitant (Istat, based on Eurostat data). (a) 2017; (b) 2016: (c) 2015; (d) 2014



Source: Istat, Water Statistics. 2019. https://www.istat.it/en/archivio/268982

In Italy, territorial differences in water withdrawal are quite evident at NUTS2 and RBD level, owing to factors such as varying water requirements, water body location, water transport infrastructure and service performance. In the South in particular, water exchanges between neighbouring regions are quite frequent, thus guaranteeing the drinking water requirements of those areas where the resource is insufficient.

In Table 6.1, water abstraction data for RBDs are reported with reference to 2018. The data are also tabulated by source.

Table 6.1 – Annual water withdrawal for the public water supply (hm^3) by RBD and source

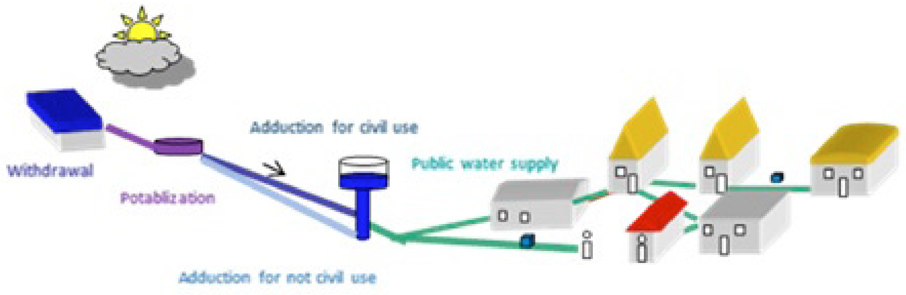
River Basin Districts	Spring	Well	River	Natural lake	Reservoir	Marine or brackish waters	Total
Eastern Alps	373.9	596.2	52.5	-	0.1	-	1 022.7
Po River	504.1	1 902.5	197.2	44.7	132.7	-	2 781.2
Northern Apennines	87.0	364.3	117.3	1.3	17.4	1.1	588.3
Central Apennines	1 080.0	349.5	15.0	1.7	34.9	0.2	1 481.3
Southern Apennines	1 071.2	813.5	56.6	-	384.1	-	2 325.4
Sardinia	32.5	31.1	0.8	-	229.3	-	293.7
Sicily	164.8	458.9	2.0	-	102.8	9.1	730.7
ITALY	3 313.4	4 515.9	441.4	47.7	901.3	10.4	9 230.2

Source: Istat, Urban Water Census. 2018. https://www.istat.it/it/files//2021/01/UrbanWaterCensus2018_Dec2020.pdf

As is widely known, no water supply system operates without any water loss between the withdrawal point and end users.

In general, water supply and distribution systems can comprise thousands of kilometres of pipelines, connecting the source with the point of use (Figure 6.4). From the abstraction point, water is generally transported first through large transmission pipes to storage tanks (adduction network), transiting in many cases via a potabilization plant to guarantee tap water quality, and thence through other pipes to reach end users (homes, shops, offices, public fountains, etc.). Pipe systems are subject to unavoidable leakages, which can occur at exchange and interconnection points, and are often due to the obsolescence and poor maintenance of the water infrastructure.

Figure 6.4 – Synthetic description of a public supply network



Source: Istat, Urban Water Census. 2018. https://www.istat.it/it/files//2021/01/UrbanWaterCensus2018_Dec2020.pdf

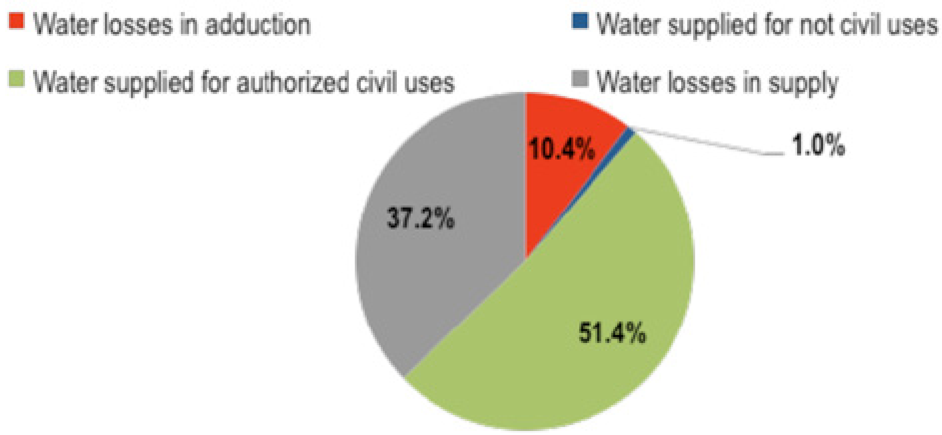
Water losses can be generated in the adduction network, between the point of withdrawal and the tank, and in distribution, account for the difference between the volumes that enter into the network and those delivered to end users. In the areas richest in water, often located in mountainous regions, the difference detected between the volume withdrawn and that actually input into the network is a consequence of available water exceeding its storage capacity, so that the surplus returns to nature.

There are also significant differences in cases where the supply network is particularly extensive, as in the case of the Centre of Italy and in the South and Island regions.

Moreover, the difference between the two volumes is more evident in the areas where water is subjected to potabilization treatment, whereby a part of the volume is lost during the process.

The volume of water withdrawn for drinkable use from abstraction points, considering also any wholesale uses (in agriculture and industry; 1 percent of the total), was reduced by 10.4 percent on entering the distribution system in 2018. This difference is mainly explained by leakages in the adduction system and by water consumption in the potabilization process. In many cases, the excess water returns to the environment. Specifically, the volume of water input into the public water supply network in 2018 (Table 6.2) amounted to 8.2 billion cubic metres (375 litres per person per day), while the water supplied for authorized uses was equal to 4.7 billion cubic metres (215 litres per person per day), including both the volumes invoiced to users and those provided for free use (for example, fountains, street cleaning, fire-fighting). The water supplied/ abstracted ratio is 51.4 percent. Just under half of the water abstracted from sources (47.6 percent) did not reach end users, due to leakages in the supply system (Figure 6.5).

Figure 6.5 – Water withdrawal by public water supply. 2018 or last year available, percentage values on the volume withdrawn. (Data source: Istat, Urban water census, 2018)



Source: Istat, Urban Water Census. 2018. https://www.istat.it/it/files//2021/01/UrbanWaterCensus2018_Dec2020.pdf

The comparison between the volumes of water input into the public water supply network and the water supplied enables us to assess water losses, namely the amount of water input into the net and not reaching end users: 3.4 billion cubic metres in 2018 (the difference between water input into the network and water supplied for authorized uses), which in percentage terms amounted to 42.0 percent at the national level. Physical losses represent the principal component of this percentage, but in some territories, administrative losses due to unauthorized consumption and measurement errors of metres (apparent losses) must also be considered.

With reference to the water abstracted, total water losses in supply network represented a share of 37.2 percent.

Table 6.2 – Water use for public water supply (hm^3) by RBD and source

River Basin Districts	Water input into the network	Water supplied for authorized civil uses	Water losses in supply (percent)
Eastern Alps	881 849	526 393	40.3
Po River	2 574 711	1 758 179	31.7
Northern Apennines	626 085	362 512	42.1
Central Apennines	1 296 779	669 449	48.4
Southern Apennines	1 873 318	973 800	48.0
Sardinia	256 592	125 268	51.2
Sicily	673 394	333 069	50.5
ITALY	8 182 729	4 748 670	42.0

Source: Istat, Urban Water Census. 2018. https://www.istat.it/it/files//2021/01/UrbanWaterCensus2018_Dec2020.pdf

Agricultural use

Introduction

In Italy, specific Mediterranean climatic conditions, landscape orography and soil characteristics necessitate the use of a reasonable amount of water for irrigation purposes in agricultural activity. By contrast, livestock farming only requires a small quantity of water. For this reason, in the following paragraphs and calculations, the data refer only to the irrigation component.

In fact, even if the data on such matter are lacking, agriculture remains the most water-intensive economic sector. Moreover, as water resources are available in defined quantities in time and space, the issue of water scarcity occurs frequently at local level.

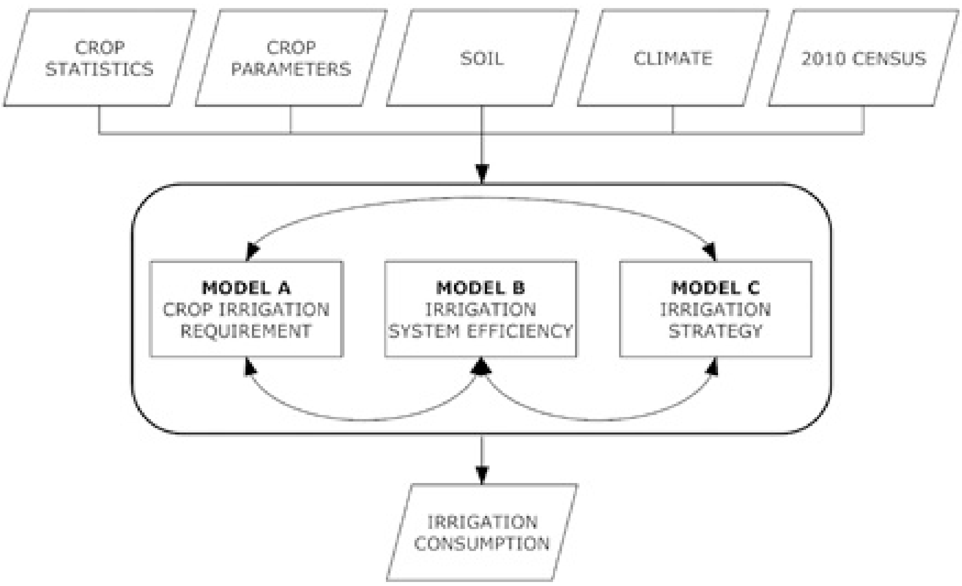
International policy on water issue has been oriented to promote and develop more sustainable ways of using resources, so that demand for statistics has also increased enormously in recent times.

Nevertheless, EU Member State activity on such matters has become more stringent as a Regulation at the European level has been issued affecting data production of water use for irrigation purposes.

Estimation of irrigation water volumes

The first estimation of water use for irrigation at farm level has been performed using a methodology developed by Italy's National Institute of Agricultural Economics) (INEA, currently CREA) and Istat under the aegis of a Eurostat grant. The methodology integrates three models illustrating the main aspects of water use in farm irrigation: crop irrigation demand (Model A), irrigation system efficiency (Model B) and farmer irrigation strategy (Model C). Each model was developed using state-of-the-art methodologies, but also takes into account the availability and characteristics of the required datasets (climate, soil, crop characteristics and statistics), expert knowledge and the nature of the information collected by the Agriculture Census (Figure 6.6) (Bellini *et al.,* 2013).

Figure 6.6 – Methodological framework: typology of required data and model relationships



Source: Istat, 6° Censimento Generale dell'Agricoltura. Utilizzo della risorsa idrica a fini irrigui in agricoltura. 2014. https://www.istat.it/it/files/2014/11/Utilizzo_risorsa_idrica.pdf

Model A simulates the amount of water required by each farm crop and the relative irrigation dates by computing a daily root zone water balance. The model uses data on crop phenology (planting/harvesting dates, root depth, values of the crop coefficient at the various development stages), soil (wilting point, field capacity and depth) and agrometeorology (evapotranspiration and precipitation).

Model B takes into account the efficiency of irrigation application and the irrigation drainage losses related to irrigation system and management factors. The efficiency of the various irrigation systems used for the crops was assessed by experts using information retrieved from field studies carried out in Italy (e.g. the efficiency of the drip irrigation is the highest, at around 90 percent, while the lowest is assigned to furrow or flooding systems, at around 70 percent). The management factors influencing the efficiency are illustrated by Model C.

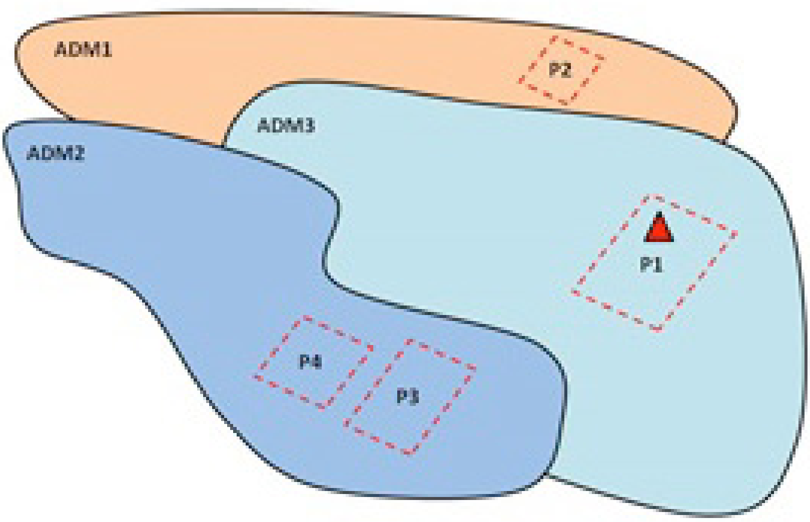
Model C simulated a farmer irrigation strategy based mainly on the decision concerning the degree of stress to allow for certain crops (in Italy it is common to grow vineyards and olive plantations with deficit irrigation). The strategy depends on crop type, but also on other factors such as water availability, the distribution system, economic dependence on irrigated crops, the farmer's educational level, the irrigation equipment, the size of the farm, and so on. Model C therefore adjusts the calculation of water already estimated by Model A and B, using factors related to the farmer's strategy collected via the census. Some of these census variables were derived from additional questions in the questionnaire, focusing on the use of irrigation advisory services, or the type of water delivery of the collective irrigation service (such as "on-demand" or "fixed-turn" irrigation provided by irrigation and land reclamation consortia).

Model-based estimation of the water used for irrigating each crop and finally for farms as whole has a level of accuracy and reliability that is strongly correlated with the quality of the input data. Tests realized during the phases of model calibration and validation, performed on a sample of 300 farms located in four Italian regions, illustrated the sensitivity of model results to agrometeorological data and to a small extent to the other parameters. Tests were also conducted by comparing model performances using meteorological data with finer and coarser resolutions.

Water consumption for rice and crops under protection cover and in greenhouses was computed with a model using a specific routine based on empirical data and coefficients. Average volumes used for rice were defined at NUTS3-level via a survey on land reclamation and irrigation consortia as well as interviews with farmers. The volume of water used for protected crops was computed by using empirical coefficients for the main protected crop groups derived from field experiments reported in literature.

The computation of irrigation water use for the totality of Italian irrigated farms was achieved by developing a software application implementing both the three models plus two additional models for the pre-processing of the collected census data. Essentially, the pre-processing modules perform two operations: building the farm's irrigated land use at crop level; and spatially allocating the irrigated farm's land use at municipal level. The software performs the estimation by reporting all data based on a common "minimum computational unit" corresponding to the administrative area of the municipalities where the farmland is located. The agrometeorological and soil parameter datasets are thus pre-processed and reported at municipal level by using spatial aggregation methodologies realized in a GIS environment (Figure 6.7)

Figure 6.7 – Representation of the spatial dimension of a farm



The farm headquarter is located in a municipality (ADM3) but the farmland is distributed in different municipalities where farm parcels are located (P1, P2, P3 and P4)

Source: Istat, 6° Censimento Generale dell'Agricoltura. Utilizzo della risorsa idrica a fini irrigui in agricoltura. 2014. https://www.istat.it/it/files/2014/11/Utilizzo_risorsa_idrica.pdf

The irrigation water estimation was performed for each farm's irrigated crop forming part of the farm's irrigated land use. The data in the "irrigation" section of the census questionnaire report provides details of irrigated surfaces and predominant irrigation systems for a single crops (e.g. "potatoes") and crop groups (e.g. "cereals for the production of grain"). To bolster irrigated land use at crop level, the pre-processing model enables the disaggregation of the irrigated surface of the crop groups into the irrigated surface of the corresponding single crops, following a pre-defined set of expert rules.

For instance, Rule no. 2 defines the irrigated surface of the group "cereals for the production of grain", reported in the irrigation section, as the sum of the irrigated surface of the following crops: "common wheat and spelt", "durum wheat", "rye", "barley", "oats", "sorghum" and "other cereals". Details of the cultivated surface of the listed crops are registered in the "arable land" section of the questionnaire. Among these crops, only "sorghum" has the highest chance of being irrigated in Italy; the irrigated surface of the group is therefore attributed to "sorghum" up to the saturation of the surface reported in the "arable land" section, while the residual share is split proportionately among the other mentioned crops.

Another example is Rule no. 6 defining the irrigated surface of the crop group "fresh outdoor vegetables " as the sum of the irrigated surface of the following crops: "table tomatoes in open field"; "plum tomatoes in open field"; "other fresh vegetables in open field"; "table tomatoes in market gardening"; and "other fresh vegetables in market gardening". The Rule establishes a two-step disaggregation procedure through a proportional allocation that uses the cultivated surface reported under "arable land":

1. The irrigated surface of "fresh outdoor vegetables" is split proportionately among two subgroups made up of crops considered equivalent: "tomatoes" ("table tomatoes in open field"; "plum tomatoes in open field"; and "table tomatoes in market gardening") and "other horticultural crops" ("other fresh vegetables in open field"; and "other fresh vegetables in market gardening"). The cultivated surface for each single crop is reported.
2. The surface allocated to the subgroup "other horticultural crops" is split proportionately among a set of fresh outdoor vegetables with the largest diffusion in Italy. The allocation is performed by taking into account the

fresh vegetable surfaces reported in the Istat crop statistics produced annually at provincial level (NUTS3), while the province is selected according to the farm's location.

The farm's land-use spatial allocation is required since farmland is generally not concentrated within a single municipality: farms can be made up of several parcels located in various municipalities. The spatial allocation is a necessary step to capture the differences in the crop water balance that may occur in municipalities with diverse territorial characteristics (namely in terms of agrometeorology and pedology).

The spatial allocation was performed by allocating the irrigated surface of each farm's crop to the municipalities where the farm's parcels are located. The procedure exploits the information registered in a specific section of the census questionnaire, which reports the cultivated surface of the main crop categories for each municipality: "arable land"; "vineyard"; "permanent crops excluding vineyards"; "kitchen gardens"; and "permanent grassland and pastures".

The spatial allocation of the irrigated surfaces for each crop is carried out by defining specific weights for each municipality and for each of the five crop categories listed above. For example, if a farm has arable land located in two municipalities, the irrigated surface of a crop belonging to the category (e.g. "potatoes") is split proportionately between the two parcels. The weights are computed as a ratio between the arable land surface of the municipality and the total arable land of the farm (Bellini *et al.*, 2013).

Methodology for the calculation of water volume used per river basin district

1 Geocoding agricultural holdings

Following Regulation 1166/2008/EU requirements, in order to geocode the agricultural holding headquarter (HH), and to release the related geographical coordinates, – latitude and longitude – with a precision of 5 minutes, Istat shas collected specific information about agriculture holding (AH) locations, through its 6th agriculture census questionnaire. The AH is where the main part of all agricultural production takes place, offering Member Nations the possibility of adopting the most suitable definition for their own situation. The definition adopted by Istat refers to the “location where the building (one or more) connected to the agricultural activities is, within the agricultural land perimeter. This building can have different functions: it can be the holder residence or the residence of agricultural labour force, or the stable for livestock, or where mechanical equipment used for agricultural activity is stored, as well as buildings used for products storage purpose. Whether within the agricultural land perimeter there are no buildings, the holding headquarter is where the largest agricultural area is located”.

Furthermore, as the holder’s residence can be considered as the reference place of the AH where the localization of the HH falls within 5 km (in a straight line), this information was also collected by questionnaire (Bellini *et al.*, 2013).

2 Assigning enumeration areas to districts

The association between the RBDs and census map can be obtained through methods overlapping the two layers based on the geographical location and the surface of the polygons within them. These methods are based on the properties of topological spaces and operations (inclusion, intersection) between geometric objects associated with them.

The first step was to bring the two layers into one geographic reference system.

The operation to geographically intersect the municipal boundaries and the RBDs was then carried out (Bellini *et al.,* 2013).

3 Assigning agricultural units to RBD

For the purposes of this research, geocoding only the holding headquarter was not sufficient, as an agricultural holding can be spread over more than one municipality, generating more than one agricultural unit (one for each municipality). As there are cases of municipalities in which more than one RBD overlaps (called border municipalities in the following), it was also necessary to geocode all the agricultural units lying in those municipalities in those EAs in which those municipalities are divided. It was thus possible to base the final calculation on irrigation-related variables and indicators, as all the agricultural units – composing the agricultural holdings – can be assigned to the specific RBDs where they are actually located.

The procedure used for this is a transposition table created in the step described in the previous paragraph, joining the single enumeration area (for border municipalities), or the municipality itself (for those included in a single RBDs) to a specific RBD (Bellini, *et al.,*2013).

Some results

The results show that the total irrigated area of the RBDs considered - that concerns 2 418 920.70 hectares – is located mainly in the Po RBDs (48 percent of the total), followed by the Southern Apennines with 19 percent and the Eastern Alps with 15 percent of the total irrigated area.

The total volume of water used is 11 099 million cubic metres. The ranking of the districts is similar to that described above, as we first find the Po RBD (64 percent of the total water used in agriculture), than the Southern Apennines with 13 percent, followed by Eastern Alps with 7 percent.

At national level the most widespread irrigation system is aspersion (sprinkling) covering 40 percent of the irrigated area, followed by superficial flowing water and lateral irrigation system (31 percent), micro-irrigation (17 percent) and flooding (9 percent). At the local level the results for the River Po district show that the irrigation systems with the smallest water-use efficiency rates (flooding and superficial flowing water and lateral irrigation system) are adopted over 18 percent and 50 percent of the total irrigated area respectively – the highest rates recorded in the whole national territory. In the Eastern Alps, Central Apennines and Sardinia Districts, only one irrigation method was adopted for more than half of the total irrigated area – the aspersion method (assuming percentages of 65, 64 and 53 respectively).

The most efficient irrigation system – micro-irrigation – is mainly adopted in Northern Apennines, Sicily and Southern Apennines, where 42, 41 and 40 percent respectively of the total irrigated area is thus served.

With reference to the water sources, 56 percent of irrigated areas are served by water pipes or artificial waterways managed by land reclamation and irrigation consortia or irrigation authorities, followed by groundwater (25 percent), superficial water bodies (15 percent) and other sources (4 percent).

At RBD level, Sardinia, Po and Eastern Alps showed the highest adoption of land reclamation and irrigation consortia or irrigation authorities used to irrigate more than 60 percent of the total irrigated area. However in Sardinia, characterized by water scarcity, the water pipes delivering "on-demand" water – a system enabling farms to use water in a more efficient way – is used across 60 percent of irrigated areas, while delivery arranged by "rotational turns" prevails in the other two districts.

The analysis of volumes of water per irrigation system and district showed the same pattern as for irrigation area per irrigation system and district

Table 6.3 illustrates the intensity of the irrigation phenomenon in the districts analysed and the overall efficiency of the practice adopted.

The first indicator describes the degree of irrigation adoption – at 19.2 percent of the Utilized Agricultural Area (UAA) on average, rising to 42 percent in the Po District, which also marks the highest water volume spread per hectare (around 6 000 cubic metres) of irrigated area coupled with the lowest water volume used in the highest water efficiency rate irrigation system (1.7 percent). The other district in which the percentage of irrigated UAA is over the average is the Eastern Alps, at 27 percent. By contrast the water volume per hectare is among the lowest (around 2 000 cubic metres) even if the irrigation systems with the highest water use efficiency rate are not so common (only 8 percent of total irrigation water is spread with micro-irrigation and other systems). Other districts such as the Northern and Southern Apennines and Sicily also adopted the most efficient irrigation system (respectively 40 percent, 38 percent and 31 percent of the total irrigation water consumed) in a relevant way.

Table 6.3 – Irrigated area and irrigation water volumes by RBD (2010)

RIVER BASIN DISTRICTS	Irrigated UAA (% over)	Irrigation water (m^3 per hectare of irrigated area)	Irrigation water volume per high efficiency irrigation systems (a) (% over total)	Irrigation water volume used in farms with irrigation consultancy service (% over total)
Eastern Alps	27.3	2 264	8.0	3.4
Po River	41.5	6 151	1.7	4.1
Northern Apennines	8.2	2 656	39.8	8.2
Central Apennines	8.4	3 488	21.1	2.4
Southern Apennines	14.8	3 204	38.0	1.8
Sardinia	5.7	4 847	22.3	3.8
Sicily	11.5	4 673	31.1	2.1
ITALY	19.2	4 588	11.1	2.9

a) Micro-irrigation and other irrigation systems

Source: Istat, 6° Censimento Generale dell'Agricoltura. Utilizzo della risorsa idrica a fini irrigui in agricoltura. 2014. https://www.istat.it/it/files/2014/11/Utilizzo_risorsa_idrica.pdf

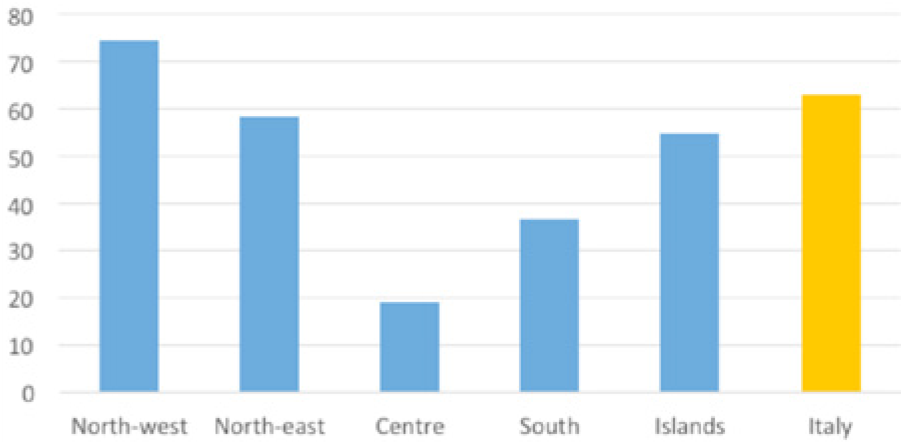
In terms of the use of irrigation consultancy, this is not common as irrigation water used with this practice amounts to only 3.7 percent of the total. However, the range of values assumed in the different districts is quite high as the minimum percentage, that is 1.8, is recorded for the Southern Apennines, while the highest value is 8.2 percent for the Northern Apennines.

Water withdrawal

Starting with water used for irrigation, water withdrawn by water bodies was estimated. This took into account the source of water supply used in the individual farms. In particular, water withdrawals from land reclamation and irrigation authorities were distinguished from those carried out directly by farms from water bodies (self-supply).

With reference to this aspect, the situation is diversified in various areas of the country (Figure 6.8), thus affecting irrigation efficiency. In fact, where self-supply is carried out, water losses in the transport phase are generally very low.

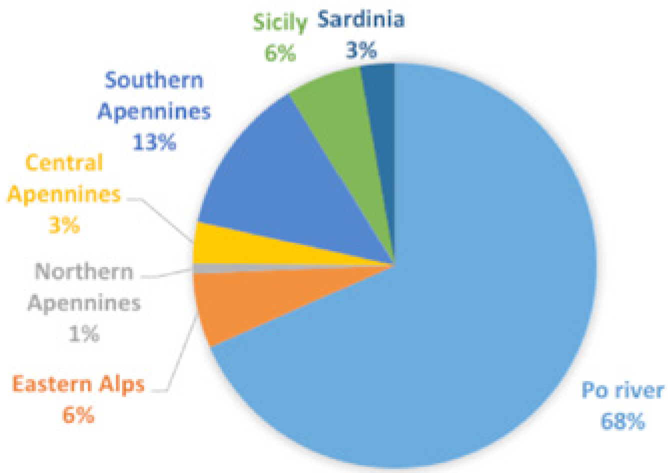
Figure 6.8 – Irrigation water used by farms and withdrawn by land reclamation and irrigation authorities, (2010, percentages)



Source: Istat, 6° Censimento Generale dell'Agricoltura. Utilizzo della risorsa idrica a fini irrigui in agricoltura. 2014. https://www.istat.it/it/files/2014/11/Utilizzo_risorsa_idrica.pdf

In total, 12 871 million cubic metres were withdrawn in 2010. The volume distribution by RBD is shown in Figure 6.9.

Figure 6.9 – Water withdrawal for irrigation by RBD (percentage composition). 2010



Source: Istat, 6° Censimento Generale dell'Agricoltura. Utilizzo della risorsa idrica a fini irrigui in agricoltura. 2014. https://www.istat.it/it/files/2014/11/Utilizzo_risorsa_idrica.pdf

Conclusions

The Italian National Institute of Statistics, aware of the importance of complete information and accurate data related to the availability and use of water resources, is working to solve information gaps and to improve basic knowledge, based on the guidelines provided by the framework directive and the initiatives of Eurostat and OECD on water statistics and water accounts.

With its 6th general agriculture census in 2010, Istat took an important step forward in the production of statistical data on water used for irrigation purpose.

What emerges, beyond the specific results already described, is that data are highly relevant for water management purposes. This kind of statistical production should therefore not be limited to a single census survey, but rather continue to play a preeminent role in the production of official statistics in future.

Industrial use

Introduction

In Italy, uniform estimates on the amount of water abstracted, supplied, discharged and treated for industrial use are lacking. It is often difficult to collate available data, as information is produced by various administrative agencies and institutions with varying levels of efficiency and archiving procedures. For this reason water statistics for Italian industrial activities are often highly fragmented and suffer from data heterogeneity and lack of standardization.

Istat has been working for several years in order to improve national knowledge on water statistics. These activities are carried out following the guidelines of the EU relating to the Water Framework Directive (WFD, 2000/60/EC) and Eurostat initiatives on water statistics and water accounts.

In this regard, statistical data have been developed concerning the waters used by the manufacturing industry (NACE Rev. 2, 10–33) and by the mining and quarrying sector (NACE Rev. 2, 05–09) at national, RBD, regional and labour market area (LMA, “local labour systems – SLL” in Italy) levels. The purpose is to collect data useful for the calibration of assessment models on water use and wastewater discharged, taking into account the various types of industrial processes and different technologies used. Technical studies currently published advocate estimating water use and pollutant loads discharged by industry. These methods are not directly suitable for analysis on a large scale because they need to be calibrated to fit the specific features of Italian industrial structure and production.

Data collection modalities rely on the use of administrative surveys and existing Istat surveys. Our objective was to integrate data from various data collection modalities to provide more complete estimates on water use by NACE code, at the national and local level of spatial aggregation.

For this purpose, we explored the possibility of using an estimation procedure based on statistics derived from the current Istat PRODCOM (Community Production) Sample Survey and selected technical processing coefficients, to obtain estimates of volumes of consumption of water used in manufacturing industry at a national level by unit of product.

Estimation methods developed by Istat on industrial water use

Motivation

Generally in manufacturing industry, water is used for more than one purpose. Moreover, industrial use of water is lower than water abstraction, due to laws requiring industrial grey water to be treated and returned to the environment. For these reasons, industrial water needs are strictly connected with the type of industry and largely dependent on the technology features of individual plants. As it is not possible to collect data concerning industrial water abstraction or discharge regularly through an official survey, we focused on designing an indirect estimation method based on the combined use of PRODCOM survey statistics for the production of manufactured goods and technical processing coefficients by product, derived from both scientific literature and data directly provided by Italian enterprises.

The purpose of our method was to estimate water volumes used in the production of manufacturing industry by amount of product (in physical terms), grouped by typology within each manufacturing sector.

Methodological aspects

Since 1997, PRODCOM has been the EU annual survey with the most coherent statistics on the production of manufactured and sold goods. This survey aims to collect information concerning the manufacture and commercialization of a wide range of products defined at Community level (Reg. CEE N.3924/91). A common list of products that is updated every year – the "PRODCOM list" – accounts for about 4 000 products. Within the PRODCOM list, products are grouped according to the manufacturer's economic sector. In fact, the list of products aims to include all manufactured products, but to keep it manageable, similar products are grouped into single items by using NACE Rev. 2 classification. For the products in the list, micro-data show the amount for each product produced and sold by industrial enterprises in each reference year. The PRODCOM survey forms part of the Italian National Statistical Programme and involves all Italian industrial firms with at least 20 employees and a sample of enterprises with 3–19 employees, by using a random sampling method and stratified elementary unit selection. The PRODCOM sampling frame is derived from the statistical register of local units (ASIA-LU), developed by Istat through the statistical integration of different administrative sources.

Concerning water used in industrial manufacturing processes, the indirect estimation method we have developed is based on the Istat survey of industrial production PRODCOM by *"units of product"* of different typologies and by *"value of output"* (instead of data by *"number of employees"*). In our opinion, this choice allows us to deepen the strong connection between water volumes used in production activities, industry type and technology used in Italy, and to apply specific technical coefficients to production units. PRODCOM statistics on industrial production cover the manufacturing sectors (NACE Rev. 2, 10–33) and the mining and quarrying sector (NACE Rev. 2, 05–09). Starting from PRODCOM statistics on industrial production in physical terms, technical processing coefficients relating to water volume use by unit of product by sector can be applied to obtain the overall amount of water resources used to produce each type of product at national level in a given year. In particular, to calculate the water used in cubic metres, a dataset consisting of annual PRODCOM data was constructed. This dataset contains statistical information on production and commercialization by product (in quantity and value terms) and by NACE Division (considering only NACE Rev. 2, 5–9 and 10–33 divisions). Industrial production is expressed in various units of measure according to the different types of products, such as weight (t, kg), volume (m^3, l), area (m^2), length (m), number of pieces and value (in euros). By integrating different sources, specific technical processing coefficients to be applied to production unit were selected (as explained in the next paragraph). The calculation is made up to 8 decimal points – according to NACE Rev. 2– and gives the overall amount of water used (m^3) in the specific production process, product by product, at national level. In fact, the PRODCOM methodological framework represents a constraint that does not allow our calculation method to obtain results on a detailed spatial scale (regional or macro-areas).

To pursue a higher feasibility degree by applying selected technical coefficients to the production of enterprises by product, the various firms' sizes (in terms of employees) were also considered. Smaller-sized companies are characterized not only by a certain type of industrial structure and technology used, but also in terms of water supplies from the urban water network. This represents an important aspect in accounting for water abstractions exclusively for manufactured industries and calculating the use components of overall national water abstraction used for agriculture, industry and urban systems.

Technical processing coefficients by product: an integration of sources

Water use can be assessed in relation to several factors, such as amount of production, number of production units, average size of firm according to each economic activity, number of employees, number of hours required by the specific stages of production, and level of sectorial productivity. Naturally the choice of one or more of these factors is linked to the fact that the same factor chosen is objectively measurable and practically available. However, one element common to all these factors is the specificity of the economic activity that represents the specialization of production. Of these various aspects the parameters of the amount of production (physical and monetary) seem better suited to describe the water use (cooling and production processes) of industrial activities. . In particular, for the evaluation of water use, we integrated various sources of technical processing coefficients, by testing the most interesting methodologies and research studies investigated:

1. specialized and scientific literature;
2. Environmental Product Declaration of firms (ISO 14025, EMAS);
3. selection of representative Italian companies by sector;
4. Italian industry associations; and
5. Istat's estimations.

Results

The total amount of water used in manufacturing industry in Italy in 2015 was 3.79 billion cubic metres.

Istat's Urban water census revealed the volumes of drinking water supplied by the municipal water supply networks and used by industrial activities.

As a result, it is possible to deepen the analysis, and suggest a hypothesis on the volumes of water abstracted by industries by self-supply, net of the volumes directly abstracted from the public water supply network. The water used and self-abstracted by firms for industrial activities in 2015. amounted to 3.47 billion cubic metres, 91 percent of the total volume used that year.

Water use by manufacturing sector

The total national amount of water used by manufacturing industry (NACE Rev. 2, 10–33) and the mining and quarrying sector (NACE Rev. 2, 05–09) was then disaggregated by sector (4 digits) in order to identify the sectors that use more water for production globally (Table 6.4). This type of analysis does not consider the use of water by product unit, but the use of water as a whole within each sector.

Four sectors are characterized by a higher water demand, accounting for half of the total amount of water used (50.8 percent): "chemicals and chemical products" (17.3 percent); "fabricated metal products, except machinery and equipment" (13.6 percent); "rubber and plastic products" (11.0 percent); and "textiles" (8.9 percent).

Table 6.4 – Water used in manufacturing industries by sector and type of supply. Volume in thousands of cubic metres (2015)

NACE Division	Water use		
	Total	Supplied by municipal water supply networks	Self-supply
7,8 Mining and quarrying minerals	48 624	-	48 624
10 Food products	288 574	34 905	253 669
11 Beverages	97 624	11 986	85 638
12 Tobacco products	23	3	20
13 Textiles	335 433	39 873	295 560
14 Wearing apparel	31 367	3 293	28 074
15 Leather and related products	37 085	3 693	33 392
16 Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	57 113	6 727	50 386
17 Paper and paper products	213 780	23 213	190 567
18 Printing and reproduction of re-corded media	806	88	718
19 Coke and refined petroleum prod-ucts	2 984	-	2 984
20 Chemicals and chemical products	656 099	79 382	576 717
21 Basic pharmaceutical products and pharmaceutical preparations	179 499	19 037	160 462
22 Rubber and plastic products	418 245	46 698	371 547
23 Other non-metallic mineral products	257 873	30 192	227 681
24 Basic metals	133 649	-	133 649

25 Fabricated metal products, except machinery and equipment	516 103	-	516 103
26 Computer, electronic and optical products	25 168	2 896	22 272
27 Electrical equipment	98 642	10 424	88 218
28 Machinery and equipment n.e.c.	199 088	-	199 088
29 Motor vehicles, trailers and semi-trailers	20 799	-	20 799
30 Other transport equipment	68 308	-	68 308
31 Furniture	9 708	943	8 765
32 Other manufacturing	84 634	9 191	75 443
33 Repair and installation of machinery and equipment	9 791	1 212	8 579
TOTAL	**3 791 019**	**323 755**	**3 467 264**

Source: Authors' own elaboration.

Water use intensity indicator by manufacturing sector

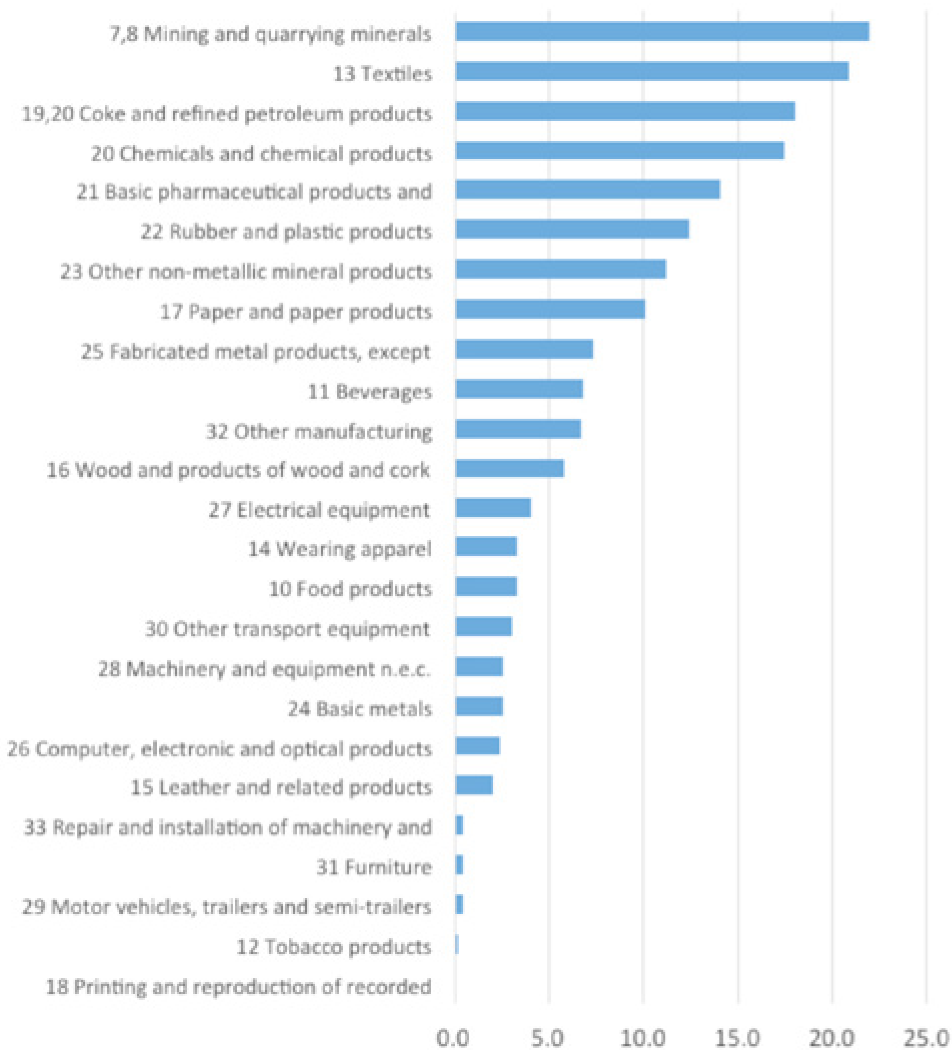
In addition to the information on the global volumes of water used by sector, it is also vital to identify which sectors use more water-intensive products, at net of production levels. Considering that in PRODCOM the measures of production by each unit vary within and between sectors among several type of measurement (weights, volumes, m^2, number of pieces, cost), one way of normalizing the volumes of water used by sectors is to calculate a ratio based on the production sold.

Normalization into monetary terms, in fact, enables us to compare the demand of water between sectors, net to the production levels/conditions.

The water-use intensity indicator represents the volumes of water necessary to produce one euro of product sold.

The mining and quarrying minerals sector, previously found in the medium-low range of demand of water, now turns out to be the most water-intensive a value equal to 22.0 litre/euro. Textiles also have a high water-use intensity value, equal to 20.9 litre/euro (Figure 6.10).

Figure 6.10 – Water-use intensity by NACE Division. Litres per euro, (2015)



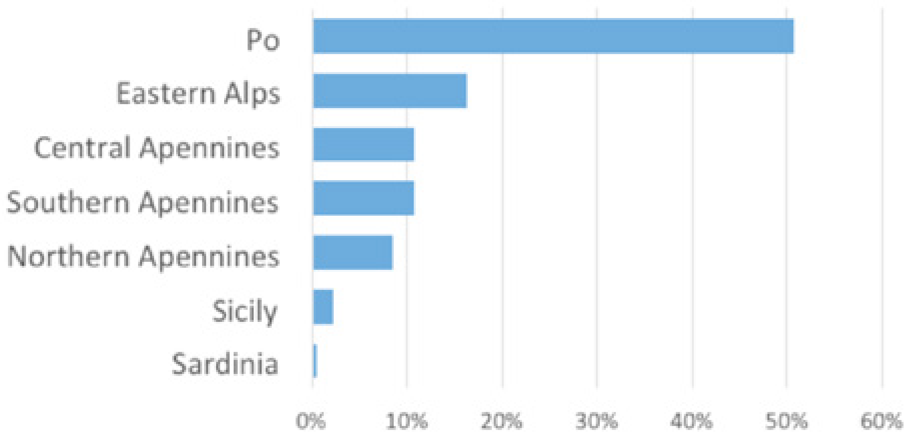
Source: Istat, Utilizzo e qualità della risorsa idrica in Italia. 2019. https://www.istat.it/it/archivio/234904

Water use at subnational level

Even though the PRODCOM survey is designed to provide national estimations, a territorial analysis can be performed to evaluate the varying demand for water at different subnational levels, such as RBDs, Italian regions, LMAs. Clearly, the volumes of water demanded by the regions are affected by level and type of production and by territorial dimensions. Figure 6.11 shows the results of the RBD analysis.

The territorial division is based on the number of employees per local unit, in particular the workers and apprentices whose number is closely related to the production activity of the company.

Figure 6.11 – Water use in manufacturing industries by RBD (2015, percentage composition)



Source: Authors' own elaboration.

Summary of water use and withdrawal indicators

With reference to the framework of water withdrawals and uses in Italy, a first estimate was made for 2015 by examining the different types of use.

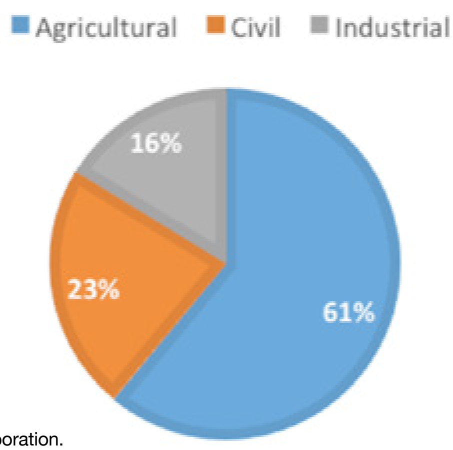
A few caveats are in order.

In terms of the water needed for the production of electricity (excluding hydroelectricity) the volume of freshwater used at the national level in the production process is approximately 75 million cubic metres, while in the cooling phase it is estimated at 2.1 billion cubic metres. These two types are not always derived from water bodies (water courses, canals and wells) but in many cases from industrial water pipes, other production processes of nearby industries and wastewater treatment plants. For this reason this was not counted in the estimation of water stress indicators.

For livestock, an overall use of water of 318 million cubic metres is estimated. This water comes from drinking (civil) use and self-supply. Given the small quantities in reference to other uses and in part the overlap with other types of use already accounted for, this component is not taken into consideration in the cumulative assessment.

In 2015 the three macro activities (public water supply, agriculture and industry) used 20.7 km^3 of water at the national level, divided as shown in the Figure 6.12. This volume is net of the water losses that occurred especially during transport from the withdrawal point to the end user.

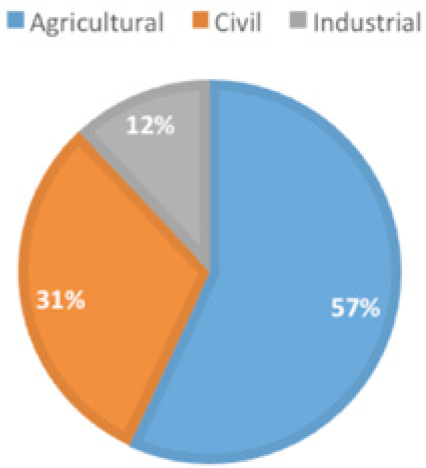
Figure 6.12 – Water uses in Italy, (2015, percentage composition)



Source: Authors' own elaboration.

Concerning the freshwater withdrawn, which represents the volumes of water abstracted from freshwater bodies, it is estimated that in 2015 the three types of supply use analysed withdrew 30.5 km^3 (Figure 6.13). Clearly the distribution by use category is not affected by water losses in the transport networks. These values were also calculated by RBD (Table 6.5).

Figure 6.13 – Freshwater withdrawals in Italy (2015, percentage composition)



Source: Authors' own elaboration.

Table 6.5 – Freshwater withdrawal (hm^3) by use and RBDs, (2015)

River Basin Districts	Civil	Agricultural	Industrial	Total
Eastern Alps	1 076	1 288	597	2 961
Po river	2 873	11 562	1 850	16 285
Northern Apennines	602	125	312	1 039
Central Apennines	1 497	471	395	2 363
Southern Apennines	2 364	2 001	394	4 759
Sardinia	313	750	22	1 085
Sicily	751	1 171	81	2 003
ITALY	9 476	17 368	3 651	30 495

Source: Authors' own elaboration.

Level of water stress calculation

As described in previous chapters, the calculation of SDG indicator 6.4.2 is performed by adopting a methodology based on BIGBANG IRWR estimates, AQUASTAT database estimates for ERWR, GEFIS estimates of percentage of EFR related to NAR and Istat data around water withdrawals.

The calculation of SDG 6.4.2 factors in the average value of the BIGBANG IRWR estimates referring to two periods: 1951 to 2020; and the most recent 30-year period spanning from 1991 to 2020. Consequently the temporal variation of the indicator could be highlighted. The change in the indicator is assessed only by the change in the availability of IRWR because the estimates used for ERWR and EFR in assessing the water resource availability, do not refer to the same period of IRWR; but are nevertheless considered representative of these same periods. Annex 1 shows the trend over time for all thirty years of climatological reference period from 1951 to 2020

Table 7.1 and Table 7.2 report in million cubic metres (hm^3), respectively for the periods 1951–2020 and 1991–2020, the estimations of TRWR, for each RBDs and for Italy, as the sum of IRWR and ERWR and the estimations of EFR as the product of the TRWR and GEFIS-based percentage. It is worth pointing out that the IRWR in the most recent period reduced on average by about 5 percent in Italy but with great percentage differences among the RBDs.

Table 7.3 and Table 7.4 show (respectively for the period 1951–2020 and 1991–2020), the final calculation of SDG 6.4.2 on water stress as a ratio of water withdrawals for all uses and water resources available ($TRWR\text{-}EFR_{BIGBANG}$). The SDG indicator values are also mapped for RBDs in Figure 7.1 and Figure 7.2.

As shown in Figure 7.1 and Figure 7.2, Italy presents different classes of water stress at subnational level.

If we compare SDG 6.4.2 at national level (36.7 percent) with the level of water stress calculated using TRWR estimated for the period 1951–2020 (Figure 7.1), the Districts of the Eastern Alps, the Northern Apennines, the Southern Apennines and Sardinia show a “no-stress” level while the Districts of the Central Apennines and Sicily have a “low-stress” level. The River Po district, on the other hand, has a “medium-stress” level. No district has a “high-stress” level.

The situation changes for the Southern Apennines District and for Sardinia District when considering the TRWR referring to the period 1991–2020 (Figure 7.2). For all RBDs and for Italy there is an increase in the water stress indicator, but for the Sardinia District and the Southern Apennines District, the increase also produces a change in the stress class, passing from a “no-stress” level to a “low-stress” level.

The territory of the Po River District remains in a “medium-stress” level, but much higher than the other districts. The greater water stress is essentially due to the greater use of water for agriculture, as evidenced by the fact that it has a much higher per capita value of water withdrawal for agriculture than in the other districts, even with a higher population density (Figure 7.3 and Figure 7.4).

Table 7.1 – Computation summary of TRWR and EFR based on BIGBANG 5.0 listed by RBD and Italy. Figures refer to the entire period available (1951–2020)

River Basin District	Area	IRWR	ERWR(*)	TRWR	EFR_{GEFIS}/NAR_{GEFIS}	$EFR_{BIG-BANG}$
	km^2	hm^3	hm^3	hm^3	%	hm^3
Eastern Alps	34 805	23 352	3 800	27 152	45.3	12 292
Po River	82 977	43 552	4 500	48 052	46.7	22 423
Northern Apennines	24 340	12 939	500	13 439	44.4	5 961
Central Apennines	42 373	18 393	0	18 393	51.0	9 378
Southern Apennines	67 646	30 091	0	30 091	36.7	11 051
Sardinia	24 100	6 836	0	6 836	35.6	2 433
Sicily	25 832	6 784	0	6 784	22.7	1 539
ITALY	302 073	141 925	8 800	150 725	44.8	67 585

(*) External inflow data is sourced from AQUASTAT database

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html. GEFIS. 2022. https://eflows.iwmi.org/. FAO AQUASTAT. 2022. https://www.fao.org/aquastat/en/

Table 7.2 – Computation summary of TRWR and EFR based on BIG-BANG 5.0 listed by RBD and Italy. Figures refer to the last thirty-year period available (1991–2020)

River Basin District	Area	IRWR	ERWR(*)	TRWR	EFR_{GEFIS}/NAR_{GEFIS}	$EFR_{BIGBANG}$
	KM^2	HM^3	HM^3	HM^3	%	HM^3
Eastern Alps	34 805	23 570	3 800	27 370	45.3	12 391
Po River	82 977	41 461	4 500	45 961	46.7	21 447
Northern Apennines	24 340	12 425	500	12 925	44.4	5 733
Central Apennines	42 373	16 627	0	16 627	51.0	8 477
Southern Apennines	67 646	27 899	0	27 899	36.7	10 246
Sardinia	24 100	5 722	0	5,722	35.6	2 036
Sicily	25 832	6 802	0	6 802	22.7	1 543
ITALY	302 073	134 479	8 800	143 279	44.8	64 246

(*) External inflow data is sourced from AQUASTAT database

Source: ISPRA. 2022. https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html.
GEFIS. 2022. https://eflows.iwmi.org/. FAO AQUASTAT. 2022. https://www.fao.org/aquastat/en/

Table 7.3 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the entire period available 1951–2020

River Basin District	Area	$TRWR-EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 860	2 961	19.9
Po River	82 977	25 629	16 285	63.5
Northern Apennines	24 340	7 478	1 039	13.9
Central Apennines	42 373	9 016	2 363	26.2

Southern Apennines	67 646	19 040	4 759	25.0
Sardinia	24 100	4 403	1 085	24.6
Sicily	25 832	5 245	2 003	38.2
ITALY	302 073	83 140	30 495	36.7

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

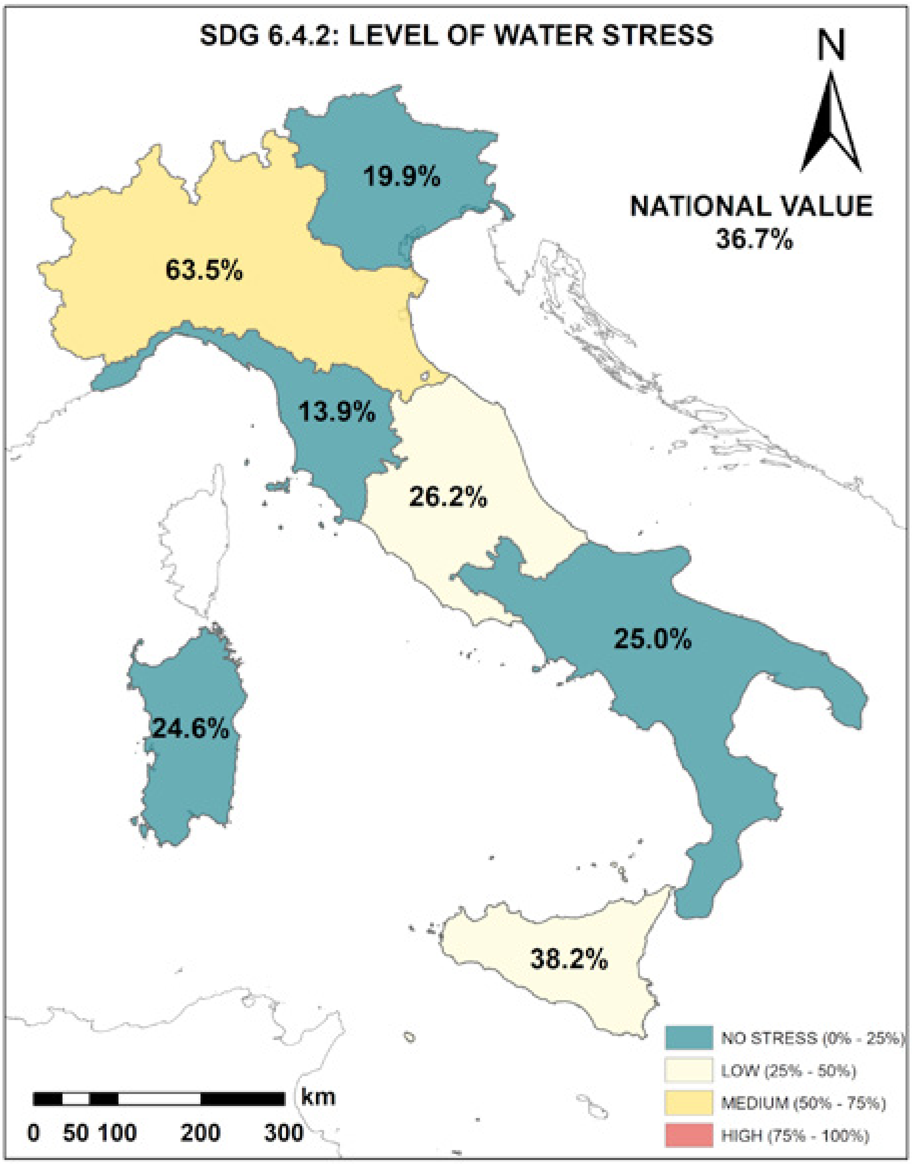
Table 7.4 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the last available thirty-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 961	19.8
Po River	82 977	24 514	16 285	66.4
Northern Apennines	24 340	7 192	1 039	14.5
Central Apennines	42 373	8 150	2 363	29.0
Southern Apennines	67 646	17 653	4 759	27.0
Sardinia	24 100	3 686	1 085	29.4
Sicily	25 832	5 259	2 003	38.1
ITALY	302 073	79 033	30 495	38.6

(*) Water withdrawal data refer to 2015

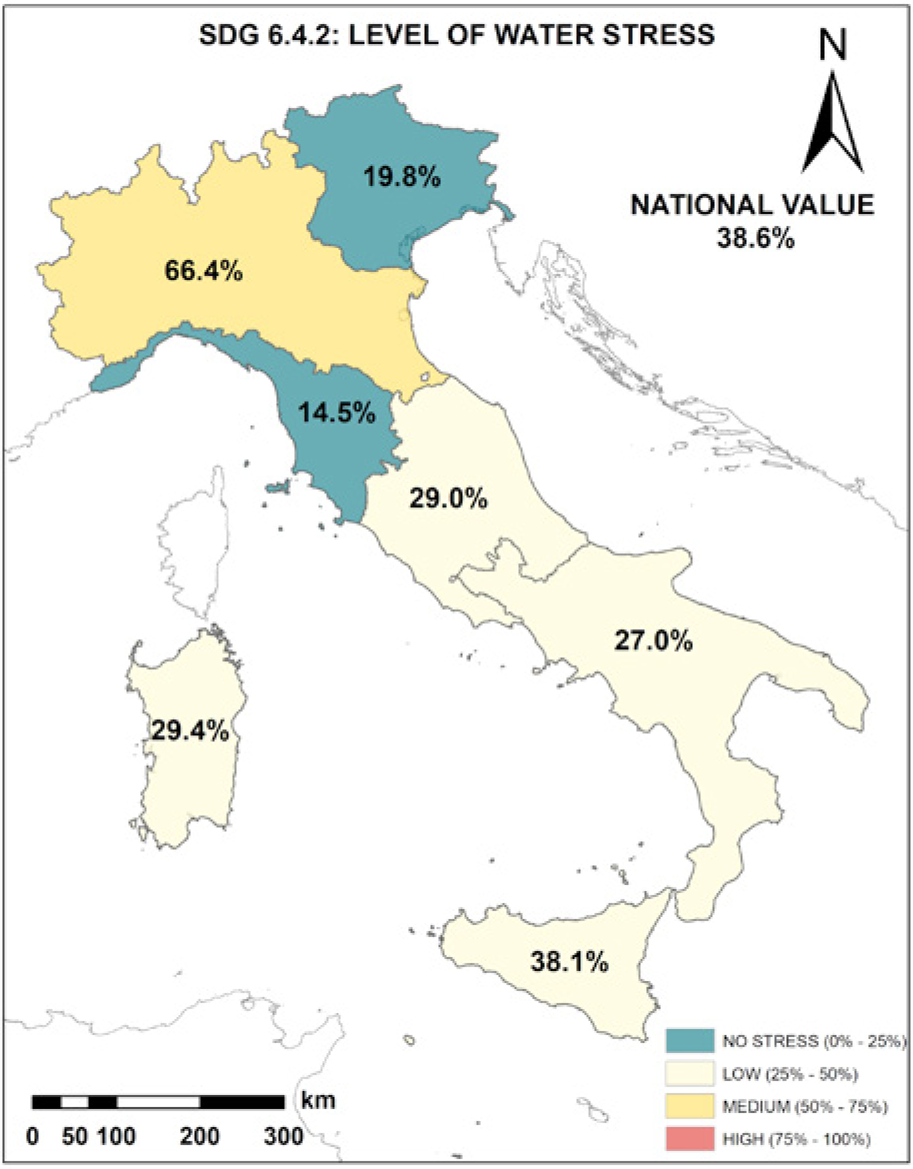
Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure 7.1 – Map of SDG 6.4.2 "Level of water stress" disaggregated at RBD level, where TRWR refer to the period 1951–2020



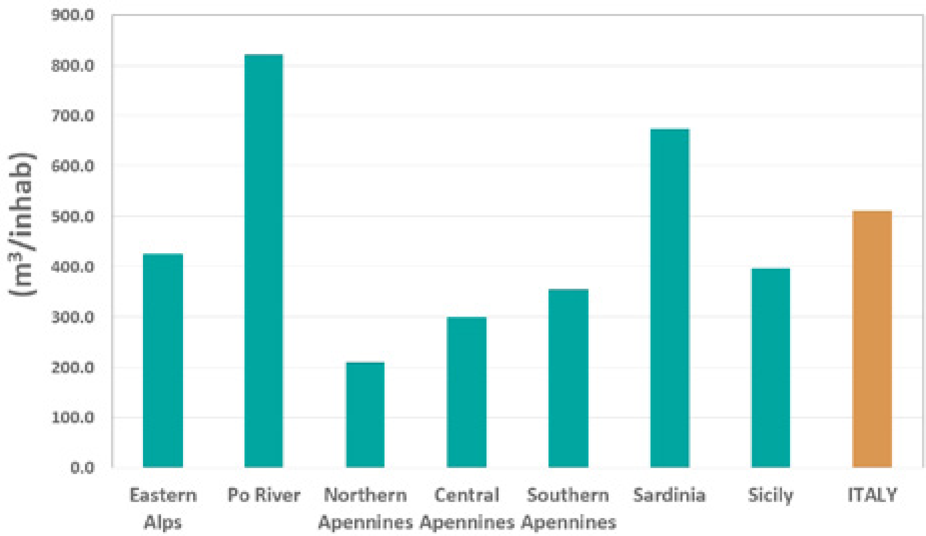
Source: Authors' own elaboration.

Figure 7.2 – Map of SDGs 6.4.2 "Level of water stress" disaggregated at RBD level, where TRWR refer to the period 1991–2020



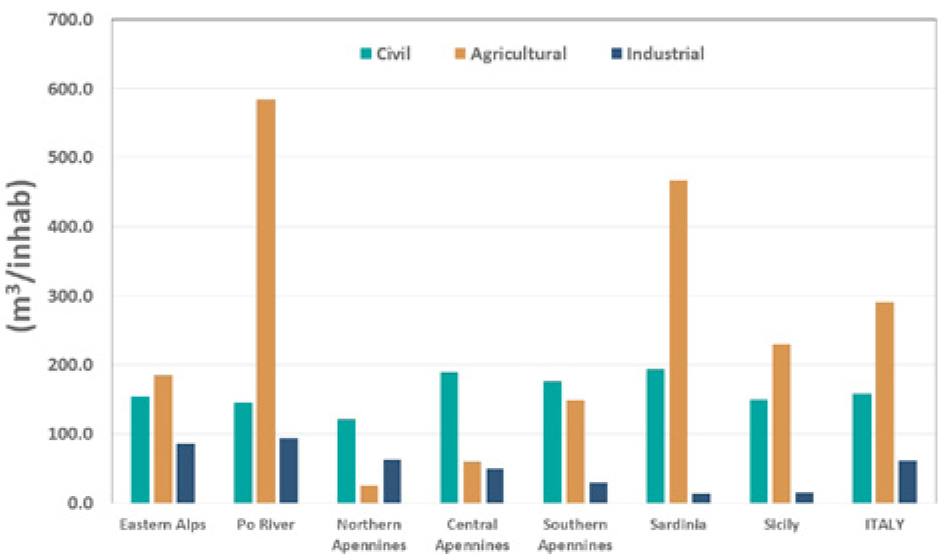
Source: Authors' own elaboration.

Figure 7.3 – Total water withdrawals per capita (m^3/inhab) in RDB and in Italy (2015)



Source: Authors' own elaboration.

Figure 7.4 – Water withdrawals per capita (m^3/inhab) for different uses in RDB and in Italy (2015)



Source: Authors' own elaboration.

After computing the indicator for each RBDs, this methodology is tested against AQUASTAT by comparing estimates referred to the latest available period of reporting for Italy: 2017–2019 (source www.sdg6data.org/en/indicator/6.4.2)

Figure 7.5 – AQUASTAT 6.4.2. indicator estimation for Italy

Source data indicator 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

Country (or area), region and world data for the latest year of reporting: 2013 - 2019

Country (or area), region, world	Year	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources			
		Overall (%)	Renewable water resources	Water withdrawal	Environmental flow requirements
Italy	2017-2019	30	191.30	34.19	77.83

Source: Authors' own elaboration.

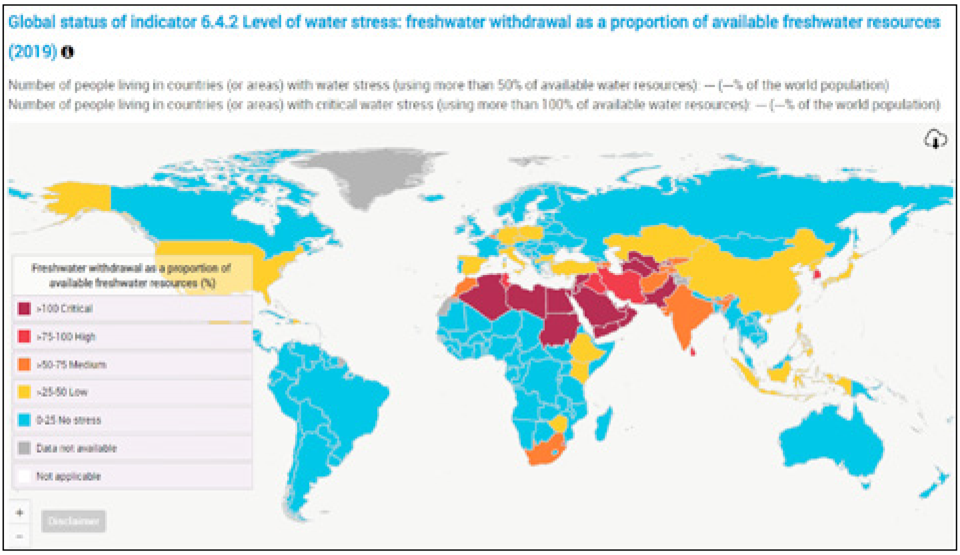
At national level, total water abstraction related to 2015 (the most recent data available) is estimated at about 30.5 billion cubic metres. LTAA (1951–2020) for IRWR estimated by BIGBANG is about 141.9 billion cubic metres, while ERWR from conterminous countries instead amounts to 8.8 billion cubic metres, as estimated in AQUASTAT database. By adding up these two figures, TRWR can be estimated at 150.7 billion cubic metres.

Considering the percentage of annual EFR estimated by the GEFIS-based methodology equal to 44.8 percent of the NAR, we obtain:

$$\textit{Water Stress} = 30.5/((141.9+8.8)\times(1-0.448))\times 100=36.7 \text{ (percent)} \qquad \textit{eq. 7.1}$$

This water stress value is moderately different from the corresponding estimation elaborated in AQUASTAT for the 2017–2019 period, equal to 30 percent. Even with the new estimations, Italy remains in the same "low" water stress class as depicted in Figure 7.6.

Figure 7.6 – AQUASTAT 6.4.2. indicator world map



Source: www.sdg6data.org/en/indicator/6.4.2

Conclusions

This document describes the approach applied in Italy for calculating SDG indicator 6.4.2 “Level of water stress” disaggregated at subnational level. This work is also to be intended as a pilot study to assess the feasibility of application of the procedure to other countries.

The approach consists of joining together the evaluations of TRWR based on the Italian national water balance model, named BIGBANG, which provides more accurate estimates than those obtainable from global models that better reflect water resource availability within the country, with the estimates of EFR elaborated by means of GEFIS. The use of GEFIS-based EFR is to be considered as a first-level estimate of the environmental flow requirements, since Italy has not yet set up and/or approved any kind of methodology that can be homogeneously evaluated across the national territory.

Therefore, this pilot study illustrates the need to define and adopt a reliable methodology to estimate EFR at national and subnational level.

In addition, the methodology was also used to calculate SDG indicator 6.4.2 for the entirety of the Italian territory. The results obtained have thus been compared and contrasted with those obtained for Italy in AQUASTAT. The comparison shows that AQUASTAT considerably underestimates the actual level of water stress.

Given the aforementioned caveat, the indicator values provided here should be considered merely as provisional estimates. These figures could be revised and changed as soon as an official methodology for EFR is available.

References

Allen R.G., Pereira L.S., Raes D. & Smith M. 1998. *Crop evapotranspiration – Guidelines for computing crop water requirements.* FAO Irrigation and drainage paper No. 56. Rome, FAO.

Bellini G., Liguori M.A., Lipizzi F., Lupia F., Magliocchi M.G., Tersigni S. 2013 - *Water use for irrigation purpose by agriculture holdings as bases for the production of statistical data at river basin district level.* ICAS VI Sixth International Conference on Agricultural Statistics – 2013

Braca G. &Ducci D. 2018. Development of a GIS Based Procedure (BIGBANG 1.0) for Evaluating Groundwater Balances at National Scale and Comparison with Groundwater Resources Evaluation at Local Scale. In **Calvache M.L., Duque C. & Pulido-Velazquez D., eds.** *Groundwater and Global Change in the Western Mediterranean Area Springer.* DOI:10.1007/978-3-319-69356-9_7.

Braca G., Bussettini M., Ducci D., Lastoria B. & Mariani S. 2019. *Evaluation of national and regional groundwater resources under climate change scenarios using a GIS-based water budget procedure.* Rend. Fis. Acc. Lincei, 30(1), 109–123. DOI:10.1007/s12210-018-00757-6.

Braca G., Bussettini M., Lastoria B., Mariani S. & Piva F. 2021. *Il Bilancio Idrologico Gis BAsed a scala Nazionale su Griglia regolare – BIGBANG: metodologia e stime. Rapporto sulla disponibilità naturale della risorsa idrica.* ISPRA, Rapporti 339/21, Rome (in Italian). www.isprambiente.gov.it/en/publications/reports/nationwide-gis-based-regular-gridded-hydrological-water-budget-2013-bigbang-methodology?set_language=en.

Braca G., Bussettini M., Lastoria B., Mariani S. & Piva F. 2022. *Il modello di bilancio idrologico nazionale BIGBANG: sviluppo e applicazioni operative. La disponibilità della risorsa idrica naturale in Italia dal 1951 al 2020 / The BIGBANG National Water Balance Model: Development and Operational Applications. The Availability of Renewable Freshwater Resources in Italy from 1951 to 2020.* L'Acqua, 2/2022.

Crespi A., Brunetti M., Lentini G. & Maugeri M. 2018. 1961–1990 high-resolution monthly precipitation climatologies for Italy. *Int. J. Climatol.*, 38, 878–895. DOI:10.1002/joc.5217.

Eurostat & OECD. 2018. *Data Collection Manual for the OECD/Eurostat Joint Questionnaire on Inland Waters and Eurostat regional water questionnaire. Concepts, definitions, current practices, evaluations and recommendations,* Version 4.

FAO. 2019. *Incorporating environmental flows into "water stress" indicator 6.4.2 – Guidelines for a minimum standard method for global reporting.* 32 pp. Licence: CC BY-NC-SA 3.0 IGO. Rome, FAO.

ISTAT. 2019. *Utilizzo e qualità della risorsa idrica in Italia.* Tersigni S. Ed. Ebook Temi – Letture statistiche. Istat 2019 (In Italian). https://www.istat.it/it/archivio/234904

Hoogeveen J., Faurès J.M., Peiser L., Burke J. & van de Giesen, N. 2015. GlobWat – a global water balance model to assess water use in irrigated agriculture. *Hydrol. Earth Syst. Sci.*, **19**, 3829–3844.

Sood A., Smakhtin V., Eriyagama N., Villholth K.G., Liyanage N., Wada Y., Ebrahim G. & Dickens C. 2017. *Global environmental flow information for the sustainable development goals.* Colombo, Sri Lanka: International Water Management Institute (IWMI), 37p. IWMI Research Report 168. DOI:10.5337/2017.201.

Webography

Eastern Alps http://www.alpiorientali.it/

Po River https://www.adbpo.it/

Northern Apennines https://www.appenninosettentrionale.it/itc/

Central Apennines https://www.autoritadistrettoac.it/

Southern Apennines https://www.distrettoappenninomeridionale.it/

Sardinia https://autoritadibacino.regione.sardegna.it/

Sicily https://www.regione.sicilia.it/istituzioni/regione/strutture-regionali/presidenza-regione/autorita-bacino-distretto-idrografico-sicilia

www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

http://eflows.iwmi.org/

www.istat.it/it/archivio/137001

www.sdg6data.org/en/indicator/6.4.2

https://www.istat.it/it/archivio/234904

https://www.istat.it/en/archivio/268982

http://www.alpiorientali.it/

https://www.adbpo.it/

https://www.appenninosettentrionale.it/itc/

https://www.autoritadistrettoac.it/

https://www.distrettoappenninomeridionale.it/

https://autoritadibacino.regione.sardegna.it/

https://www.regione.sicilia.it/istituzioni/regione/strutture-regionali/presidenza-regione/autorita-bacino-distretto-idrografico-sicilia

https://www.fao.org/aquastat/en/

Annex 1. Change over time of SDG 6.4.2 Level of Water Stress indicator

In order to highlight the variation over time of the Water Stress indicator in Italy and into its River Basin Districts, values of the indicator are calculated first considering the value of the availability of the average water resource for the various thirty-year periods, keeping the validated value of water withdrawals constant and equal to that relating to 2015; second, the indicator is calculated by keeping the value of the availability of the water resource constant at the value relating to the last thirty-year period 1991-2020 but considering the values of the withdrawals, even if provisional, of the years 2016, 2017, 2018 and 2019.

First scenarios

The change in the indicator is assessed only by the change in the availability of TRWR without change to the value of WW which remain those relating to 2015. The value of the EFR is also constant over time which is estimated with GEFIS.

In the Table A1.1 – Table A1.6 are reported the calculation of water stress indicator for the five thirty period from 1951 to 2020 and for the entire period 1951-2020. Figure A1.1, for the same periods, for a quick comparison, shows the maps of the indicators disaggregated by RDBs and finally the Figure A1.2 and Figure A1.3 show the trends of the indicator respectively by comparing the values assumed in the different territories for the same period and by comparing the values for the same territory taken over time.

In Italy and in all districts, the indicator shows an increasing trend in the first thirty-year periods which testifies to a reduction in the availability of renewable water resources, considering that all the other terms of the indicator formula have remained constant.

The maximum values occurred for Italy and for all RBDs, with the exception of Sicily, in the thirty-year period 1981-2010. A trend reversal has taken place in recent periods.

The Po River District always showed the highest value of the indicator and always at a level of medium stress while all the other RBDs showed a level between no stress and low stress.

Italy showed an indicator value ranging from a minimum of 33.4 percent to a maximum of 40.4 percent always contained in the range corresponding to a low stress level.

Table A1.1 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the 30-year period 1951–1980

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	15 362	2 961	19.3
Po River	82 977	27 790	16 285	58.6
Northern Apennines	24 340	8 176	1 039	12.7
Central Apennines	42 373	10 291	2 363	23.0
Southern Apennines	67 646	21 481	4 759	22.2
Sardinia	24 100	5 409	1 085	20.1
Sicily	25 832	5 639	2 003	35.5
ITALY	302 073	91 281	30 4955	33.4

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.2 – SDG 6.4.2 “Level of water stress: freshwater withdrawal as a proportion of available freshwater resources” disaggregated by RBD, where TRWR refer to the 30-year period 1961–1990

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 484	2 961	20.4
Po River	82 977	25 727	16 285	63.3
Northern Apennines	24 340	7 458	1 039	13.9
Central Apennines	42 373	9 363	2 363	25.2
Southern Apennines	67 646	19 239	4 759	24.7
Sardinia	24 100	4 740	1 085	22.9
Sicily	25 832	4 709	2 003	42.5
ITALY	302 073	83 314	30 495	36.6

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.3 – *SDG 6.4.2 “Level of water stress: freshwater withdrawal as a proportion of available freshwater resources” disaggregated by RBD, where TRWR refer to the 30-year period 1971–2000*

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 067	2 961	21.0
Po River	82 977	25 781	16 285	63.2
Northern Apennines	24 340	7 013	1 039	14.8
Central Apennines	42 373	8 759	2 363	27.0

Southern Apennines	67 646	17 955	4 759	26.5
Sardinia	24 100	3 945	1 085	27.5
Sicily	25 832	4 681	2 003	42.8
ITALY	302 073	80 009	30 495	38.1

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.4 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the 30-year period 1981–2010

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	13 926	2 961	21.3
Po River	82 977	23 702	16 285	68.7
Northern Apennines	24 340	6 731	1 039	15.5
Central Apennines	42 373	8 062	2 363	29.3
Southern Apennines	67 646	16 945	4 759	28.1
Sardinia	24 100	3 616	1 085	30.0
Sicily	25 832	4 750	2 003	42.2
ITALY	302 073	75 538	30 495	40.4

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.5 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – EFR$_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 961	19.8
Po River	82 977	24 514	16 285	66.4
Northern Apennines	24 340	7 192	1 039	14.5
Central Apennines	42 373	8 150	2 363	29.0
Southern Apennines	67 646	17 653	4 759	27.0
Sardinia	24 100	3 686	1 085	29.4
Sicily	25 832	5 259	2 003	38.1
ITALY	302 073	79 033	30 495	38.6

(*) Water withdrawal data refer to 2015

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

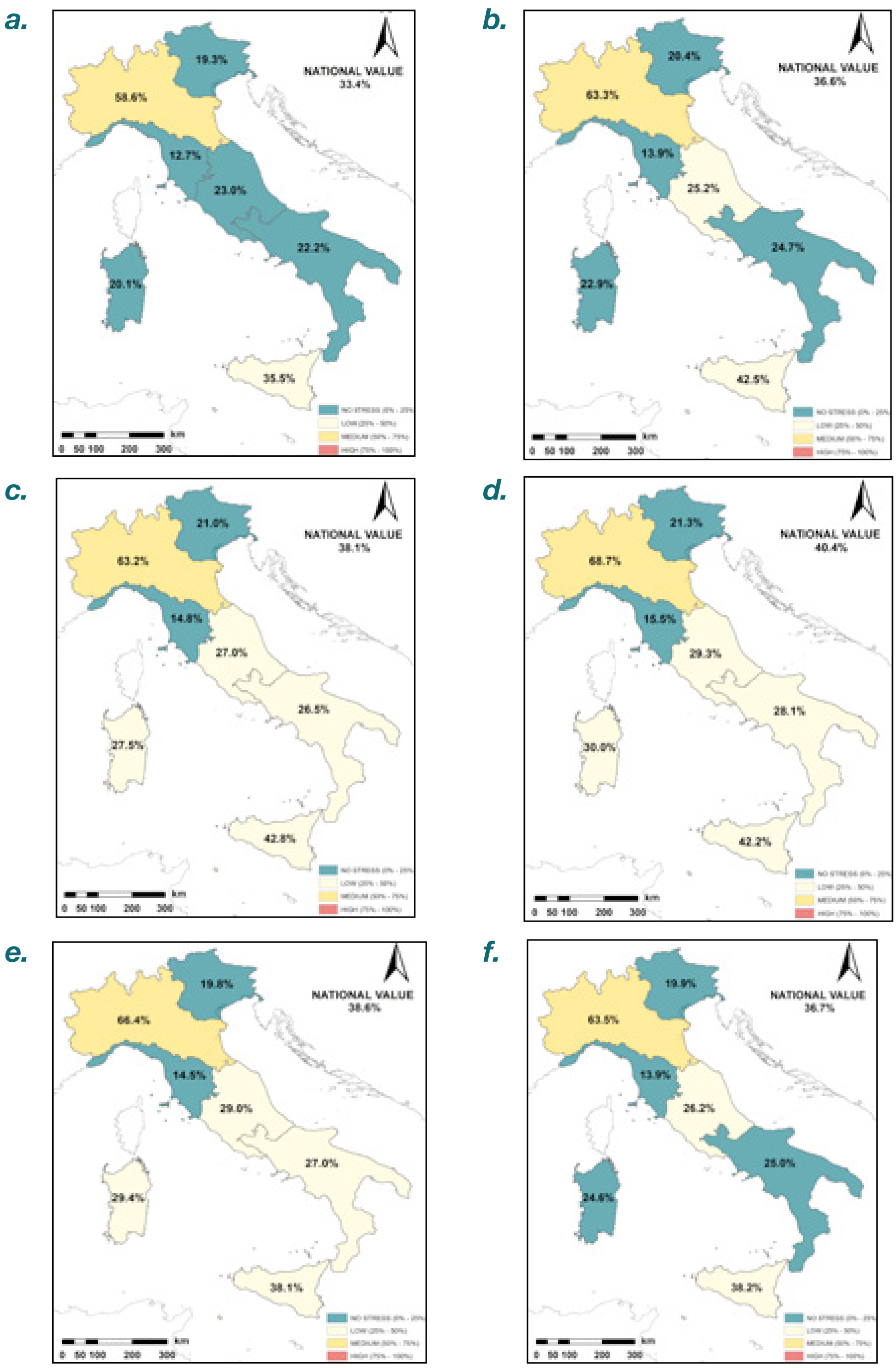
Table A1.6 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the entire 70-year period 1951–2020

River Basin District	Area	TRWR-EFR$_{BIGBANG}$	WW(*)	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 860	2 961	19.9
Po River	82 977	25 629	16 285	63.5
Northern Apennines	24 340	7 478	1 039	13.9
Central Apennines	42 373	9 016	2 363	26.2
Southern Apennines	67 646	19 040	4 759	25.0
Sardinia	24 100	4 403	1 085	24.6
Sicily	25 832	5 245	2 003	38.2
ITALY	302 073	83 140	30 495	36.7

(*) Water withdrawal data refer to 2015

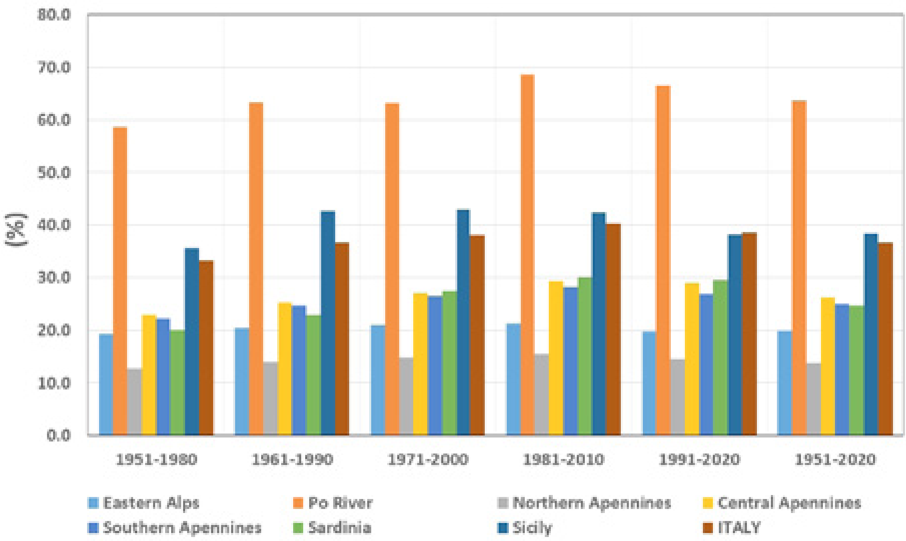
Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure A1.1 – Maps of SDG 6.4.2 "Level of water stress" disaggregated at RBD level, where TRWR refer to the periods: (a) 1951–1980; (b) 1961–1990; (c) 1971–2000; (d) 1981–2010; (e) 1991–2020; (f) 1951-2020



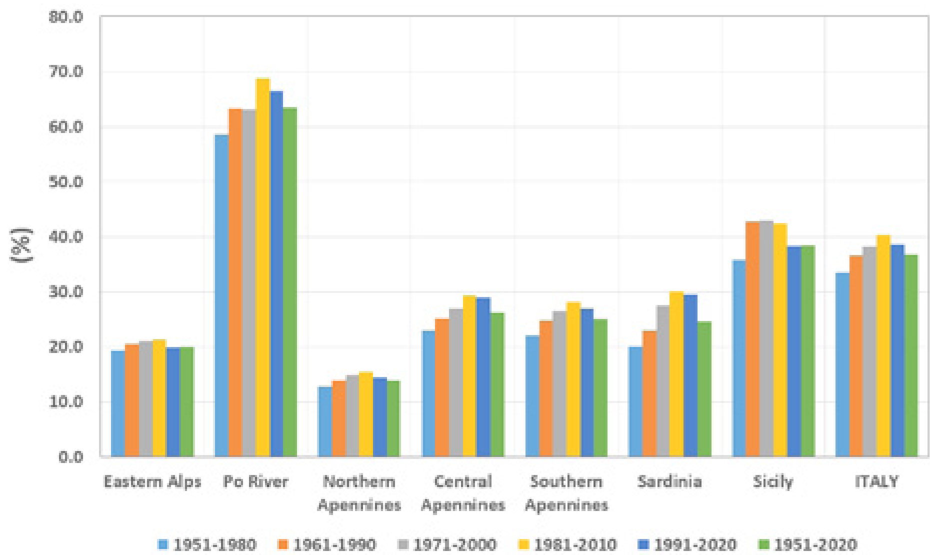
Source: Authors' own elaboration.

Figure A1.2 – Time variation of SDG 6.4.2 where TRWR refer to various 30-year periods from 1951 to 2020 and WW data refer to 2015. Comparison among values assumed in the different territories for the same period



Source: Authors' own elaboration.

Figure A1.3 – Time variation of SDG 6.4.2 where TRWR refer to various 30-year periods from 1951 to 2020 and the entire period 1951-2020. WW data refer to 2015. Comparison among values for the same territory for different time period



Source: Authors' own elaboration.

Second scenarios

The change in the indicator is also assessed by the change in the values of WW relating to years 2016, 2017, 2018 and 2019, without changes to the value of availability of TRWR which remain those of 1991–2020. In these scenarios the value of the EFR is also considered constant over time, as it is estimated using GEFIS.

As shown the following tables and figures, the value of the indicator in the years 2015-2019 varies in Italy between 37.0 percent in 2018 and 40.8 percent in 2017, a year that was characterized by a significant drought, particularly in central-northern Italy. The same variation occurred in almost all the RBDs and in particular in the Po River District where in 2017 the indicator value reached 70.8 percent.

However, such variability does not have an impact on the class of level of water stress which remains the same at country level and for the RBDs.

Table A1.7 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW 2015	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 961	19.8
Po River	82 977	24 514	16 285	66.4
Northern Apennines	24 340	7 192	1 039	14.5
Central Apennines	42 373	8 150	2 363	29.0
Southern Apennines	67 646	17 653	4 759	27.0
Sardinia	24 100	3 686	1 085	29.4
Sicily	25 832	5 259	2 003	38.1
ITALY	302 073	79 033	30 495	38.6

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.8 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where WW refer to 2016 and TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW 2016	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 863	19.1
Po River	82 977	24 514	15 704	64.1
Northern Apennines	24 340	7 192	1 023	14.2
Central Apennines	42 373	8 150	2 306	28.3
Southern Apennines	67 646	17 653	4 611	26.1
Sardinia	24 100	3 686	1 158	31.4
Sicily	25 832	5 259	2 294	43.6
ITALY	302 073	79 033	29 958	37.9

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.9 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where WW refer to 2017 and TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW 2017	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 988	19.9
Po River	82 977	24 514	17 345	70.8
Northern Apennines	24 340	7 192	1 094	15.2
Central Apennines	42 373	8 150	2 432	29.8
Southern Apennines	67 646	17 653	4 967	28.1
Sardinia	24 100	3 686	1 232	33.4
Sicily	25 832	5 259	2 194	41.7
ITALY	302 073	79 033	32 252	40.8

Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.10 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where WW refer to 2018 and TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW 2018	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	2 944	19.7
Po River	82 977	24 514	15 562	63.5
Northern Apennines	24 340	7 192	1 046	14.5
Central Apennines	42 373	8 150	2 383	29.2
Southern Apennines	67 646	17 653	4 707	26.7
Sardinia	24 100	3 686	724	19.6
Sicily	25 832	5 259	1 901	36.1
ITALY	302 073	79 033	29 267	37.0

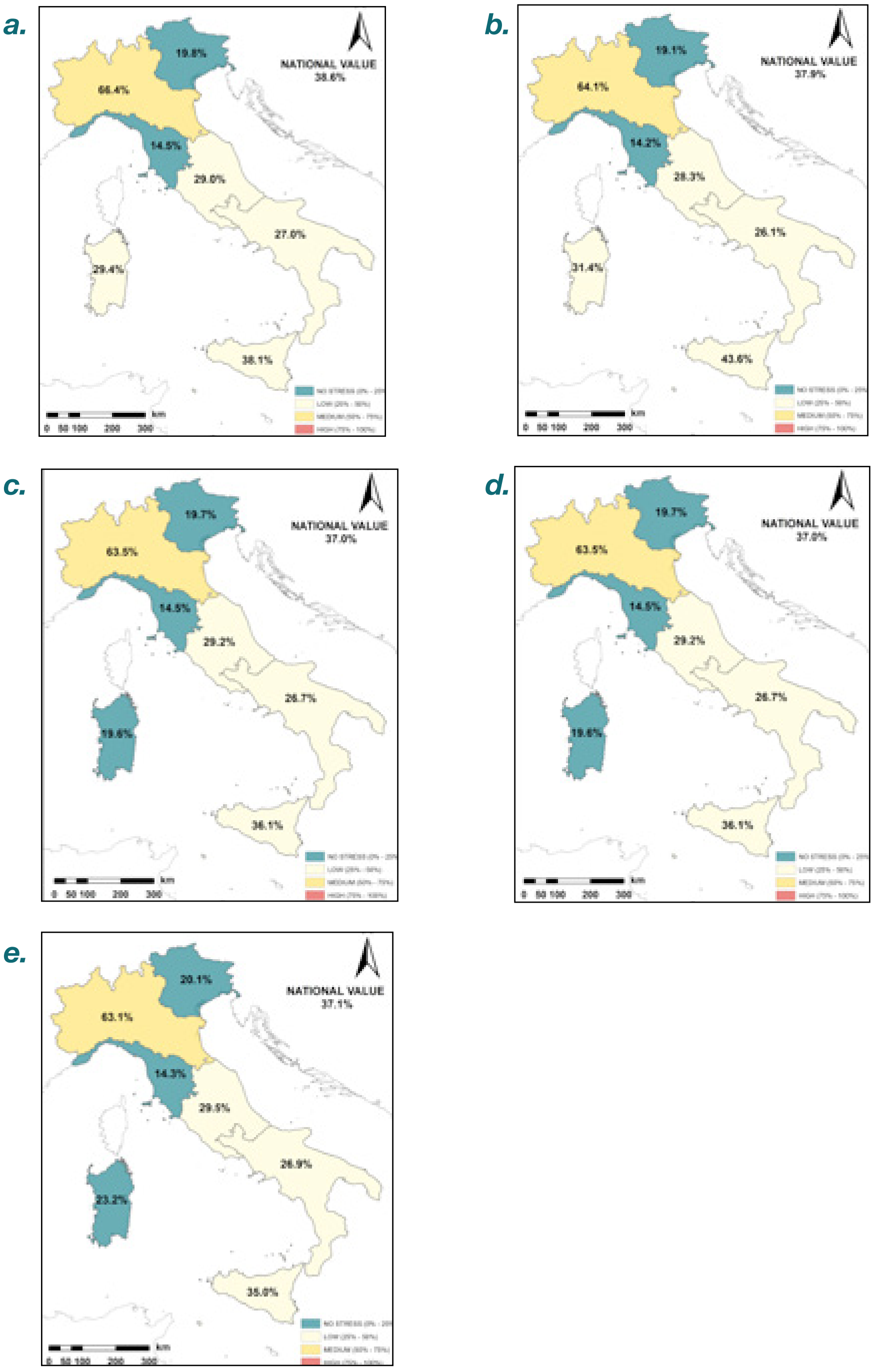
Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Table A1.11 – SDG 6.4.2 "Level of water stress: freshwater withdrawal as a proportion of available freshwater resources" disaggregated by RBD, where WW refer to 2019 and TRWR refer to the 30-year period 1991–2020

River Basin District	Area	TRWR – $EFR_{BIGBANG}$	WW 2019	Water Stress
	km^2	hm^3	hm^3	%
Eastern Alps	34 805	14 979	3 004	20.1
Po River	82 977	24 514	15 456	63.1
Northern Apennines	24 340	7 192	1 026	14.3
Central Apennines	42 373	8 150	2 401	29.5
Southern Apennines	67 646	17 653	4 756	26.9
Sardinia	24 100	3 686	856	23.2
Sicily	25 832	5 259	1 839	35.0
ITALY	302 073	79 033	29 340	37.1

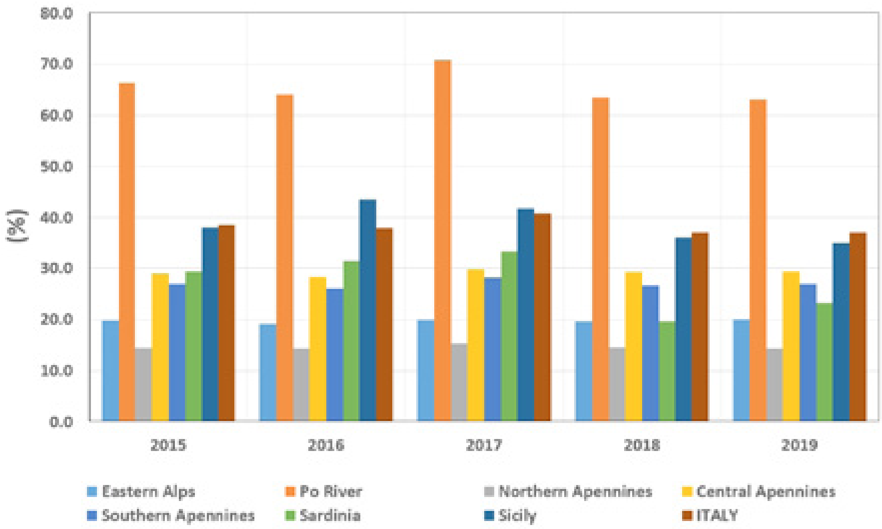
Source: Authors' own elaboration and ISPRA. 2022.
https://www.isprambiente.gov.it/pre_meteo/idro/BIGBANG_ISPRA.html

Figure A1.4 – Maps of SDGs 6.4.2 "Level of water stress" disaggregated at RBD level, where TRWR refer to the period 1991–2020 and WW refer to the years: (a) 2015; (b) 2016; (c) 2017; (d) 2018; (e) 2019



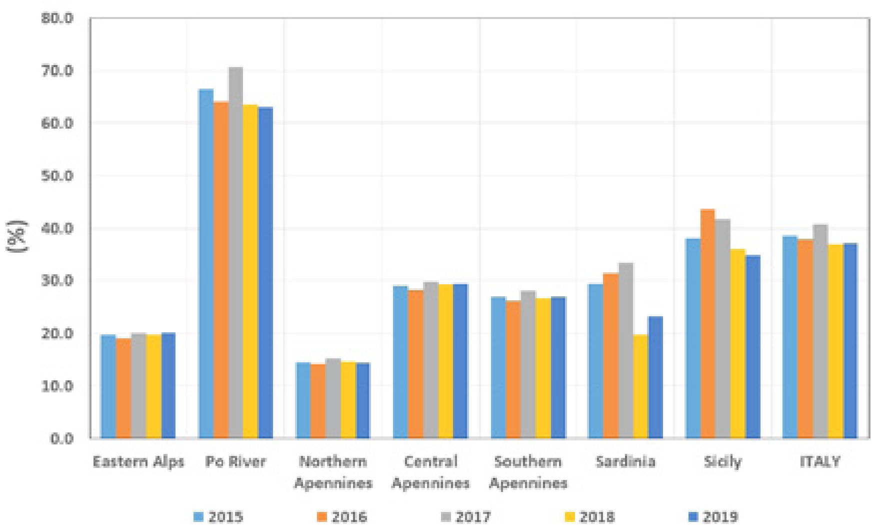
Source: Authors' own elaboration.

Figure A1.5 – Time variation of SDG 6.4.2 where TRWR refer to the 30-year period from 1991 to 2020 and WW data refer to 2015, 2016, 2017, 2018, and 2019. Comparison among values assumed in the different territories for the same period



Source: Authors' own elaboration.

Figure A1.6 – Time variation of SDG 6.4.2 where TRWR refer to the 30-year period from 1991 to 2020 and WW data refer to 2015, 2016, 2017, 2018, and 2019. Comparison among values for the same territory for different time period



Source: Authors' own elaboration.

This report is the presentation of the methodology applied in Italy to spatially disaggregate the computation of the level of water stress from the national to the subnational scale (SDG indicator 6.4.2). Compared to the national assessment which results in a low level of water stress in the country, the spatial disaggregation of the indicator by hydrological unit highlighted the presence of basins affected by water stress exceeding 60% (district of the Po river basin).

The analysis was performed considering the long term average of the available fresh water resources calculated on different reference periods (1951-2020, 1961-90, 1991-2020) and this put in evidence the impact of climate change on the level of water stress. This report is part of the series SDG 6.4 MONITORING SUSTAINABLE USE OF WATER RESOURCES PAPERS that collects all the achievements on SDG 6.4. The study was implemented by the Italian Institute for Environmental Protection and Research (ISPRA), responsible of the model and data used to assess the total renewable freshwater resources, and the Italian National Institute of Statistics (ISTAT), which has provided the methodology and the official statistics related to water withdrawals by economic sector (Agriculture, Services, and Industry).

The study is the outcome of an agreement between FAO and ISPRA under the Integrated Monitoring Initiative for SDG 6 (IMI-SDG6), designed to produce a map of Italy showing the SDG indicator 6.4.2 “Level of water stress: freshwater withdrawal as a proportion of available freshwater resources” disaggregated at river basin district level. To learn more about the Integrated Monitoring Initiative for SDG 6, visit www.sdg6monitoring.org

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