The future of water availability and use in the EU

A foresight study and policy options to address water scarcity

STUDY

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This study aims to offer an in-depth analysis of water scarcity, availability, and usage in the face of climate change. By employing a comprehensive foresight methodology that includes an extensive literature review, qualitative and quantitative data analysis, and broad stakeholder consultation, the research provides a detailed overview of current water availability and consumption within the European Union (EU). It highlights the current and projected trends related to water resources, identifying the pressures and challenges that climate change imposes on water supply and demand. The study also proposes a range of policy options, divided into short-term options (up to 2030) and medium- to long-term options (up to 2050), aimed at ensuring that both EU citizens and businesses have reliable access to adequate water resources. These policy options are geared towards sustainable water management, ensuring resilience to future climate-related water challenges.

AUTHORS

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Executive summary

Water as a strategic resource and its role in the EU

Water is essential for life and plays a crucial role in the economy, with sectors like agriculture, energy, industry, and households relying heavily on its availability. Climate change has begun affecting water availability and demand, which could lead to more severe water scarcity across the EU in the future.

Europe is increasingly experiencing the effects of the (global) water crisis, facing droughts and floods that compromise both the quality and quantity of water and access to safe drinking water. Europe also faces significant inefficiencies in water use across various sectors, which poses a significant risk to European competitiveness. Access to water, once taken for granted, is now becoming more and more uncertain. Agriculture, the largest water user and a key economic sector for many EU Member States, is particularly vulnerable to water scarcity.

Study objectives and scope

The study specifically examines demand for and supply of freshwater, highlighting that water scarcity occurs when demand exceeds supply. It revolves around the question of freshwater availability within the context of water scarcity and drought caused by climate change. It covers the current situation (2025) and extends to the short-term future (2030) and medium- to long-term future (2050). It aims to:

1. **Analyse the present water context, including sources, usage, and trends**. This includes assessing freshwater sources within the EU-27, examining regional and temporal disparities, and analysing water use and consumption patterns across different sectors and EU regions. The study also elaborates on the current issues related to water scarcity in the EU.
2. **Examine short-term trends and policies to address water scarcity and drought**. The analysis focuses on trends and policies to address water scarcity and drought in the short term, specifically up to 2030. It also identifies key factors that will influence water use and availability
3. **Investigate long-term structural changes required to address the impacts of climate change.** Looking ahead to the medium- to long-term future by 2050, the study explores how climate change continues to impact water availability in Europe, with seasonal variations becoming more pronounced. It presents four potential future scenarios, which help to illustrate how societal, economic, technological, and environmental trends could shape Europe's water resources by 2050 and guide long-term policy decisions.

Water scarcity arises when water demand surpasses the available supply, resulting in insufficient resources for human and environmental needs. Droughts are defined as prolonged periods of abnormally low rainfall, which can lead to the drying up of natural water sources and exacerbate water scarcity. Climate change is expected to worsen water scarcity in the EU, leading to more frequent and severe droughts. Currently, water stress impacts 30 % of Europe's population each year. Although there was a 15 % reduction in water abstraction between 2000 and 2019, the areas facing water scarcity have not diminished. Droughts negatively affect human livelihoods, biodiversity, water quality, and ecosystem services. Additionally, they result in significant economic losses, costing up to €9 billion annually, particularly impacting key sectors such as agriculture.

While climate change may also impact water quality, this study focuses primarily on water quantity while acknowledging the interaction between the two factors. In terms of sectoral focus, the study discusses agriculture, energy, industry, and households. Although floods are critically important, this study does not directly address that topic, which would be better suited for a separate analysis or individual study.

Sectoral and regional disparities in water use

Significant disparities in terms of water use exist across the economic sectors discussed in this study as well as at the regional level. The energy sector is the largest user of water, while agriculture is the largest consumer. Water consumption in agriculture accounts for 28 % of annual water abstraction, with over 80 % of irrigation needs occurring in southern Europe. Climate change poses significant risks to agriculture, particularly during periods of drought, threatening food security.

The energy sector, responsible for more than 90 % of freshwater abstraction, faces challenges in its water dependence, especially as the EU moves toward decarbonisation. While renewable energy sources like wind and solar are less water-intensive, biofuels and certain hydropower installations still consume considerable amounts of water.

The industrial sector also has a high demand for freshwater, both in terms of quantity and quality. Although water use in industry has declined, pollution remains a major concern. The public water supply sector, mainly serving households, has seen reduced consumption in recent years due to water pricing, efficiency improvements, and infrastructure investments.

Regional disparities in water stress

The study also observes regional disparities in water stress, which refers to a situation where there is not enough water of sufficient quality to meet the human or ecological demand for water. Mediterranean countries like Spain, Italy, and Greece experience the highest levels of water stress, driven by a dry climate and heavy agricultural water consumption. In contrast, countries in northern, central, and eastern Europe face water pressures related to industrial activities and energy production. Water stress in the EU is further complicated by over-abstraction in many river basins, where water is withdrawn faster than it can be naturally replenished.

Water scarcity is already a year-round issue in many regions, with as much as 70 % of the population in some areas experiencing seasonal water stress. Even in northern Europe, countries like Belgium and the Netherlands report water shortages during droughts. Over-abstraction in these regions has led to declining groundwater and river levels, with little improvement in the quantitative status of water bodies despite reduced water abstraction.

EU water-related policy

The challenge of water scarcity extends to the European water policy landscape, which is currently fragmented and has not proven effective in addressing the pressing and growing issues of water availability. Despite the advanced state of EU legislation regarding water compared to the rest of the world, many goals remain unfulfilled due to insufficient funding, delayed implementation, and a lack of comprehensive integration of water concerns into sectoral policies.

Water management is one of the oldest policy areas in EU environmental regulation, with the Water Framework Directive (WFD) being the primary legislation since 2000. However, while significant progress has been made on water quality, policies on water quantity are less developed. Efforts like the 2007 Communication on Water Scarcity and Drought and the 2012 Blueprint to Safeguard Europe's Water Resources have seen slow implementation, and the study suggests that EU policy needs a more cohesive strategy to address water scarcity.

In response, the European Economic and Social Committee (EESC) has called for an EU Blue Deal, a comprehensive set of recommendations for a sustainable water policy. The Blue Deal addresses water challenges related to agriculture, industry, and infrastructure and seeks to ensure the resilience of Europe's water resources in the face of climate change.

The short-term future of water availability and use in the EU (2030)

As we look towards 2030, several key trends will influence water availability, usage, and consumption. These trends include population growth, economic development, consumption patterns, digitalisation and use of AI, agricultural innovations, and technological advancements, as well as a changing political climate. The continued impact of climate change is taken as a given.

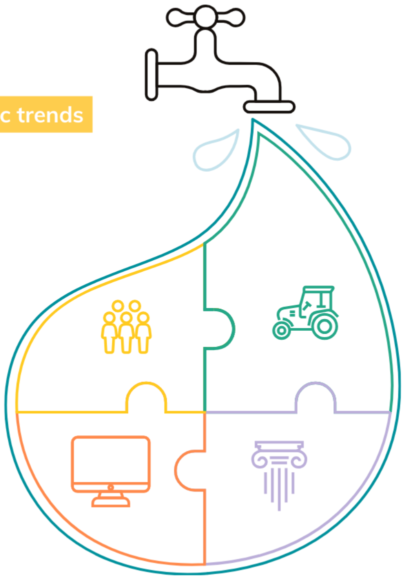
Short-term trends

Societal, demographic and economic trends

- Increase in population
- EU economy expected to grow at a low rate
- Increasing consumption patterns
- More circular economy and society

Technological trends

- Digitalisation and use of Artificial Intelligence (AI)
- Energy transition
- Technological solutions for water scarcity



Agricultural trends

- Agriculture remains largest consumer of water
- Common Agricultural Policy (CAP) reforms
- Innovation: e.g., smart irrigation & metering, crop adaptation

Political, ethical and legal trends

- More resistance to “green” policies
- Nature-based solutions (NBS) in spatial planning

The medium- to long-term future of water availability and use in the EU (2050)

Extending the analysis to 2050, additional trends become important, including resource scarcity, growing global food demand, a changing security paradigm, demographic shifts, continuing technological and agricultural advancements, and a shifting geopolitical balance. As in the short-term, the continuing impact of climate change is taken as a given.

Medium- to long-term trends

Societal, demographic and economic trends

- Aggravating resource scarcity
- Changing security paradigm
- Urbanisation, migration, demographic
- Imbalances, and inequalities
- Growing consumption patterns

Technological trends

- Accelerating technological change and hyperconnectivity
- Innovative solutions to address water scarcity (e.g. Fog harvesting)

Agricultural trends

- Agricultural sector remains largest consumer of water
- Growing global food demand
- Technological advancements (smart irrigation and metering, crop adaptation)

Political, ethical and legal trends

- Shift in geopolitical balance
- Rise of populism
- Participatory governing systems

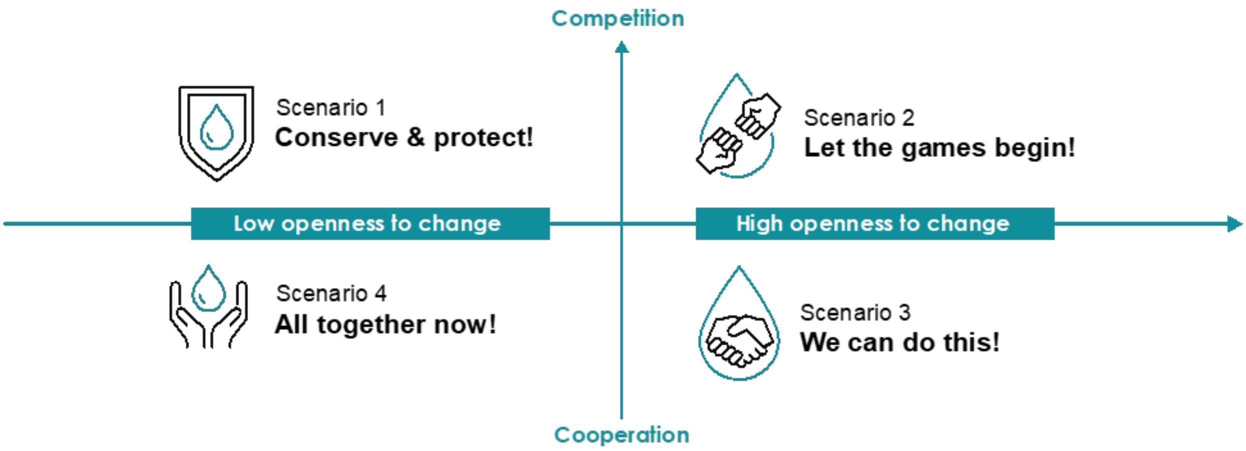
Scenarios for water availability and use in 2050

As the medium- to long-term future is challenging to predict, scenarios help to explore uncertain future developments. They provide context for policy, and identify effective strategies, long-term actions, and socio-economic trends. Climate change and water scarcity are certain and, despite global mitigation efforts, the EU will face severe water shortages by 2050, making adaptation essential. Two key uncertainties shape our scenarios for 2050:

Cooperation vs. Competition – Competition drives innovation, while cooperation fosters shared solutions but may maintain the status quo.

Openness to Change – Some societies embrace change as progress, others prioritise stability over transformation.

Four scenarios for 2050



Policy options to address water scarcity

The study outlines two sets of policy options designed to tackle the pressing challenges of water scarcity, each tailored to different timeframes and focusing on distinct but interrelated approaches. Both sets of policies work in tandem, addressing both immediate concerns and long-term challenges, with the ultimate goal of ensuring that EU citizens and businesses will continue to have access to sufficient water resources. They both incorporate elements related to efficient water use, the crucial role of innovation and technology, the alignment of water management with other EU policies, and the importance of public-private partnerships and public awareness regarding water conservation and sustainable water practices.

Short-term policy option (2030)

Short-term policy options address pressing issues related to acute water shortages and the adverse effects of drought on critical sectors. They are designed to have immediate and tangible effects. These **policies have an immediate impact on preventing and addressing urgent water scarcity**.

Policy option A

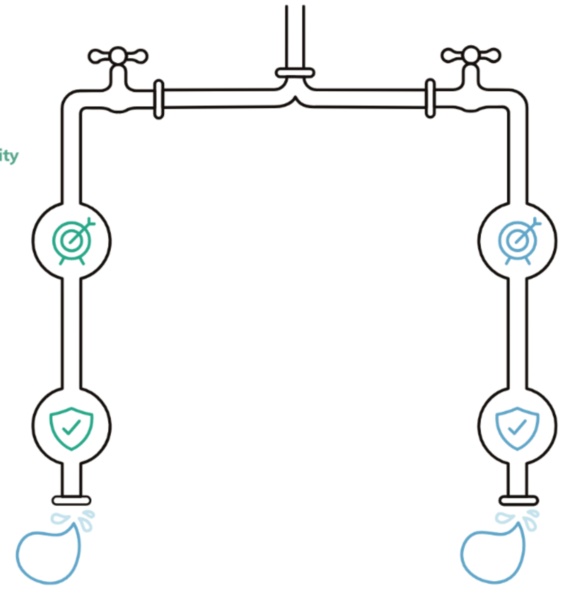
Develop and implement strategies and measures to reduce water use/ consumption in times of water scarcity

Objectives

Introduction of practical, swiftly implementable measures offering immediate and effective responses to water shortages impacting key economic sectors

Policy interventions

- Installation of **smart metering** in water-intensive sectors, aquifers, and private wells
- **Seasonal/context-based** water pricing/taxation schemes.
- Require water-intensive sectors to have a **drought insurance** in regions with a high risk of water scarcity



Policy option B

Integrated EU-wide water strategy and legislative framework to mitigate water scarcity impacts

Objectives

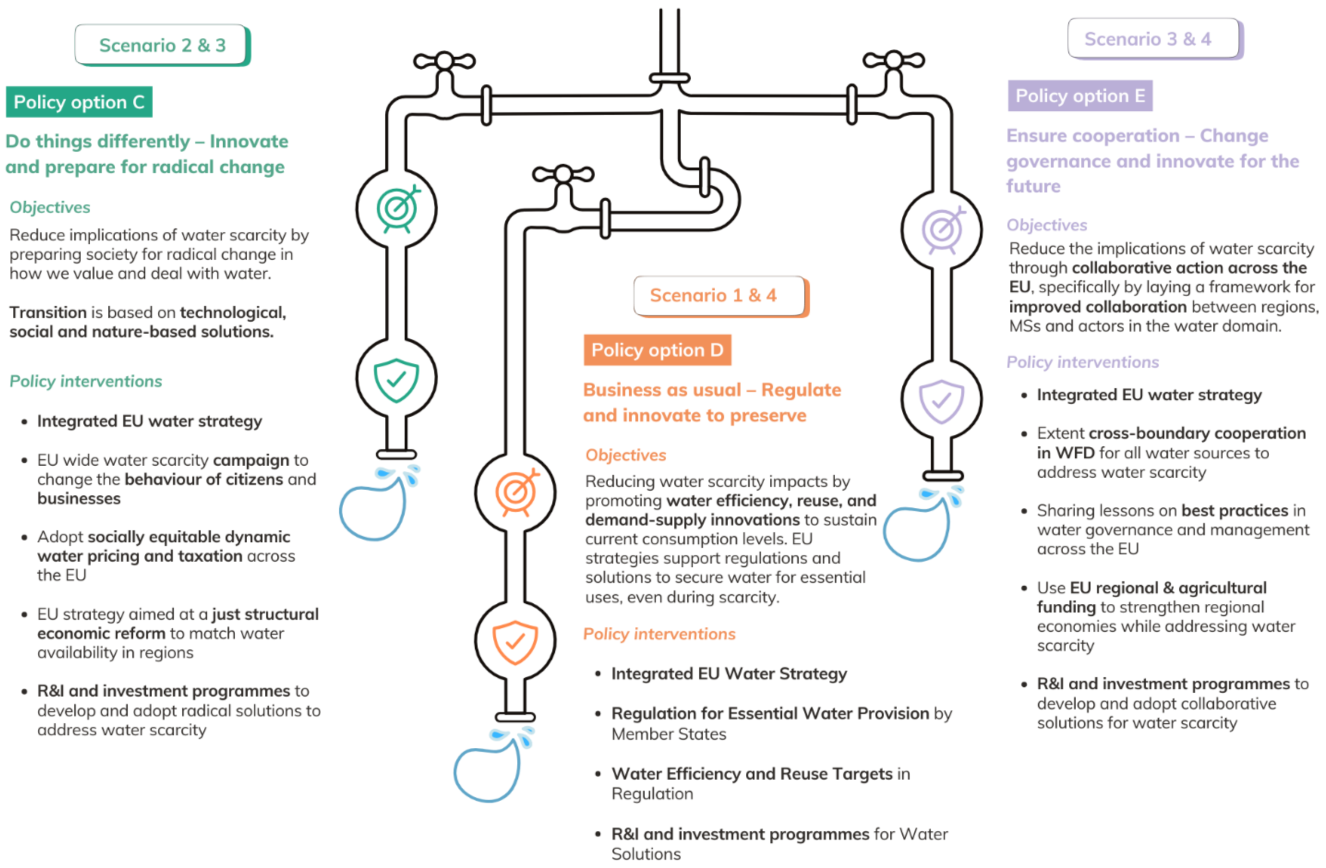
Establishment of a **robust (legislative) framework** for **water resilience** to be implemented during the current mandate of the **EC/EP**

Policy interventions

- **Revision of WFD** with focus on **water quantity** and introduction of **digital water management** at MS level.
- Provision of a **Drought Directive** as counterpart of the Floods Directive
- Provision of additional **funding** targeting water scarcity through **EIB water infrastructure & nature-based solutions** (NBS).
- Provision of additional **funding**, through the **European Innovation Council,** for **start-ups** and **SMEs**

Medium- to long-term policy options (2050)

Policy options for the medium to long term are based on the scenarios for 2050. These policy options are developed to prevent future water scarcity and improve the long-term resilience of the European water system. While their impact takes time, early implementation is important. Delaying could mean missing opportunities to prepare for future challenges or prevent unwanted developments – such as a future with reduced cooperation between EU Member States, which is essential for addressing cross-border water scarcity.



Conclusions

In addition to the policy options, the following are some general conclusions derived from this work into how the issue of water use and availability should be analysed and what policy approach to take:

Climate Change and Water Scarcity in Europe

Intensified water scarcity threatens ecosystems, agriculture, energy, and tourism.

Water-Climate Change Nexus

Water as a vital component for economic productivity, ensuring social wellbeing and maintaining environmental sustainability.

Need for Collective Action and Fair Access

EU-wide cooperation is essential to ensure equitable water access, balancing environmental and social equity.

Nature-based and Digital Solutions

Enhance resource efficiency, improve decision-making and water management.

Proactive Water Management Policies

Early risk identification for proactive, intersectoral water policies.

Data-driven Water Policy

Improved data collection, accessibility, and integration across sectors to improve decision-making, optimise resource allocation, and enhance drought resilience.

Critical Role of Research & Innovation

Implementing transformative solutions will demand substantial investment in research and innovation.

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1. Introduction

1.1. Relevance and purpose of the study

Water is a strategic natural resource that is essential for human, animal and plant life, and that is of economic importance for many sectors. Given its importance, access to water is recognised by the UN as a human right.[1] Climate change has effects on water and may influence the availability of, and demand for freshwater (both surface and ground water). This may lead to (additional) water scarcity in the EU in the future.

In recent years, the "water-smart" concept has gained prominence at the EU level. This concept, endorsed by many stakeholders[2] and by EU institutions, promotes sustainable water management practices to ensure the efficient use of water resources. It aims to address challenges related to water scarcity, pollution, and the impacts of climate change by encouraging the adoption of innovative technologies, better governance, and collaboration across sectors.

To better understand the risks of water scarcity in the EU in the future, and to be prepared to mitigate water scarcity with potential policy options, this study was launched by the European Parliamentary Research Service (EPRS) on the request of the STOA Panel of the European Parliament.

The purpose of this foresight study is to provide a holistic look into water scarcity, water availability and water use in light of climate change and to propose short (2030) and medium-long (2050) term policy options to ensure that EU citizens and businesses will continue to have access to sufficient freshwater.

The report is aimed at politicians and policy makers to help them in priority setting and policy development to mitigate water scarcity in the EU in the future.

1.2. Water scarcity, drought and related key concepts

Water scarcity is defined as a long-term imbalance between water supply and demand. It happens when water demand frequently exceeds the sustainable supply capacity of natural sources for freshwater, such as surface water and groundwater. It is quantifiable as the ratio between renewable freshwater resources and water abstraction and use.[3] In addition to water quantity, significant problems with water quality can also result in a shortage of clean water due to pollution.[4]

While water scarcity refers to the long-term unsustainable use of water resources, which water management can influence, drought is a natural hazard, caused by large-scale climatic variability,

[1] United Nations (n.d.). Human Rights to Water and Sanitation, https://www.unwater.org/water-facts/human-rights-water-and-sanitation

[2] The value of water. Towards a water-smart society (2023).Water Europe: https://watereurope.eu/wp-content/uploads/2023/11/WE-Water-Vision-2023_online.pdf

[3] It should not be interpreted though as the sum of abstraction and use given the in order to be used, the water needs to be collected, harvested from precipitation/rain or abstracted (surface water, groundwater)

[4] European Commission (2024). Water scarcity and droughts, https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en

and cannot be prevented by local water management. Making the distinction between drought and water scarcity is not trivial as they often occur simultaneously.[5]

Water scarcity and droughts are becoming more common and severe across multiple areas in the EU. Water scarcity may arise in some areas due to the intensity and regularity of droughts. Drought effects can worsen if available water supplies are overused. Furthermore, if temperatures rise because of climate change, further reduction of Europe's water resources is expected.[6]

Key concepts and definitions related to water scarcity

Water scarcity

The term water scarcity indicates a long-term imbalance between water supply and demand in a region (or in a water supply system) possibly characterised by a semi-arid or arid climate and/or enhanced by a fast increase of water demand, associated with population growth and/or an extension of irrigated agriculture.[7] Climate change may create or intensify water scarcity problems in a region, either through a reduction in water supply or through an increase in water demand.[8]

Water stress

Water stress refers to a situation where there is not enough water of sufficient quality to meet the human or ecological demand for water. Compared with scarcity and shortage, water stress is a more inclusive and broader concept.[9]

Drought

A drought refers to a temporary deviation from average water supply conditions due to reduced precipitation and increased evapotranspiration over a significant area and time. When prolonged, this may cause reduced levels of soil moisture (soil moisture drought) and reduced levels of natural water flows to surface water and groundwater (hydrological drought), leading to shortages in water supply.[10][11] Drought can severely impact, for example, agriculture & livestock, freshwater ecosystems, waterborne transport, and energy & industry.[12]

[5] Van Loon, A. F., and H. A. J. Van Lanen (2013), Making the distinction between water scarcity and drought using an observation-modelling framework, Water Resour. Res., 49, 1483–1502, doi:10.1002/wrcr.20147

[6] Warmer temperatures enhance evaporation, which reduces surface water and dries out soils and vegetation. This makes periods with low precipitation drier than they would be in cooler conditions.

[7] It is noteworthy though that other sectors than agriculture could contribute to a fast increase in water demand, e.g. industrial water use/cooling water for energy production, if not released close to the intake point.

[8] European Commission (2000) Water scarcity and droughts. https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en

[9] EEA (1999). Water stress definition https://www.eea.europa.eu/help/glossary/eea-glossary/water-stress

[10] EEA (2021). Drought definition. https://www.eea.europa.eu/help/glossary/eea-glossary/drought

[11] European Commission (2009). Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document No. 24.

[12] Stahl et al. (2016). Impacts of European drought events: insights from an international database of text-based reports. Natural Hazards and Earth System Sciences, 16, 801-819. https://doi.org/10.5194/nhess-16-801-2016

Water use

Water use regards the total volume of water used by a socio-economic activity, including e.g. households, agriculture and industry.[13] This may incorporate excess water which does not serve the needs of the activity (water waste). Water use includes both consumptive and non-consumptive activities. Non-consumptive use regards water that is returned to surface water or groundwater after use, potentially with changed physicochemical properties. Consumptive use involves water that is not returned due to evaporation, transpiration of water or its integration into products.[14]

Water abstraction

Water abstraction is the process of taking water from a source, either temporarily or permanently. Sources can include surface waters (rivers, reservoirs, and lakes) or groundwater. Most water is used for irrigation or treatment to produce drinking water, but it can also be used for energy (electricity cooling), industry, public water supply, etc.

Water consumption

Water consumption regards the total volume of water that is not returned and not available for use after being withdrawn. This includes water lost through evaporation, transpiration, incorporation into products, absorption by crops, consumption by humans or animals, released into seas and any other means of removal from the freshwater system. Water consumption excludes water losses occurring during transportation between points of abstraction and use.[15]

Water exploitation index (WEI+)

The Water Exploitation Index Plus (WEI+) indicator is used to indicate the intensity, duration and the socioeconomics impacts of water scarcity. WEI+ can be calculated for the consumption of water and is defined as the ratio of the total water net consumption divided by the available freshwater resources in a region including upstream inflowing water. The total water net consumption is the difference between the water abstraction and the return flow. WEI+ is an advanced version of the WEI which considers only the ratio of water abstraction divided by the available freshwater resources.[16]

[13] Eurostat (2002). Glossary: Water use https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Water_use

[14] Eionet Glossary. https://forum.eionet.europa.eu/nrc-eionet-freshwater/library/wise-country-profile-on-water-resources/1.-landing-page/005

[15] EEA (2021). Water consumption definition. https://www.eea.europa.eu/help/glossary/eea-glossary/water-consumption

[16] EEA (2006). Water exploitation index, plus (WEI+). https://www.eea.europa.eu/en/datahub/datahubitem-view/6c086807-f88f-4978-9823-c4b17bb52400

1.3. Objectives and scope of the study

This study has four main objectives, addressing different timeframes from now (2025) to the medium- to long-term future (2050):

- **Now**: To provide a comprehensive look at the context of water as a resource in the EU, insofar as possible from a quantitative viewpoint and with sufficient geographical resolution: where water is coming from, how and where it is used, where it is going.
- **Short-term future (2030)**: To map out short-term trends in water use and availability, technological, social and economic trends. Investigate responses and policy solutions to mitigate the expected impacts of climate change and acute scarcity, especially because of prolonged droughts.
- **Medium- to long-term future (2050)**: To examine the medium- to long-term situation and suggest policy options, including any necessary structural changes, as a response to water scarcity, increased seasonality and the expected future impacts of climate change.

The scope of the study is limited to freshwater in the context of water scarcity and drought due to climate change. Although climate change may affect water quality as well, in the scope of this study we focus on water quantity and specifically water scarcity and droughts in the EU27. The study explores both demand and supply of freshwater, as water scarcity occurs when freshwater demand frequently exceeds freshwater supply. For demand key users and consumers of water are addressed at sectoral level: agriculture, environment, electricity production, industry and households.

The study recognises the importance of both tourism[17] and ecosystem services[18] in the overall sustainable use and management of water resources discussion. However, it does not specifically address these two sectors in details. Particularly, tourism is seen as part of household and services sector. Furthermore, despite the increasing frequency of floods due to climate change, the study does not cover this topic.

Droughts, alongside floods, are among the most common and costly natural disasters in Europe. Floods, in particular, are becoming more frequent due to climate change and have devastating effects, endangering lives and causing significant economic losses. Although floods are critically important, this study does not address that topic, which would be better suited for a separate analysis or individual study.

There is already a Floods Directive (Directive 2007/60/EC) dedicated to assessing and managing flood risks. This directive is closely coordinated with the Water Framework Directive and requires EU Member States to create and update Flood Hazard Maps and Flood Risk Maps as the foundation for drafting flood risk management plans. EU countries implement integrated river basin management through the River Basin Management Plans mandated by the Water Framework Directive, and some have adopted Drought Management Plans for vulnerable river basins.

[17] Any change in water consumption due to tourism is going to be small compared to the water being used on irrigation for agriculture for instance. However, this comes from the public water supply, which does not necessarily have the same sources as agricultural water, plus there may be an issue of capacity. In addition, tourism can also create new sources of demand, golf courses and pools being the most obvious.

[18] More concretely, aquatic ecosystems (rivers, lakes, groundwater coastal waters, seas) support the delivery of crucial ecosystem services, such as fish production, water provisioning and recreation. Key ecosystem services are also connected to the hydrological cycle in the river basin, for example water purification, water retention and climate regulation. Environmental impact restricts water use by other sectors in several places in Europe, and hence it may create water scarcity for these sectors. See also Grizzetti B., et al., (2016). Assessing water ecosystem services for water resource management, Environmental Science & Policy, Volume 61, https://doi.org/10.1016/j.envsci.2016.04.008

In terms of geography, the study focuses on Europe and specifically EU27, while trying to highlight regional disparities and regional approaches to water scarcity. For such approaches we consider actions in water management and water policies, that can be inspirational for future-proof policies at the EU level that help in addressing water scarcity in the future.

Based on the timeframe and the scope, we have identified eight research questions central to this study (see text box).

Research questions

1. What is the current situation (as-is) regarding water scarcity (water availability and use) in the EU?
   i. Where is water abstracted from across the EU (i.e. where is water coming from)?
   ii. How is water used (water consumption and other use) across the EU (i.e. where is water used and where is it going)?
   iii. How much water is available and used across the EU and in its Member States?
   iv. What are current issues in water scarcity (water availability and use) across the EU?
   v. What policies, actions and EU legislations are in place to address water scarcity issues (water availability and use)?
2. What are trends in water availability and use in the EU in short (2030) and medium/long (2050) term?
3. What issues in water scarcity (water availability and use) are expected in the EU in the short (2030) and medium/long (2050) term?
4. What is the expected impact of (various) climate change scenarios on water scarcity in the EU in the medium/long (2050) term?
5. What are trends in technology, society and economy to address issues in water scarcity (water availability and use) in the short (2030) and medium/long (2050) term?
6. What EU level policy options could address issues in water scarcity (water availability and use) in key sectors impacted in the short (2030) term (i.e. mitigate acute scarcity and prolonged droughts)?
7. What are the potential future scenarios for the availability and use of water in the EU in the medium/long (2050) term and its impact on society? [in relation to climate change scenarios]
8. What EU level policy options could address future issues in scenarios for water scarcity (water availability and use) in key sectors impacted in the medium/long (2050) term?

1.4. Reading guide

This report is structured along Three Horizons: today, the short-term future and the medium- to long-term future. Before we dive into each of these horizons, Chapter 2 first provides an overview of the methodology that is used to produce this foresight report.

Chapter 3 then describes the first horizon by sketching the situation of water as a resource in Europe today. In this chapter, we describe the use and consumption of water in the EU, the current availability of water in Europe, current issues faced when it comes to water scarcity and the policies and practices in place to manage water in Europe.

Chapter 4 addresses the short term (2030) and chapter 5 medium- to long-term (towards 2050) future of water availability and use in Europe. To that end, we describe trends that will affect the future and their implications on water scarcity in the EU. As the medium- to long-term is uncertain, we describe longer term climate change projections, relevant megatrends and three scenarios developed for the water availability and use in the EU. The scenarios are instrumental for the development of policy options to combat water scarcity in the EU.

We then share policy options for the future in chapter 6. This chapter contains a number of short-term policy options, related to emergency responses to water scarcity and droughts faced currently. The policy options for the medium- to long-term address the structural challenges of water scarcity. The medium- to long-term policy options are developed using the scenarios and concern how to deal with, mitigate or reduce the effects of water scarcity so that sufficient access to water is maintained. Chapter 7 provides our conclusions based on the findings described in the previous chapters, related to the study's research questions. Chapter 8 contains the study's references.

The report ends with two annexes that provide supplementary information related to the methodology used and EU legislative framework and policy initiatives.

2. Methodology and resources used

2.1. Overview

A study that explores the future of a specific strategic topic typically employs foresight methods. These methodologies can be categorised based on their approach to predicting the future, exploring possible futures, and creating desired scenarios. The core of this foresight study is to outline potential futures that are significant in the context of water scarcity. Three different time horizons are used in this study. The time horizon closest to the present is suited for a predictive approach, while the two more distant horizons (2030 and 2050) are better aligned with exploratory future methodologies. To achieve this, several methodologies were combined to incorporate both approaches effectively.

The study has been structured with a sequence of interconnected work packages, beginning with a scoping phase in which we refined our focus and identified the main lines of analysis. Following this, we conducted an extensive literature review and quantitative data collection, which helped us gain a deeper understanding of the context and current situation regarding water management and availability in the face of scarcity. This review also provided insights into future trends. These findings formed the foundation for the interviews, workshops, and scenario drafting.

We conducted interviews with a wide range of stakeholders representing different geographical areas and sectors to create a comprehensive overview of the relevant stakeholders' ecosystem. Additionally, we organized two interactive regional workshops to validate findings from the initial analysis, gather input on the Three Horizons and trends, and receive guidance for scenarios and policy options.

The results from these activities were then analysed to develop medium- to long-term scenarios that include future consequences and developments related to water management and usage in the context of scarcity. A validation and policy workshop, involving relevant stakeholders and policymakers, was held to confirm the findings and gather input for an initial list of policy options.

Annex A provides a thorough and detailed description of the data collection and analysis methods, as well as the foresight techniques that were used.

It is noteworthy to state here that we have encountered certain challenges related to the quantitative data. One of them concerns some discrepancies in data of different sources. Even within reports of the same organisation, for example the EEA, we noted differences in figures. To deal with this we decided to: first check whether the differences are small or large. If differences are considered small, we took the figures that are consistent with each other, are specific for the EU/Europe, from a reliable source and recent. If differences were large and hard to explain, we decided to discuss this in the text.

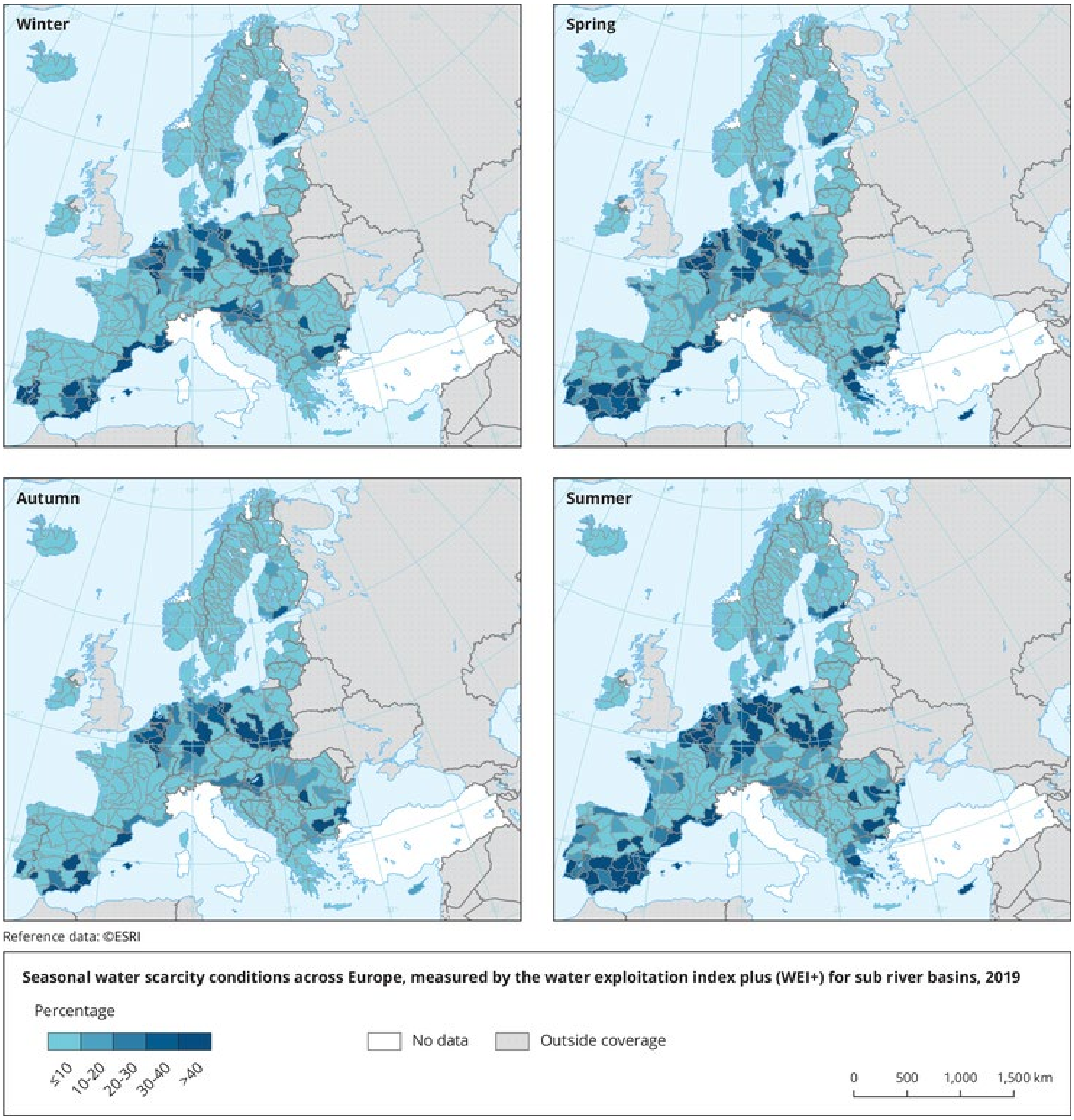
Another challenge concerns the annual variability in the provided data. This variability can relate to fluctuations or differences in one or more of the presented variables (e.g. water availability, precipitation, temperature, etc.) either within a given year (potentially impacting annual averages) or between years. Throughout the report, to address variability within a year, we used the Water Exploitation Index Plus (WEI+), which by default, takes seasonal changes into account (e.g. Figure 1: Seasonal water scarcity conditions across Europe, measured by the water exploitation index plus (WEI+) for sub river basins, 2019.). Furthermore, in terms of variability between years, the most recent data available was used and particularities (e.g. the extreme drought in 2022 as discussed in section 3.4.1.) have been highlighted. While using the most recent data, it is also important to consider these particularities because these are important for policy.

Regarding the climate change projections, the IPCC scenarios are our guiding framework for understanding potential climate change outcomes, impacts, risks, and future pathways for mitigation and adaptation in the water sector. These scenarios are based on various technical models that consider different trajectories for climate change and socio-economic pathways. It is important to note though that different sources may not always use the same combinations of these trajectories and pathways. Additionally, the IPCC reports on a global scale, but we need to understand these scenarios and their implications specifically at the European level, especially for water and the sectors covered in this study. To address this, we will rely on the relevant work of the JRC and Copernicus Climate Change Services and the climate scenarios they use to explain and forecast climate change impacts on water and the sectors in this study. In developing qualitative scenarios for this study, we have considered the outcomes of different IPCC scenarios, particularly focusing on the effects of water scarcity, and may assume the worst-case scenario for water scarcity while varying other external factors in the scenarios.

3. Today: water as a resource in the EU

Water is vital for the three pillars of Europe's sustainable growth: its society, its economy, and its environment. All three depend on an adequate supply of water at the right time and the right location. However, in many parts of the EU, a mismatch has evolved between the demand for water and the volume of available water, resulting in water stress.

Figure 1: Seasonal water scarcity conditions across Europe, measured by the water exploitation index plus (WEI+) for sub river basins, 2019.

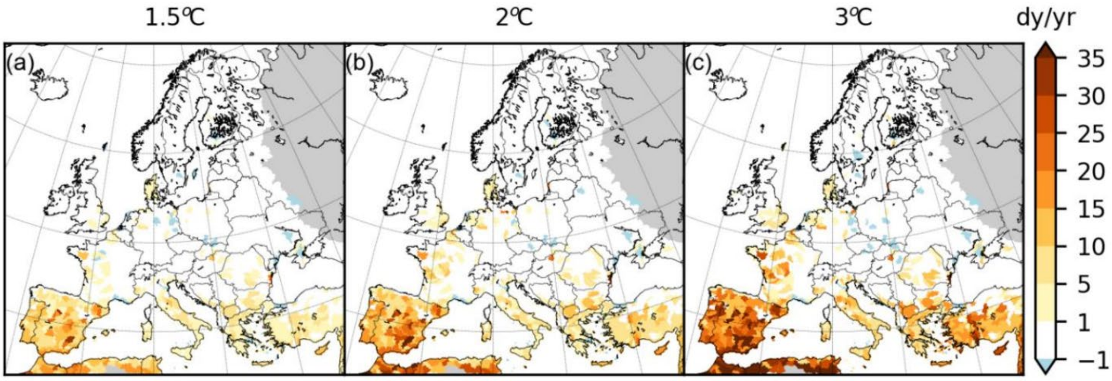


Source: EEA (2024): https://www.eea.europa.eu/en/analysis/maps-and-charts/seasonal-water-exploitation-index-plus-4 NB: Cyprus and Malta are small in the map, but both had a high WEI+ (towards 40% or higher) in 2019 – Malta year-round and Cyprus in spring and summer.

According to estimates from the EEA's Water Exploitation Index Plus (WEI+), on average approximately 20% of the European territory and 30% of the European population are affected by water stress every year.[19] The WEI+ is a measure for the ratio of water consumption over renewable water sources – it indicates the pressure that water demand puts on local water sources. A WEI+ above 20% indicates water scarcity and a WEI+ of over 40% indicates severe water scarcity. The WEI+ across Europe in 2019 is provided per season in Figure 1. It shows that certain regions in the Iberian Peninsula and Benelux dealt with severe water scarcity year-round in 2019. That year, all seasons were significantly warmer than average, and Europe faced a heat wave in summer, precipitation was EU-wide close to average that year, but largely due to a wetter end of year than usual.[20]

Figure 2 demonstrates the change in water scarcity days (WEI+ >0.2) relative to the current climate for three warming levels (+1.5, +2 and +3 degrees Celsius). This shows an intensification and a longer duration of water scarcity in the EU under global warming, specifically in the Mediterranean countries. Water scarcity is projected to gradually increase in duration from current climate towards the 3°C warming level in the Mediterranean regions, especially in the Iberian Peninsula. Here, water scarcity can increase up to more than 1 month per year for the 3°C warming levels compared to current climate.

Figure 2: Projected change in water scarcity days (WEI+ > 0.2) in a year compared with present day for a global temperature increase of (a) 1.5°C, (b) 2°C, and (c) 3°C. [21]



Source: JRC (2020)

Europe is facing a critical issue with excessive water use.[22] While overall water withdrawal and consumption at EU scale have decreased since 2000,[23] the local pressure on water resources has intensified, particularly in regions already at high risk. In addition, decades of poor water management practices, such as damming and drainage, have in some regions severely impacted freshwater ecosystems, compromising their ability to withstand droughts, heatwaves, and floods. Activities like river channelisation, soil artificialisation, and wetland drainage have further contributed to declining water levels, jeopardising soil health and agricultural yields.

[19] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[20] Copernicus (2020). European State of the Climate 2019, https://climate.copernicus.eu/ESOTC/2019

[21] The results of both the 1.5°C and 2°C warming levels are based on the average of the 11 climate model simulations from both the RCP4.5 and RCP8.5 emission scenarios, while the results of the 3°C warming level are solely based on the 11 simulation of the RCP8.5 emission scenario. JRC (2020). Climate change and Europe's water resources. https://joint-research-centre.ec.europa.eu/system/files/2020-05/pesetaiv_task_10_water_final_report.pdf

[22] WWF (2023). Water for nature, water for life. Adapting to Europe's water scarcity challenge, https://wwfeu.awsassets.panda.org/downloads/water-scarcity_report_final.pdf

[23] EurEau (2021). Europe's Water in Figures An overview of the European drinking water and waste water sectors, https://www.eureau.org/resources/publications/eureau-publications/5824-europe-s-water-in-figures-2021/file

The impact of water stress reaches beyond water scarcity. Water stress can exacerbate pollution in European river basins as a decrease in water volume leads to higher concentrations of pollutants. This not only affects the physical and chemical processes, but also disrupts the vital biological processes that are essential for the health of aquatic ecosystems and aquifers.[24] This study focuses on water scarcity, and while pollution related to water scarcity and stress is an important related challenge, it is beyond the scope of this research.

This chapter presents a comprehensive analysis of water availability in Europe, encompassing water sources, abstraction, and regional and temporal disparities. It delves into the specifics of water use and consumption in the EU, highlighting key consumers, such as the agricultural sector, electricity production, industry, and households. Furthermore, it addresses pressing issues surrounding water scarcity in Europe, particularly the impact of droughts. The chapter culminates with an overview of the current policies and actions enacted at the EU level to combat water scarcity.

3.1. Use and consumption of water in the EU

Within the EU, there are significant regional differences in terms of the use and consumption of water. This section discusses trends in the EU overall. Regional differences are discussed in Section 3.2. The main users of water in the EU – by water abstraction – are the energy (cooling), agriculture, manufacturing and public water supply sectors. Public water supply is used for "household water consumption" as discussed further in section 3.1.4. As can be observed in Figure 3, abstraction for cooling in electricity generation is the largest contributor to total annual water abstraction (~32%) in 2019 across the EU, followed by abstraction for agriculture (~28%), public water supply (~20%) and manufacturing (~10%). Furthermore, cooling in manufacturing, mining and quarrying, and construction accounting for only 1% of total abstraction each. These sectors combined make up the "industry" as discussed in section 3.1.3.[25]

[24] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[25] EEA (2022). Water abstraction by source and economic sector in Europe, https://www.eea.europa.eu/en/analysis/indicators/water-abstraction-by-source-and?activeAccordion=

Figure 3: Water abstraction in the EU-27 per economic sector (2000-2019)

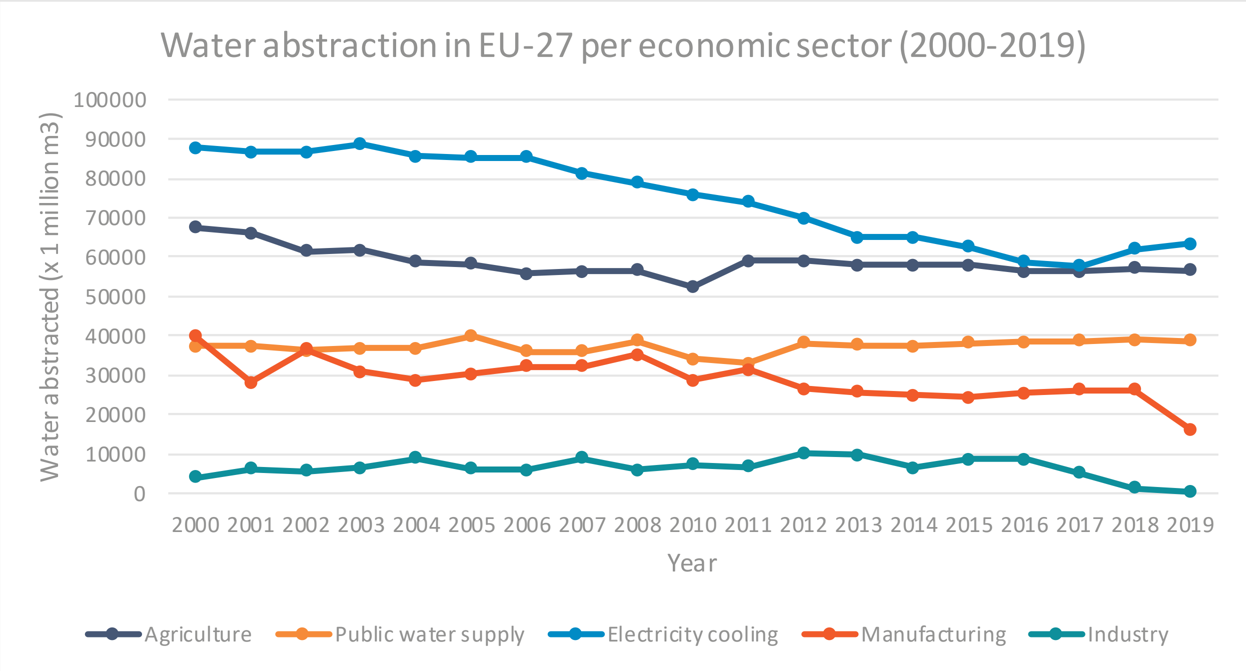
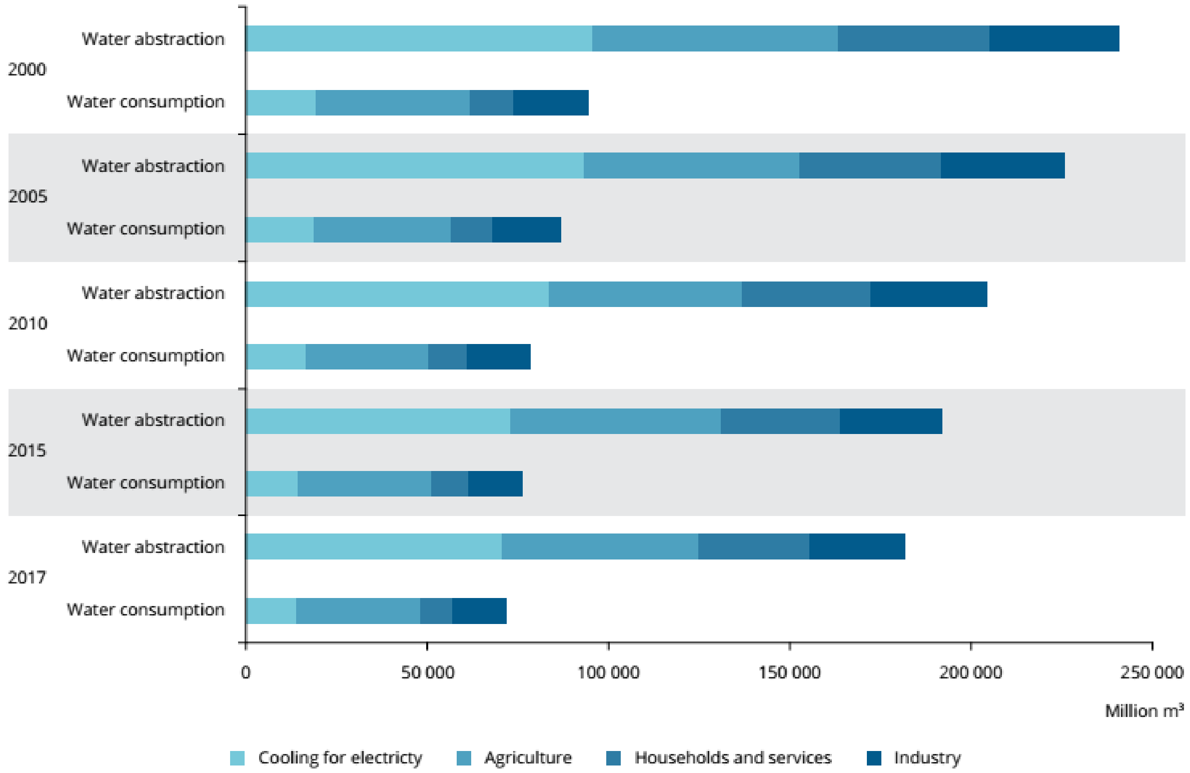


Figure 4: Water abstraction vs consumption by economic sector in Europe in 2000-2017



Source: European Environment Agency (2021)[26]

[26] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

Although the energy sector is the largest user of water, agriculture is the largest consumer of water in Europe (see Figure 4). Industry also has a higher water consumption than the energy sector. Household consumption is the lowest across Europe. Overall, over the period 2000-2017 water consumption has reduced in Europe. As consumption does not return water to one of the sources, reducing water consumption will be a key factor in future discussions about water allocation and sustainability.

According to the EEA, between 2000 and 2017, there was an overall decline in water abstraction, from 247 to ≈1804 billion cubic meters. This decline was largely due to the policy measures implemented under the Water Framework Directive (WFD).[26] However, this decline was not uniform across all sectors. Between 2000 and 2019 (Figure 3), a trend of reduction in water use can be seen for all sectors, apart from the public water supply sector, where water use seems to have slightly increased over the same period.

Abstraction for cooling in electricity and agriculture decreased, while water abstraction for cooling in manufacturing and public water supply increased. The largest decrease was with cooling in electricity generation (-27%) and the strongest increase was with water cooling in manufacturing (almost tripled, but with high return rate – i.e. low consumption). Although water abstraction for agriculture has overall decreased during the period 2000 – 2019 (Figure 3), this trend is not linear. Between 2008 and 2010 there had been a slight, sharp decrease in water abstraction, followed by a slightly bigger increase a year later (in 2011), before showing a slow decline again from 2011 to 2019.

These sectoral disparities highlight the varying impacts of different sectors on freshwater resources and the need for targeted strategies to address these pressures in a balanced manner.

3.1.1. Agriculture

Agriculture is a dominant force in water abstraction across Europe, accounting for 28% of the total annual water abstraction in 2019,[26] with most of this being directed towards irrigation.[26] Southern Europe accounts for over 80% of the total freshwater abstraction for irrigation.[27] The demand for irrigation water fluctuates significantly throughout the year, peaking in the spring and summer months. Other factors including crop types, irrigation technology, and legal restrictions also influence the rates of water use in agriculture. Given the high variability in water availability, especially in Southern Europe, there are concerns about over-abstraction, groundwater depletion, and environmental degradation if irrigation is not managed properly. For this reason, a collection of 28 agri-environmental indicators (AEI) has been established to monitor the integration of environmental considerations into the Common Agricultural Policy (CAP).[28]

Interviews with stakeholders highlight the urgency for the agricultural sector to improve its water-use efficiency, particularly in regions facing severe water scarcity. Agriculture is not only one of the largest contributors of water abstraction in the EU, but also a sector facing the greatest challenges from climate change. This combination of factors urges the agricultural sector to adapt significantly, as water might not be available when most needed, threatening crop yields and food security. This is possible either with crops with lower water demands and/or using alternative water resources,

[27] Eurostat (2018). Agri-environmental indicator – water abstraction, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_water_abstraction#:~:text=Abstraction%20for%20irrigation%20is%20markedly,River%20basin%20districts%20(RBDs)

[28] Eurostat (2024). Glossary: Agri-environmental indicator (AEI), https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Agri-environmental_indicator_(AEI)

such as recycled water, and by conservation of water in the wet season without compromising the environment.

3.1.2. Electricity production

Electricity production, encompassing combustion plants, nuclear stations, hydropower, wind turbines, and solar panel installations, represents more than 90% of the total freshwater abstraction of the whole the energy sector in the EU-27 and the UK.[29] Electricity production is heavily dependent on water, particularly for cooling in thermal power plants and for hydropower generation. Hydropower alone contributes around 10% of the total EU's electricity,[30] requiring significant water resources for continuous operation, though much of the water used in these processes is returned to the hydrological system. In the case of thermal plants, the returned water often has higher temperatures (thermal pollution) which can negatively impact local ecosystems. Despite only about 6% of the withdrawn water being consumed, primarily through evaporation, the energy sector's impact on water resources is still profound and is most pronounced in Western Europe.

The interdependence between water use and energy production presents significant challenges as the EU progresses towards decarbonisation goals. Although renewable energy sources, such as wind and solar have lower water requirements compared to traditional energy sources, the production of certain renewables, like biofuels and specific types of hydropower, remain water intensive.[30] Additionally, according to interviewees, the Water Framework Directive (WFD) has brought the energy sector into closer interaction with water-related regulations, particularly regarding the temperature of water discharged from power plants. The responsibility for implementing measures to meet these regulatory requirements largely falls on the energy sector, which since then then took efforts to comply. As the EU continues to pursue climate neutrality targets, the challenge will be to balance the reduction of carbon emissions with the sustainable management of water resources, ensuring that efforts to decarbonise the energy sector, given the growing demand of water from certain renewables or clean energy carriers such as the green hydrogen[31], do not inadvertently exacerbate water scarcity or environmental degradation.

3.1.3. Industry

The industrial sector, which includes manufacturing and mining and quarrying, both affects and is being affected by freshwater. Industrial activities use significant quantities of water, while at the same time, water availability and quality of water generate risks for industry.[32] Impacts of imbalances in water availability include restrictions on production plants and even plant shutdowns in highly-water dependent operations.[33]

[29] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[30] Adamovic, M., et al. (2019). Water Energy Nexus in Europe. EUR 29743 EN. Luxembourg: Publications Office of the European Union, doi:10.2760/968197.

[31] For a deeper dive on hydrogen production water needs see: Renewable Energy and Water. A factsheet on the sector's water-intensive practices, (2024). Water Europe: https://watereurope.eu/wp-content/uploads/2024/12/Renewable-Infographics-and-Factsheets-11.2024.pdf

[32] United Nations (2024). The United Nations World Water Development Report 2024: Water for Prosperity and Peace. Paris: UNESCO, https://unesdoc.unesco.org/ark:/48223/pf0000388948

[33] Adamovic, M., et al. (2019). Water Energy Nexus in Europe. EUR 29743 EN. Luxembourg: Publications Office of the European Union, doi:10.2760/968197.

Water use in the industrial sector across the EU is on a declining trend, even as the value of industrial production continues to rise in regions, such as Western, Northern, and Eastern Europe.[34] This is in part due to increased efficiency due to technological advancements, regulatory pressure and environmental policies, and shifts in production patterns including offshoring of water-intensive products. Nonetheless, the sector stills accounted for 18% of the annual total water abstraction in the EU (including abstraction for cooling in manufacturing).[35]

Despite the declining trend in the relationship between water use and industrial production, interviews reveal that the pressure from industrial activities, including pollution, continues to affect the availability of sufficient quality water for industrial use. This ongoing issue highlights the need for further improvements in water efficiency and pollution control within the sector to ensure sustainable water use alongside industrial growth.

3.1.4. Households and services

Public water supply includes providing water to meet the demands for drinking, washing, cleaning, sanitation, cooking, home gardening, etc., in residential and business premises. It also includes water for tourism and, sometimes, for the industrial or agricultural sector. In Europe, about 60-80% of the public water supply is used for household consumption.[36] This water is supplied by freshwater sources drawn mainly from groundwater, being 65% of the total public water supply. Over 60% of this water infrastructure is managed by publicly owned enterprises, with the remainder provided by regulated entities with varying levels of private ownership.[37]

the water use within the public water supply sector in Europe has remained largely the same over the period 2000 - 2019, the volume of water supplied has increased in Southern European countries, largely due to the demands of tourism, which has exerted significant local pressures, particularly in Mediterranean regions. This reflects regional variations in household water consumption and the influence of external factors – such as tourism – on water demand.[38]

Interviews reveal a clear trend of decreasing average household water consumption across Europe, driven by multiple factors.[39] According to most recent data from Eurostat, the use of water per inhabitant in the EU has decreased between 2000-2022 with 8%.[40] The adoption of more efficient household appliances, heightened awareness of water scarcity, and specific policies aimed at

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[34] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[35] Water abstraction by economic sector in the EU-27, 2000-2019: https://www.eea.europa.eu/en/analysis/indicators/water-abstraction-by-source-and?activeAccordion=

[36] EEA (updated 2021). Water in the city. Originally published in 2012, https://www.eea.europa.eu/articles/water-in-the-city

[37] Rossi, L., et al. (2023). European Drought Risk Atlas. Luxembourg: Publications Office of the European Union, doi:10.2760/608737.

[38] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[39] Note that abstraction for public water supply has increased in **Error! Reference source not found.** but that this includes more than only household consumption. Figure 4 shows the decline under household and services between 2000-2017.

[40] Eurostat (2024). Water statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_statistics#Water_uses

reducing water consumption are contributing to this decline. For instance, education and awareness campaigns for water conservation in Spain have had a noticeable impact on reducing water use.[41]

Additionally, water pricing plays a role, particularly in rural areas where there is a stronger correlation between pricing and consumption. Public water operators are also investing in strategies to increase water availability, including building new reservoirs, implementing nature-based solutions, and enhancing interconnections to bolster resilience. However, there remains a need to ensure that water pricing remains affordable for vulnerable households, balancing efficiency with equity.

Another important variable in the water use and supply is water loss, as inadequate infrastructure for storing, treating and distributing water prevents effective water management. In Europe, on average 23% of treated water is lost during distribution in the EU due to leaky pipes, outdated treatment facilities, and insufficient reservoirs.[42] This number however, varies greatly between Member States and even regions, as less developed countries tend to have a more severely outdated infrastructure causing more water loss.

When looking specifically at water loss due to leakages, significant differences between member states can be seen. In Bulgaria, up to 60% of water loss is caused by leakages, while in Luxembourg, this number is less than 5%.[43]

3.2. Regional disparities in water use and consumption

Water use and consumption across the EU exhibit significant regional disparities, driven by a combination of climate, economic activities, population density, and technological advancements.[44] In parts of southern Europe, and in densely populated areas across the EU, water stress is a permanent, year-round problem. In other parts of Europe, water stress occurs only temporarily or even only occasionally due to drought. These differences are a result of the geographical and temporal variation in meteorological conditions, which affect water availability, and of the water demand of ecosystems, society and the economy[45].

These disparities present unique challenges for managing water resources and developing effective policies, particularly in the face of increasing water scarcity and climate change impacts[46].

3.2.1. Southern Europe: High Water Stress and Agricultural Demand

Southern Europe, especially Mediterranean countries, like Spain, Italy, and Greece, faces some of the highest levels of water stress within the EU. The region's hot, dry climate, coupled with limited freshwater resources, makes its agriculture heavily reliant on water-intensive practices, particularly

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[41] Tortajada, C., F. González-Gómez, A.K. Biswas and J. Buurman (2019). Water demand management strategies for water-scarce cities: The case of Spain. Sustainable Cities and Societies (45), https://doi.org/10.1016/j.scs.2018.11.044.

[42] European Commission (N.d.). Available at: https://environment.ec.europa.eu/topics/water/water-wise-eu/poorly-managed-water_en#:~:text=Leaky%20pipes%2C%20outdated%20treatment%20facilities,during%20distribution%20in%20the%20EU.

[43] Interreg Central Europe (2020). Water loss. Available at: https://programme2014-20.interreg-central.eu/Content.Node/Digital-Learning-Resources/03-Water-Loss.pdf

[44] De Roo, A., B. Bisselink, and I. Trichakis (2023). Water-Energy-Food-Ecosystems pathways towards reducing water scarcity in Europe. Luxembourg: Publications Office of the European Union, doi:10.2760/478498, JRC133439.

[45] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[46] De Roo, A., B. Bisselink, and I. Trichakis (2023). Water-Energy-Food-Ecosystems pathways towards reducing water scarcity in Europe. Luxembourg: Publications Office of the European Union, doi:10.2760/478498, JRC133439.

irrigation. In these areas, agriculture accounts for a significant share of the total water consumption, often exceeding 50%. The high demand for irrigation, combined with the scarcity of water resources, leads to severe water shortages during the summer months, with water exploitation rates sometimes reaching or exceeding 100% of available annual freshwater resources[47]. The over-reliance on fossil groundwater[48] (from deep aquifers) in these regions further exacerbates the problem, leading to long-term groundwater depletion, a critical issue in places, like southern Spain and parts of Greece.

Tourism, which peaks during the same summer months, adds to the pressure on water resources, particularly in coastal and popular tourist destinations. This seasonal spike in water demand for public supply intensifies the strain on already limited resources.

While high levels of water stress are common in almost every Southern European country, the situation in Cyprus and Malta is even more severe. The entire population of Cyprus and Malta is living in conditions of water scarcity. During summer, the exploitation of water in the Mediterranean area approaches 100%, meaning that maximum possible freshwater is being used. In this period the region is often relying on abstraction of a substantial amount of fossil groundwater resources (groundwater that is not renewed), causing groundwater depletion. There are multiple reasons for the high levels of water stress that countries experience, such as high levels of tourism (especially during summer), climate change impacts, such as rising temperatures and decreasing rainfall, and agriculture. Furthermore, the fact that both Cyprus and Malta are located in the Mediterranean Sea, makes it so that they are reliant on surface water, such as rivers and dams, because sea water can only be used after desalination.

3.2.2. Northern, Central and Eastern Europe: Industrial and Energy Sector Pressures

In contrast, Northern, Central and Eastern Europe face different types of pressures on their water resources, primarily related to industrial activities and energy production. Countries, such as Germany, France, and Poland have historically had high water withdrawals for energy production, particularly for cooling in thermal and nuclear power plants. Although a large portion of this water is returned to rivers and lakes, the return of heated water can have detrimental effects on aquatic ecosystems, impacting water quality and biodiversity. Projected changes in energy production, including a shift away from coal and nuclear power towards renewable energy sources, are expected to reduce water withdrawals in these regions by 2050. However, this transition is not uniform, with some countries, like Romania and Slovenia projected to see slight increases in water withdrawals due to differing energy strategies.

[47] In the long run this could result in the depletion of water resources if water consumption only relies on freshwater resources. For example, in Malta desalination provides more than half of the water supply, resulting in a higher consumption of water than freshwater resources in the country and thus a WEI+ of over 100%. It indicates that to meet the local water demand more water is needed than freshwater sources can provide.

[48] Water that infiltrated in the aquifer millennia ago. Aquifers containing fossil water generally receive no or very little recharge and can be considered a non-renewable source.

Regional disparities in water use and consumption: Policy implications and future challenges

The regional disparities in water use and consumption across the EU have significant policy implications. Effective water management must account for these regional differences, with tailored approaches that address the specific challenges faced by different areas. In Southern Europe, where agriculture dominates water use, policies aimed at improving irrigation efficiency and promoting water reuse are essential. Meanwhile, in Northern and Central Europe, efforts should focus on reducing industrial water pollution and mitigating the environmental impacts of energy production. It is important to note however that there is a significant amount of export of water-intensive crops (such as olives and citrus fruits) from southern Europe (water-poor areas) to Northern Europe (water-rich) areas, exacerbating agriculture-induced water scarcity in Southern Europe. This "virtual water" trade effectively transfers the environmental burden of water use to southern regions without adequate compensation or acknowledgment.

As climate change continues to alter water availability patterns across Europe, with Southern regions likely to experience even greater water stress and Northern regions potentially seeing increased water availability, adaptive management strategies will be crucial. These strategies must respond to evolving conditions and ensure that water resources are used efficiently and sustainably across all regions. By integrating water and energy policies and prioritizing both immediate efficiency improvements and long-term climate resilience, the EU can better manage its diverse water resources and safeguard them for future generations.

Source: De Roo, A., B. Bisselink, and I. Trichakis (2023). Water-Energy-Food-Ecosystems pathways towards reducing water scarcity in Europe. Luxembourg: Publications Office of the European Union, doi:10.2760/478498, JRC133439.

Industrial water use, although declining overall, remains a significant concern, particularly in terms of water pollution and the need for clean water in manufacturing processes. The disparity between water-rich regions and those experiencing moderate stress highlights the need for regionally adapted approaches to managing water resources, ensuring that industrial growth does not compromise water availability or quality. In these regions, policies may need to focus more on reducing industrial water pollution and managing the environmental impacts of energy production to maintain a sustainable balance.

3.3. Water availability in the EU

Water availability is the difference between water supply and demand and relates to the quantity of water that can be used or consumed. Within Europe, water availability differs between geographical regions, caused by differences in (the composition of) available water sources, climate, meteorological conditions, water demand of ecosystems and society, abstraction rates, (other) regional disparities and temporal disparities.

Other systemic challenges affecting European surface waters and groundwaters include population growth, the need for new or upgraded infrastructure, integrated management and governance, and threats to ecosystem health quality.[49][50]

3.3.1. Water sources: Surface water and groundwater

Freshwater can be obtained from various sources, of which surface water (rivers, lakes, (artificial) reservoirs) and groundwater (aquifers) are most used. Freshwater can also be obtained from snowmelt, glaciers or ice caps and rainwater. Technically, freshwater can also be obtained from salt water through desalination and recycling from wastewater.

In Europe, surface water, and more specifically rivers, are the most important source for freshwater abstraction.[50] Figure 5 displays the national and international river basin districts in Europe. River basin district means the area of land (and sea), made up of one or more smaller neighbouring river basins together with their associated groundwaters and coastal waters.[51] National river basin districts, displayed in green, relate to districts that are in a single country. International districts, displayed in pink, are transboundary and cover multiple countries – clearly showing the EU dimension of water scarcity. Europe counts a multitude of river basin districts that significantly differ in size. The Danube district is the largest river basin district in Europe, covering (parts of) Germany, Czech Republic, Slovakia, Austria, Hungary, Switzerland, Bulgaria and Romania.

[49] Caretta, M. A. et al. (2022). 'Water.' In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

[50] EEA (2021). European Climate Risk Assessment.

[51] Water Framework Directive - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

Figure 5: Map of European river basin districts

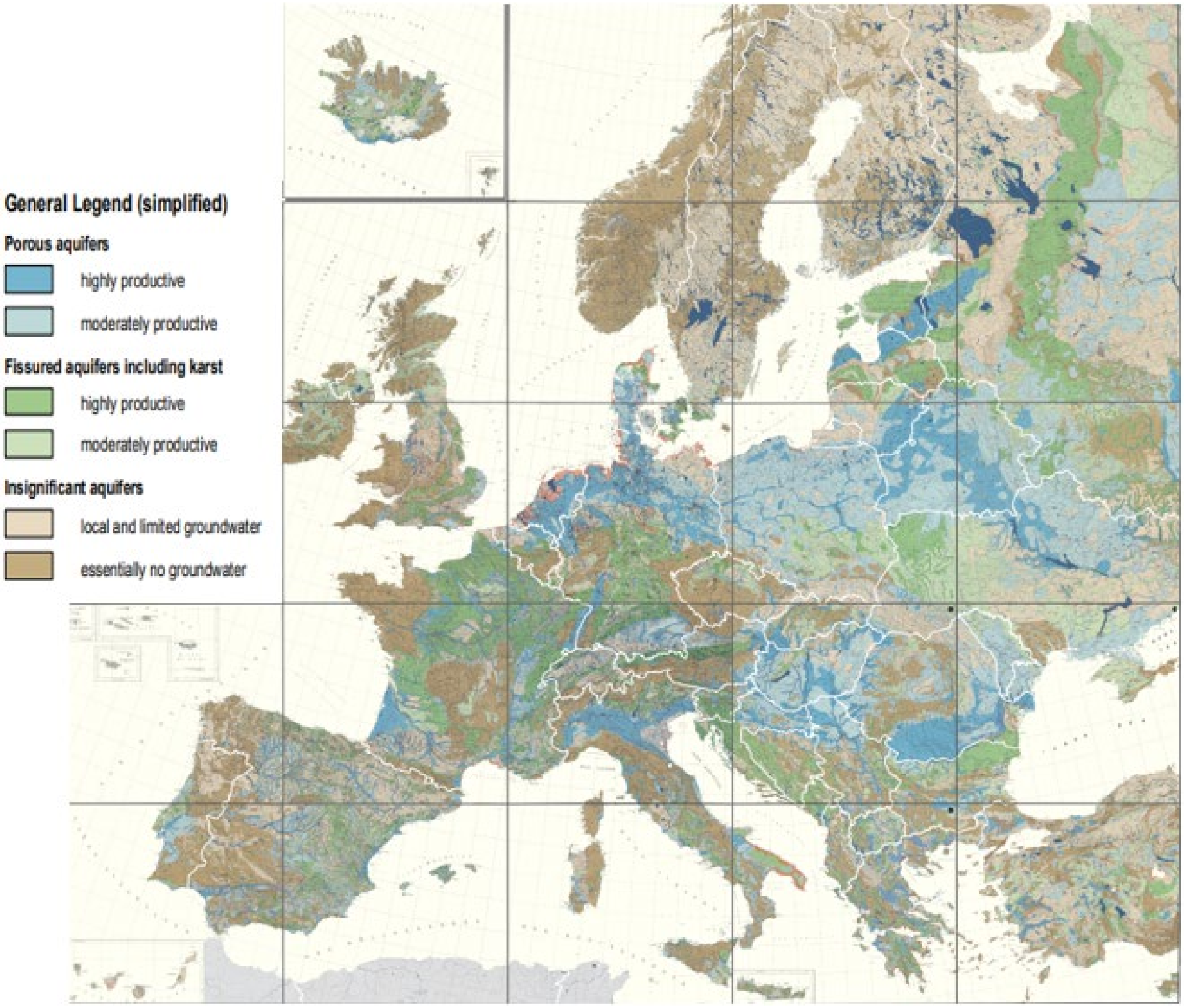
Source: European Environment Agency, 2012

After surface water, the most important source for freshwater abstraction is groundwater. It provides a safe and sustainable resource to meet demands for hygiene and household consumption, agriculture, industry, and tourism. Meeting water demands for hygiene and household consumption and agriculture depends significantly on groundwater. Groundwater is a finite resource that needs to be protected from pollution and over-exploitation, to ensure the long-term sustainability of its use for human activities and natural ecosystems. For example, 65% of drinking water in the EU is coming from groundwater. It is an integral part of the natural water cycle – once depleted or degraded, it can take years or decades for groundwater reservoirs to be recharged and groundwater quality to recover[52].

[52] EEA (2022). Europe's groundwater. A key resource under pressure. https://www.eea.europa.eu/publications/europes-groundwater

Figure 6 provides an overview of the groundwater resources (aquifers) in Europe. As indicated by the legend, the different colours relate to how productive aquifers are for different types of geologies. Aquifers in porous geological layers are more productive than those in less or non-porous and geologies. Fissured geologies may be productive, particularly if these are developed in karstified rocks. There are vast differences across the European continent in terms of types of aquifers and their productivity. Some regions have access to more productive aquifers than other regions. While Europe's most northern part (mainly the Scandinavian Peninsula) and the southern part (including Portugal, Spain, Italy and the Balkans) to a large extent consist of mainly non or limited porous geologies, several Western, Central and Eastern European countries (including the Netherlands, Denmark, Germany, Poland, Hungary, Romania, Ukraine and the Baltic States) tend to have geologies with higher levels of porosity.

Figure 6: Hydrological map of Europe



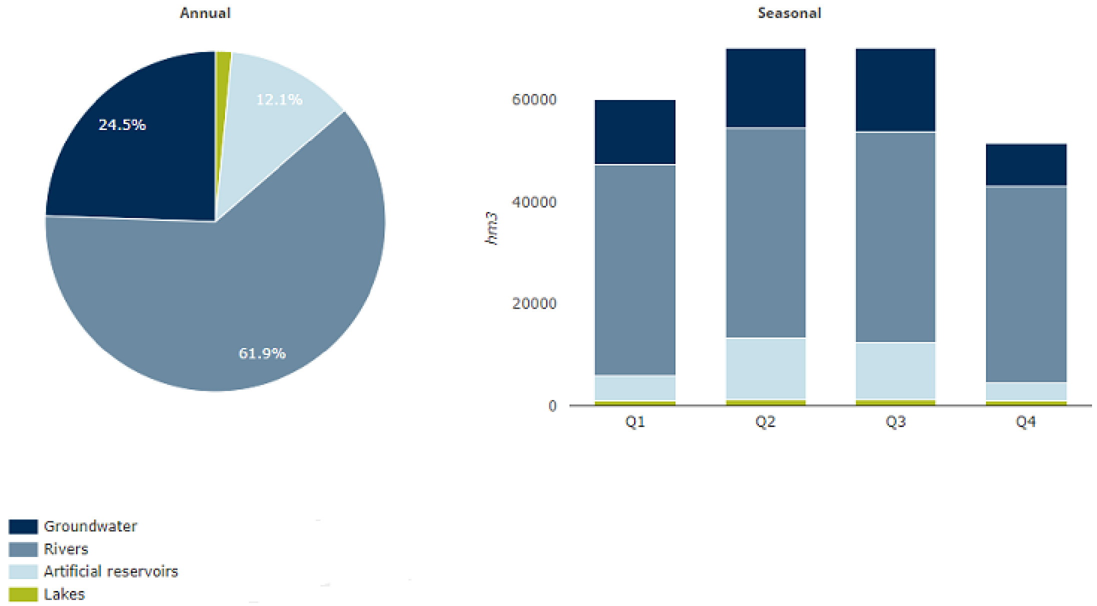
Source: International Hydrogeological Map of Europe 1 : 5.000.000 (BGR , EGS , UNESCO, 2008).[53]

[53] https://fishy.bgr.de/ihme1500/pdf/ihme_150dpi.pdf

3.3.2. Water abstraction in Europe

In 2017, 75% of freshwater in Europe was abstracted from surface water, while 25% was abstracted from groundwater (Figure 7)[54]. Water abstracted from surface water is largely obtained from rivers (62%), but also from reservoirs (12%) and lakes (1%)[55]. The amount of water abstracted also differs per season (see Figure 7). The highest abstraction is reported in Q2 and Q3 of the year, followed by Q1 and Q4.

Figure 7: Freshwater abstraction from different sources in Europe in 2017



Source: WISE (2024) based on EEA's Indicator Assessment 2019[56]

In many European river basins, more water is abstracted than can be naturally replenished (i.e. water is over-abstracted)[57], even though the total volume of water abstracted is decreasing. Over-abstraction is a driver of water scarcity and is characterised by declining groundwater and river water levels, implying that these do not return anymore to their normal levels. According to data from the European Environment Agency (EEA)[58], from 2000 to 2019, the total volume of water abstracted from surface water and groundwater declined by around 15% in the EU, while the relative contribution of groundwater to the total volume abstracted is increasing.

[54] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

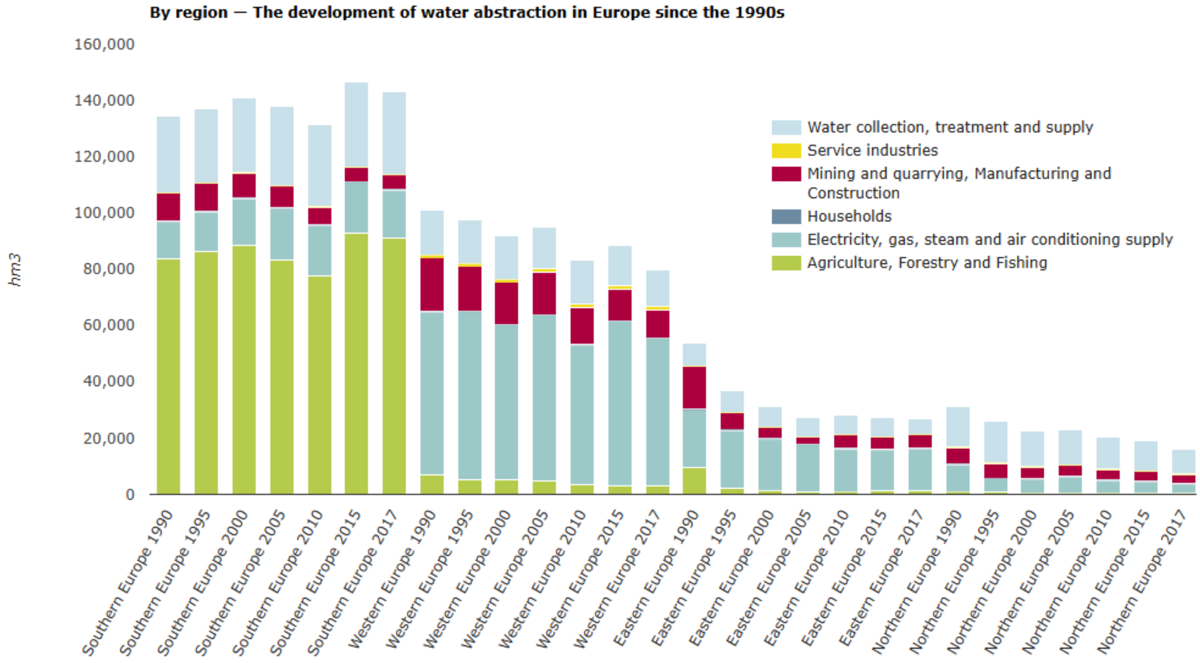
[55] WISE (2024). Water resources of Europe. https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/water-resources-europe

[56] WISE (2024). Water resources of Europe. https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/water-resources-europe

[57] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[58] EEA (2022). Water abstraction by source and economic sector in Europe: https://www.eea.europa.eu/en/analysis/indicators/water-abstraction-by-source-and

Figure 8: Development of water abstraction per economic sector and region in Europe



Source: WISE (2024) based on EEA's Indicator Assessment 2019[59]

Figure 8 provides insight in the development of water abstraction per economic sector and region in Europe. While this figure shows some inconsistencies with other figures (e.g. Figure 3 and Figure 4) in terms of total water abstraction, it does reveal valuable insights in more general regional and sectoral trends in terms of water abstraction.

Water abstraction has decreased in most European regions since the 2000s. A decline in abstraction for cooling in electricity generation has contributed significantly to the overall decrease of water abstraction, as this sector accounts for more water abstraction than any other sector in the EU. [60] However, most of this water is returned and thus has a limited effect on water scarcity. When looking at trends in water abstraction, it is important to consider regional differences. In southern Europe, by far the largest share of water abstraction takes place by the agricultural sector, while in western Europe, most water is being abstracted by the electricity (generation) sector. This means that a decline in abstraction by the electricity sector has a bigger effect on the total quantity of water abstracted in western Europe compared to southern Europe. In addition, water abstracted for agriculture is to a large extent consumed and thus has a stronger effect on water scarcity.

The observed decreasing trend in water abstraction volumes has so far not translated into an improvement in the quantitative status of water bodies. This is largely because reductions have mostly been realised in the non-consumptive use of water. In addition, this effect may be partly due to the slow process of recovery and to climate change, which can offset the volumetric gains and aggravate local pressures.[61]

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[59] WISE (2024). Water resources of Europe. https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/water-resources-europe

[60] EEA (2022). Water abstraction by source and economic sector in Europe.

[61] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

The relative share of groundwater in comparison to surface water in overall water abstraction has slightly increased from 19% in 2000 to 23% in 2019, as surface water abstraction continued to decrease. This shift is influenced by growing demand in sectors (e.g. the public water supply which increasingly turns to groundwater sources). This pattern is particularly noticeable in Southern European countries, where climate factors exacerbate seasonal water shortages, pushing for higher groundwater use to meet demand.[62] [63] Even within Southern European countries however there are vast differences in the extent to which groundwater abstraction has increased. In Spain (4%), Italy (6%) and Portugal (11%) there have only been small to moderate increases, whereas in Greece the groundwater abstraction relative to the total water abstraction has increased with 70%.

In fact, groundwater levels have been declining in several EU Member States.[64] Specifically, some countries including Spain, France, Italy, Greece and southern Germany have reported significant groundwater depletion. Furthermore, some parts of Eastern Europe (including Poland, Romania, and Bulgaria) are showing early signs of groundwater stress due to insufficient precipitation and high agricultural water needs. [65] [66] Groundwater is often seen as a buffer resource, which can be used to supply high-quality drinking water, especially when local surface waters are not suitable for exploitation or at times of water stress. However, it is important to note that since groundwater is an invisible resource, over-exploitation cannot be easily observed or proven.

Finally, a last factor to consider when looking at water sources and abstraction in the EU is water reuse. Water reuse can reduce the need for abstraction from overexploited aquifers and rivers, as well as the need for fertilisation because of the nutrient content of reclaimed water. [67]

3.3.3. Regional disparities in water availability

In 2024, approximately 52 million people, 11% of the total population of the EU-27, live in water scarce regions. This means that at least during part of the year, the demand for freshwater can scarcely be satisfied by the available freshwater. Of this population, the majority live in Southern European countries, including Spain (22 million or 50% of the national population), Italy (15 million, 26%), Greece (5.4 million, 49%) and Portugal (3.9 million, 41%). Furthermore, the entire population of Cyprus and Malta is living in conditions of water scarcity. During summer, the exploitation of water in the Mediterranean area approaches 100%, meaning that maximum possible freshwater is being used. In this period the region is often relying on abstraction of a substantial amount of fossil groundwater resources (groundwater that is not renewed), causing groundwater depletion[68] reflected in declining groundwater levels.

Central/Western Europe has a higher water availability and higher consumption. In the incidence of a prolonged period of droughts they also face water scarcity issues – for instance the agricultural sector is impacted, as it is not dependent on irrigation but on natural precipitation, while in Southern

[62] EEA (2021). European Climate Risk Assessment.

[63] WISE (2024). Annual water abstraction from surface and groundwater resources: https://water.europa.eu/freshwater/countries/water-resources/visualizations/wr-fig-2.1

[64] EEA (2018). European waters: assessment of status and pressures 2018, https://www.eea.europa.eu/publications/state-of-water

[65] EEA (2022). Europe's groundwater – a key resource under pressure: https://www.eea.europa.eu/publications/europes-groundwater

[66] POLITICO (2023). Europe's next crisis: Water: https://www.politico.eu/article/europe-next-crisis-water-drought-climate-change/

[67] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[68] Climate Adapt (2023). Water-Energy-Food-Ecosystems pathways towards reducing water scarcity in Europe.

Europe irrigation is the pattern.[69] There are some exceptions, however, as parts of Belgium and the Netherlands report water scarcity already under normal climate conditions (see for example Figure 1 for the case of 2019).

In general, water scarcity is more common in Southern Europe (in particular Spain, Italy, Greece and Portugal), whereas mentioned above, a significant percentage of the population is living in areas with permanent water stress and up to 70% of the population living in areas with seasonal water stress during summer.[70] However, water scarcity is not limited to Southern Europe. It extends to river basins across the EU, particularly in Western Europe, where (temporal) scarcity is primarily caused by a high population density in urban areas, combined with high levels of abstraction for public water supply, energy, and industry.[71] For example, the case of the Tesla factory in East Brandenburg demonstrates how local factors are crucial in industrial projects that strain regional water resources. Located in one of Germany's driest regions, the factory's significant water demands raised concerns about depleting groundwater and risking public water supplies, especially given the area's declining precipitation and proximity to protected ecosystems. This situation highlights how industrial growth can conflict with local environmental conditions.[72]

In 2019, Southern European countries—including Cyprus, Malta, Greece, Portugal, Italy, and Spain—experienced the most severe water scarcity conditions among the EU-27 (see Figure 1). This was evident on a seasonal scale, as indicated by the WEI+ (seasonal WEI+ >40%). Malta, for example, is experiencing permanent water scarcity conditions; partly due to its natural hydro-climatic conditions, while eastern European countries, such as Romania display water scarcity challenges as well (seasonal WEI+ >20%). In 2019, all seasons were significantly warmer than average, and Europe faced a heat wave in summer, precipitation was EU-wide close to average that year, but largely due to a wetter end of year than usual.[73]

3.3.4. Temporal disparities in water availability

In parts of southern Europe and in densely populated areas across the EU, water stress is a permanent, year-round problem. In other parts of Europe, water stress is usually not a permanent issue, as it occurs occasionally and in specific hotspots, where the key pressures are water used by cooling processes in electricity and industrial production, public water supply and mining. These differences are the result of the geographical and temporal variation in meteorological conditions, which affect water availability, and of the water demand of ecosystems and society and the economy.[74]

The pressure on surface and groundwater resources in Europe overall is higher in spring and summer because of abstractions by agriculture and public water supply. In autumn and winter, the highest pressure, especially on rivers, is currently from abstraction for cooling water for the energy and manufacturing sectors.[75] These factors however differ regionally. Figure 1 displays this seasonal

[69] Based on interviews.

[70] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[71] EEA (2022). Water abstraction by source and economic sector in Europe, https://www.eea.europa.eu/en/analysis/indicators/water-abstraction-by-source-and

[72] Thierauf, T. (2024). Fixing the Future? The Controversy Surrounding Tesla's 'Gigafactory Berlin-Brandenburg' as a Site of Contested Future-Making in Times of Climate Change. https://doi.org/10.1177/0961463X241273786

[73] Copernicus (2020). European State of the Climate 2019, https://climate.copernicus.eu/ESOTC/2019

[74] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[75] Ibid.

water scarcity in terms of water use in Europe in 2019. In 2019, all seasons were significantly warmer than average and Europe faced a heat wave in summer, precipitation was EU-wide close to average that year, but largely due to a wetter end of year than usual.[76] According to the map, the regions that are most affected by seasonal scarcity in terms of water use are southern Spain and Portugal, Cyprus and parts of Greece and Bulgaria, as these parts of the map turn darker blue during spring and summer season, indicating water resources in these areas are under greater stress.

In a more general sense, water scarcity conditions in most European countries intensify between July and September. This is due to a combination of various regional conditions: dry conditions (i.e. evapotranspiration exceeds rainfall), reduced flows and increased abstractions for irrigated agriculture, tourism and recreational activities, and other socio-economic activities during that period of the year.

3.4. Current issues in water scarcity in the EU

Changing climate is a major overarching driver, which puts direct and indirect pressures on water availability, use, and abstraction. Water is intricately linked with climate through many connections and feedback cycles, so that any alteration in the climate system will induce changes in the hydrological cycle. Greenhouse gases, the main cause of global warming affect water cycles primarily and more significantly. Global warming augments the water-holding capacity of the air and amplifies evaporation. This leads to larger amounts of moisture in the air, an increased intensity of water cycling, and changes in the distribution, frequency and intensity of precipitation. Consequently, the distribution in time and space of freshwater resources, as well as any socio-economic activity depending thereon, is affected by climate variability and climate change. For the coming decades, global warming is projected to further intensify the hydrological cycle, with impacts that will probably be more severe than those observed so far.[77]

In Europe, climate change has already exacerbated water scarcity. Water stress affects 30% of the European population on average every year[78]. Despite water abstraction declining by 15% in the EU between 2000 and 2019, there has been no overall reduction in the areas affected by water scarcity conditions.

Water availability problems frequently appear in areas with low rainfall, but also in areas with high population density, intensive irrigation and/or industrial activity. Water scarcity is reported for the whole Southern area, and for some areas in Central, Eastern and Northern Europe. Beyond water quantity, a situation of water scarcity can also emerge from acute water quality issues (e.g. diffuse or point source pollutions) which lead to reduced fresh/clean water availability[79].

[76] Copernicus (2020). European State of the Climate 2019, https://climate.copernicus.eu/ESOTC/2019

[77] European Commission (2009). Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document No. 24. Technical Report – 2009 – 040, https://circabc.europa.eu/sd/a/a88369ef-df4d-43b1-8c8c-306ac7c2d6e1/Guidance%20document%20n%2024%20-%20River%20Basin%20Management%20in%20a%20Changing%20Climate_FINAL.pdf

[78] European Patent Office (2024). Innovation in water-related technologies, https://link.epo.org/web/publications/studies/en-innovation-in-water-related-technologies.pdf

[79] Global Water Partnership (2020). Revision of the policy instruments and their potential to contribute to EU droughts and water scarcity policies. Danube Region Strategy, https://www.gwp.org/globalassets/global/gwp-cee_files/idmp-cee/revision_of_the_policy_instruments_of_drought_2020.pdf

Water scarcity particularly shows up during drought. Droughts cause economic damage of up to 9 billion Euros annually and additional unquantified damage to ecosystems and their services[80]. Both water scarcity and droughts have broader impacts on natural resources at large scale through negative side-effects on biodiversity, water quality, increased risks of forest fires and soil degradation[81]. This, compounded with the fact that climate change is expected to further increase the frequency, intensity, and impact of drought events in multiple regions in the EU, makes it somewhat unlikely that water scarcity overall will reduce by 2030. In that sense, balancing the need for enough water of high quality for human health, economic activities, and nature remains a key challenge in the EU.

3.4.1. Drought

Drought in Europe is a natural hazard with a wide range of transboundary, environmental and socio-economic impacts on various sectors including agriculture, energy production, and public water supply.[82] Prolonged droughts can lead to decreased soil moisture in agricultural land (agricultural drought) and reduced water flows to surface water and groundwater (hydrological drought). Drought conditions can also cause water stress to ecosystems and the economy.[83]

Due to the changing climate, many European regions are already facing more frequent, severe and longer lasting droughts. Over the past thirty years, droughts have dramatically increased in number and intensity in the EU.

Major drought in Europe in 2022

In 2022 Europe experienced a major drought due to an ongoing lack of precipitation beginning in the winter of 2021/22. Throughout the year, surface soil moisture reached its second-lowest level in the past 50 years. Elevated temperatures, combined with recurring heatwaves starting in spring and lasting through summer, further intensified these drier-than-normal conditions. This drought had significant effects on natural ecosystems and crucial economic sectors, including agriculture, energy production and the water supply sector (see section 4.2.2. of this report).[84]

Initially, the number of wet days and total precipitation in wet days decreased significantly throughout Europe. The most severe month in terms of precipitation was March. Figure 9 shows the anomaly in total precipitation in wet days (left) and anomaly in the number of wet days (right) relative to the average in the period 1991-2020. Only the Iberian Peninsula saw an increase in wet days and precipitation, while the rest of Europe—especially Northern and Central regions—experienced a severe decline.

[80] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

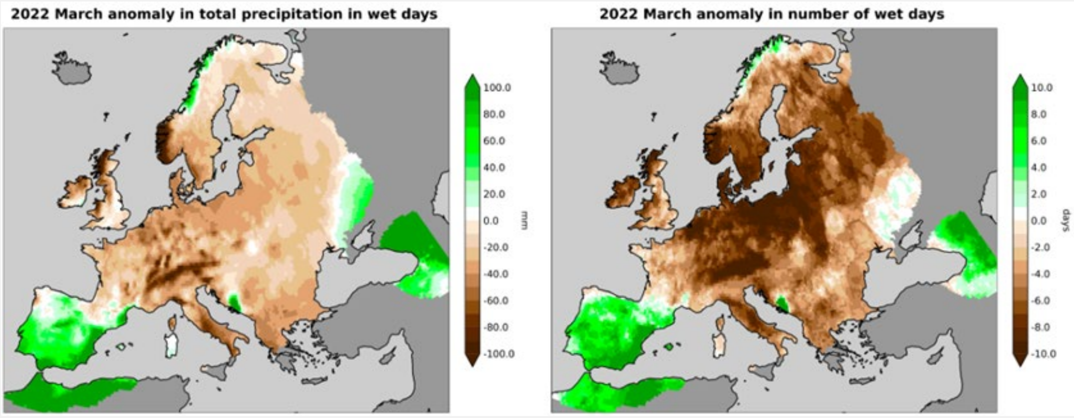
[81] Global Water Partnership (2020). Revision of the policy instruments and their potential to contribute to EU droughts and water scarcity policies. Danube Region Strategy, https://www.gwp.org/globalassets/global/gwp-cee_files/idmp-cee/revision_of_the_policy_instruments_of_drought_2020.pdf

[82] Stahl et al. (2016). Impacts of European drought events: insights from an international database of text-based reports, Nat. Hazards Earth Syst. Sci., 16, 801–819, https://doi.org/10.5194/nhess-16-801-2016.

[83] WISE Freshwater (2024). Exposure of European ecosystems to drought, https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/drought?activeAccordion=&activeTab=acd63a02-23fb-4eae-aa3c-2697524ac903

[84] https://climate.copernicus.eu/esotc/2022/drought

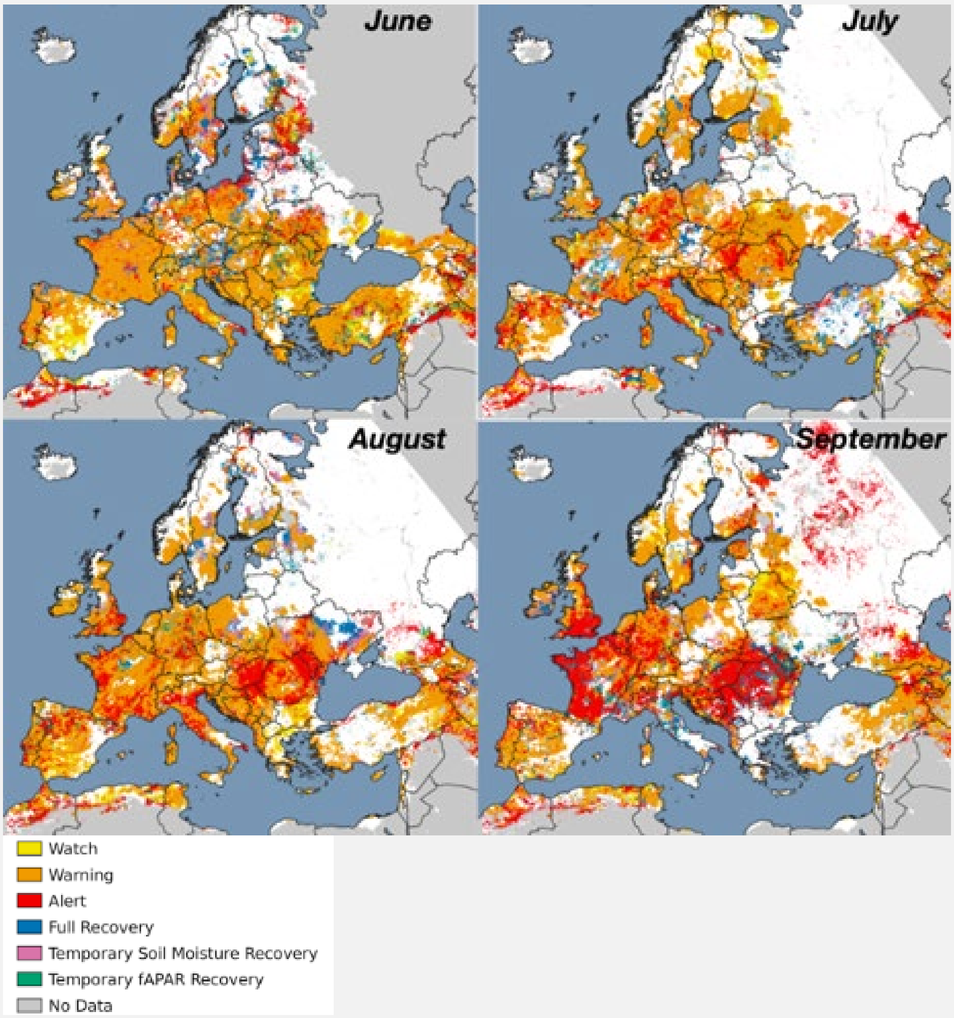
Figure 9: Anomaly in total precipitation in wet days (left) and in number of wet days (right) in March 2022 relative to the average for the period 1991-2020



Source: Copernicus climate change service (https://climate.copernicus.eu/esotc/2022/drought)

Then, in addition to reduced precipitation, warmer-than-usual temperatures and summer heatwaves (June–September 2022) worsened the drought (see Figure 10).

Figure 10: Combined drought indicator for Europe in summer 2022



Source: Copernicus climate change service (https://climate.copernicus.eu/esotc/2022/drought)

Droughts severely impact the EU economy. PESETA IV estimates current annual losses from drought to be around EUR 9 billion, with the highest losses in Spain (EUR 1.5 billion/year), Italy (EUR 1.4 billion/year), and France (EUR 1.2 billion/year).[85] The total cost of droughts over the past thirty years amounts to € 100 billion[86] and the yearly average cost quadrupled over the same period.[87]

Droughts have significantly impacted nearly all regions of the EU, affecting critical systems such as agriculture, water supply, energy, river transport and ecosystems.[88] Depending on the region, between 39%-60% of the losses relate to agriculture and 22-48% to the energy sector. Public water supply accounts for between 9%-20% of the total damage[89].

As droughts directly affect the vegetation cover and reduce the ability to intercept solar radiation, droughts can also affect ecosystem, trigger wildfire and reduce agricultural productivity. contribute to wildfires, by making the vegetation very dry. Prolonged droughts can have severe impacts on water availability, especially in rivers, lakes, and wetlands (surface water), as well as major aquifers.

[85] JRC (2020). Climate change impacts and adaptation in Europe, PESETA IV final report. https://joint-research-centre.ec.europa.eu/document/download/68960967-4846-47c2-8818-533906ab9539_en?filename=pesetaiv_summary_final_report.pdf

[86] European Commission (2007). Mediterranean Water Scarcity and Drought Report. Technical report on water scarcity and drought management in the Mediterranean and the Water Framework Directive. Technical Report—009-2007, www.emwis.net/topics/WaterScarcity/PDF/MedWSD_FINAL_Edition.

[87] European Commission (2007). Communication from the Commission to the Council and the European Parliament, Addressing the challenge of water scarcity and droughts in the European Union. COM (2007) 414 final.

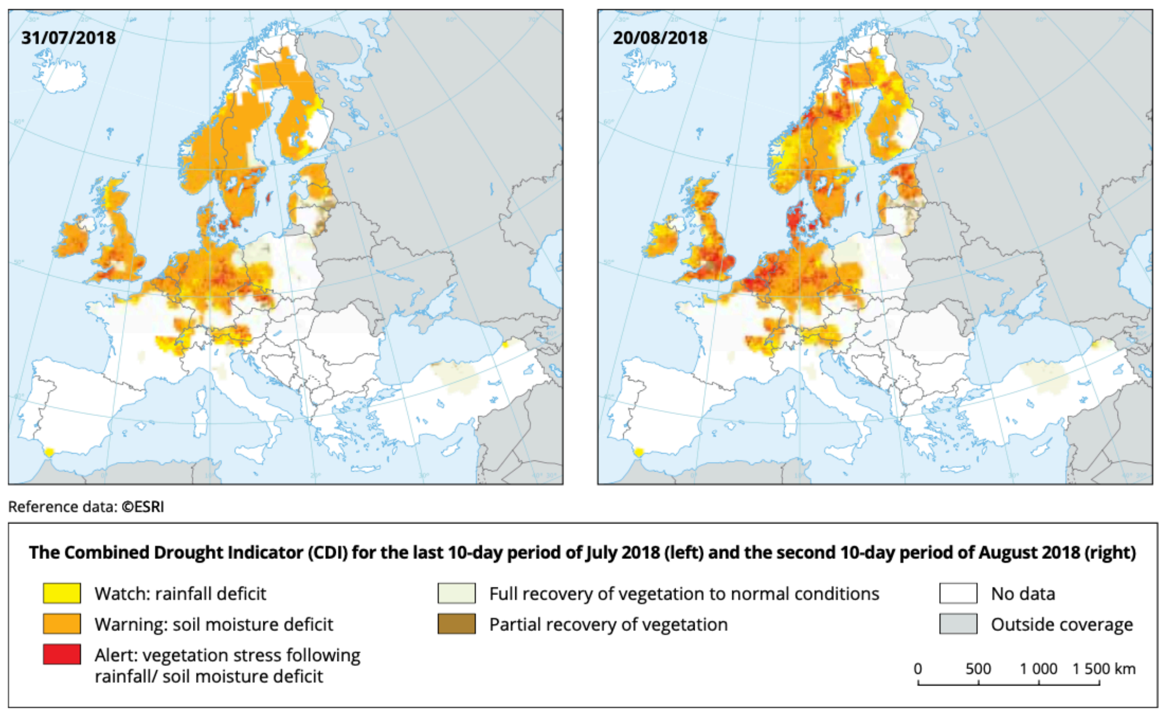
[88] European Patent Office (2024). Innovation in water-related technologies, https://link.epo.org/web/publications/studies/en-innovation-in-water-related-technologies.pdf

[89] Cammalleri, C., et al. (2020). Global warming and drought impacts in the EU. Luxembourg: Publications Office of the European Union, doi: 10.2760/597045.

The 2018 drought in Central and Northern Europe

During the spring and summer of 2018, Central and Northern Europe experienced severe drought conditions, because of a combination of exceptionally warm temperatures and low precipitation (Figure 11). Many Member States in these areas recorded one of their three hottest and driest summer ever. In contrast, Southern Europe and particularly the Iberian Peninsula recorded a wetter than usual spring and summer.

Figure 11: The 2018 drought in Central and Northern Europe



This drought affected farmers throughout Northern Europe. The yields of cereals, potatoes, sugar beet and other crops that account for a large share of crop production in Northern European countries were much lower than those in 2017. The drought also heavily affected pasture, which had detrimental effects on the livestock and dairy sector.

It also had severe impacts on other socioeconomic sectors, for example higher than usual death rates among elderly people, difficulties in cooling power plants, stability issues in the Dutch dike system due to lack of freshwater, extremely low river levels, with negative impacts on the transport sector and industries dependent on waterway transport, and forest fires.

Source: EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

3.4.2. Regional and temporal disparities in drought conditions

In the past six decades, Northern and Eastern Europe experienced a decrease in drought frequency and, less prominently, in drought severity, while Southern and Western Europe experienced an increase in drought frequency and severity, particularly over the Mediterranean region.[90] Although the increasing drought signal in southern Europe is only weak, its similarity to projected drought changes suggests that it may be a consequence of anthropogenic climate change. This may have larger implications, as drought has been shown to significantly increase the probability of impacts on industry, farming, water supply, as well as on wildfire dynamics.[91] The extent to which the increasing drought is caused by climate change is not certain. However, a study coordinated by the Helmholtz Centre for Environmental Research (UFZ)[92] found that 30% of the extraordinary intensity and physical extent of the drought in Europe can be attributed to human-induced climate change.

When looking at drought risk in the various regions of the EU, Southern Europe presents the highest drought risks. Moreover, this region is set to have the largest increases in drought risk due to climate change driven by a general drying of the region. Within this, the Iberian Peninsula (and Spain in particular) has the highest level of drought risk under both current and projected climate conditions[93].

In Northern Europe, projections show limited changes in drought risk between current and future conditions (compared to that for Southern Europe). Eastern and Western Europe are expected to experience more complex effects, with some projections showing increased drought risks, while others show similar or even decreasing risk[94].

Rainfall deficit droughts and cold snow season droughts are the dominant drought event type in Western, Eastern, and Northern Europe. Rainfall deficit and cold snow season droughts are important from autumn to spring, while snowmelt and wet-to-dry season droughts are important in summer. Finally, moderate droughts are mainly driven by rainfall deficits while severe events are mainly driven by snowmelt deficits in colder climates and by streamflow deficits transitioning from the wet to the dry season in warmer climates[95].

when looking at the drought risk per sector, distinct differences can be seen between and within sectors. Figure 12 shows the variation of drought risk for agriculture and Figure 13 shows this variation for the energy production and water supply between current and projected climate conditions. Risk is measured as average annual drought-induced reduction compared to the average expected value under current climate conditions. Results of future simulations forced with eleven climate models in Representative Concentration Pathways (RCP) 4.5 and RCP 8.5 are averaged for each warming level (+1.5 °C, +2.0 °C, +3.0 °C). The analysis was conducted at national level, for countries with sufficient data for computation.

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[90] Poljanšek, K., M. Marin Ferrer, T. De Groeve, and I. Clark (Eds.) (2017). Science for disaster risk management 2017: knowing better and losing less. Luxembourg: Publications Office of the European Union, doi:10.2788/842809.

[91] Gudmundsson, L. and Seneviratne, S. I.: European drought trends, Proc. IAHS, 369, 75–79, https://doi.org/10.5194/piahs-369-75-2015, 2015.

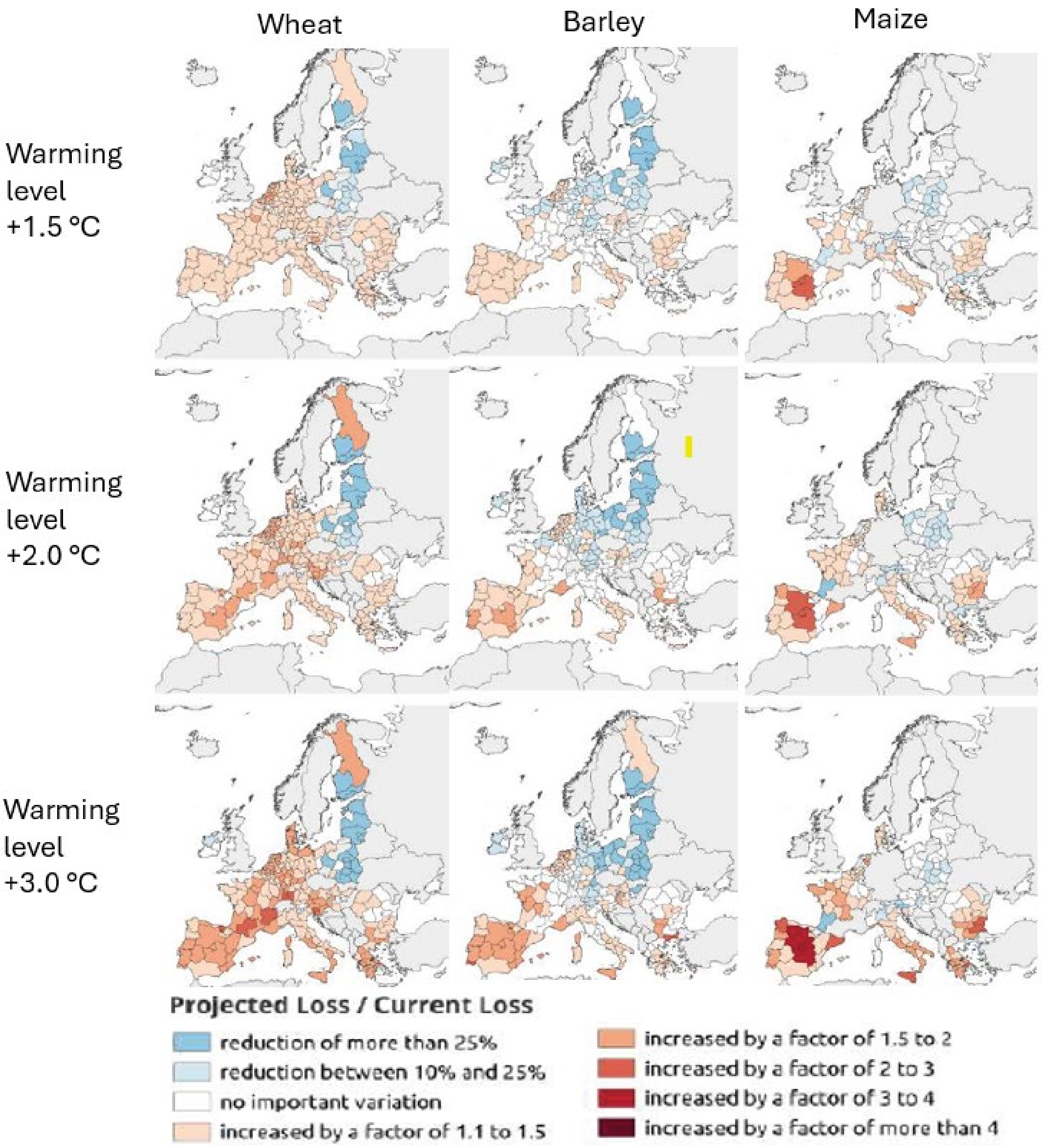
[92] Emanuele Bevacqua, Oldrich Rakovec, Dominik L. Schumacher, Rohini Kumar, Stephan Thober, Luis Samaniego, Sonia I. Seneviratne, Jakob Zscheischler. Direct and lagged climate change effects intensified the 2022 European drought. *Nature Geoscience*, 2024; DOI: 10.1038/s41561-024-01559-2

[93] Rossi, L., et al. (2023). European Drought Risk Atlas. Luxembourg: Publications Office of the European Union, doi:10.2760/608737.

[94] Ibid.

[95] Brunner, M. I., A.F. Van Loon, and K. Stahl (2022). Moderate and Severe Hydrological Droughts in Europe Differ in Their Hydrometeorological Drivers. Water Resources Research (Vol. 58, Issue 10). American Geophysical Union (AGU). https://doi.org/10.1029/2022wr032871

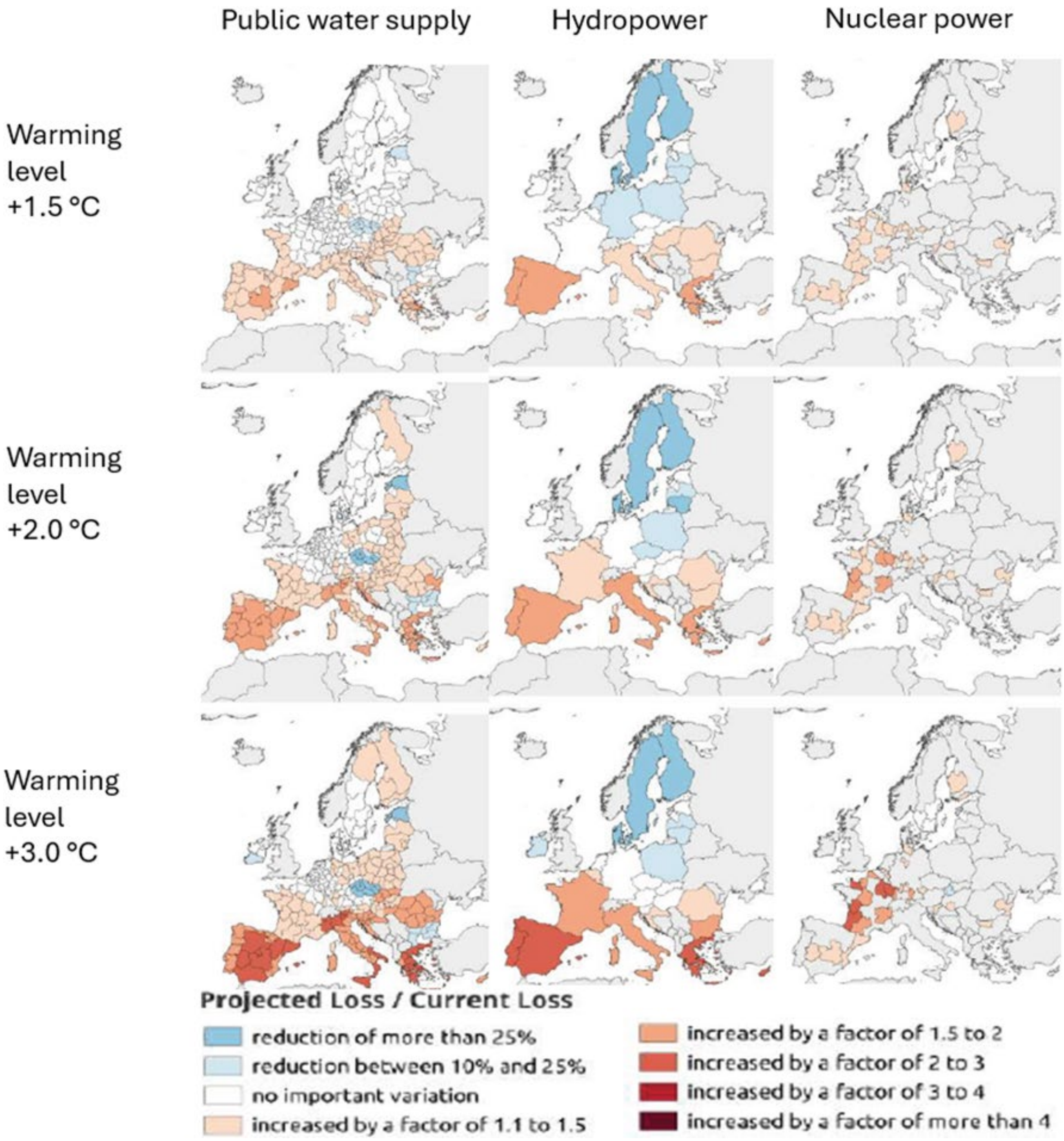
Figure 12: Variation in drought risk for crops (wheat, barley and maize) between current and projected conditions



Source: Rossi et al. (2023). European Drought Risk Atlas, Publications Office of the European Union, doi:10.2760/33211, JRC135215.

Figure 12 shows that all for 3 crops there are yield losses due to droughts rise with increasing warming levels almost all over Europe. While for wheat the biggest loss under the increased warming levels can be seen in France and Germany the yield loss for maize and barley is projected to be most significant in the Mediterranean under the different warming levels.

Figure 13: Variation in drought risk for the public water supply and energy production (hydropower and nuclear power) between current and projected conditions



Source: Rossi et al. (2023). European Drought Risk Atlas, Publications Office of the European Union, doi:10.2760/33211, JRC135215.

Figure 13 shows that there are differences in the way that increased levels of warming affects the energy production and water supply sectors. For energy production it is interesting to see that the projected changes in hydropower losses show very distinct differences between central/northern Europe and southern Europe. In the Mediterranean region (Spain, Portugal, Greece) hydropower losses at a warming level of +3 °C are projected to double or even triple, while in central and northern Europe, the losses are projected to fall. For the nuclear power sector, drought-induced losses are projected to increase in all global warming scenarios and across Europe.

The risk for the water supply sector is projected to increase in almost all Europe and especially around the Mediterranean, where large increases in drought-induced water abstractions can be expected.

3.5. Current policies and actions to address water scarcity

3.5.1. Water management and governance in the EU

Water is one of the oldest and most advanced policy areas in EU environmental regulation. Since 2000, the Water Framework Directive (WFD) has been the primary legislation governing water in the EU. It coordinates a wide variety of EU regulatory instruments, strategies, and policy mechanisms that have emerged and evolved over decades. While the EU has made significant strides in addressing water quality, EU policies on water quantity lag behind and are generally less developed.[96] Despite the publication of the European Commission's communication on water scarcity and drought in 2007 and the Blueprint to Safeguard Europe's Water Resources in 2012, EU policy on water stress remains scattered and the implementation of policy options and recommendations has been slow.[97]

3.5.2. EU policies and legislations

EU policy on water stress is based on four main pillars; the Water Framework Directive, the Groundwater Directive, the Floods Directive, and the new Water Reuse Regulation.[98] These constitute a very comprehensive acquis and address both water quality and quantity. The EU has authority to regulate and subsequently protect the quality of water. When it comes to water quantity and water distribution across different sectors and users, however, the EU's normative power is limited due to the principle of subsidiarity and the exclusive competence of EU Member States.[99] It is also important to note that there is currently no specific EU directive on drought.

Annex B provides an inventory of the EU wide legislative framework along with the most relevant policy initiatives and other actions in places to address the issue of water scarcity. While this represents a wide range of legislation and policy initiatives, the main directive in the area of water scarcity is the Directive for Community action in the field of water policy — often referred to as Water Framework Directive (WFD).[100] The aim of the WFD is to enhance the protection of water bodies and the status of aquatic ecosystems by promoting sustainable water use. The WFD covers a wide variety of water bodies and includes legislation on both water quality and quantity. The focus of the directive, however, is on water quality. This leaves ample room to include more quantitative aspects, such as measures addressing drought impacts in River Basin Management Plans (RBMPs). The 2019 Fitness Check of the EU Water Framework Directive and related legislation was largely positive, highlighting the WFD's significant impact on water body protection and flood risk management.

The EU's policy response to water scarcity was outlined in the 2007 Communication "Addressing the challenge of water scarcity and droughts in the European Union" and a follow-up communication in

[96] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[97] ibid

[98] Water Framework Directive 2000/60/EC, Groundwater Directive 2006/118/EC, Floods Directive 2007/60/EC, Water Reuse Regulation (EU) 2020/741

[99] According to Article 192 of the Treaty of the Functioning of the European Union (TFEU) the issues regarding water quantity are meant to be addressed by unanimity.

[100] European Commission (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy 2000/60/EC

2012. These describe the main concerns regarding water scarcity and its underlying causes. In addition, it proposes various measures to address water scarcity at regional, national and EU levels.[101]

The European Green Deal (EGD) addresses water scarcity and drought as one of its focal points. Consequently, water scarcity has been included in various strategies, including the Circular Economy Action Plan, the EU Strategy on Adaptation to Climate Change, the EU Biodiversity Strategy for 2030; as well as multiple guidance documents and best practice exchanges.[102] The EU strategy on Adaptation to Climate Change strongly emphasises nature-based solutions as effective means to maintain ecological health and to improve water supply while providing multiple co-benefits in a cost-effective manner.[103] Nature-based solutions on water management may involve the use of ecosystem services to improve water quantity and quality, and increase resilience to climate change. Examples include natural solutions to manage flood and surface water in rural and (peri-)urban areas, as well as strategies for wastewater management and resource recovery.[104]

Additionally, sectoral policy instruments, such as Pillar II of the common agricultural policy (CAP) or funding schemes across the cohesion and regional funds, also play a pivotal role in water policy. Agricultural policies, particularly the CAP, can complement existing water policies or act as a hindrance. A report by the European Court of Auditors, shows that agricultural policies at both the EU and Member State levels are not consistently aligned with EU water policy, resulting in excessive water use without promoting sustainability.[105]

The same report suggests that the CAP could incentivise sustainable agriculture in the EU by linking payments to environmental standards. Within the framework of the European Green deal, the ongoing CAP reform for 2023-2027 includes several policy reforms to support the transition towards sustainable agriculture and forestry across the EU. [106] This reform also creates opportunities for more sustainable water management.[107] In this context, the European Parliament has called on the Commission to take specific actions related to the CAP reform, including: developing programmes to improve water management in agriculture, increase resilience and ensure water supply; supporting the storage and use of treated wastewater for agriculture; accelerating implementation

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[101] European Commission, Addressing the challenge of water scarcity and droughts in the European Union COM (2007) 414 final

[102] Circular Economy Action Plan COM/2020/98 final, Strategy on Adaptation to Climate Change COM/2021/82 final, Biodiversity strategy COM/2020/380 final, for guidance documents, see Annex A

[103] Clive Davies, et al. (2021).The European Union roadmap for implementing nature-based solutions: A review, *Environmental Science & Policy,* Volume 121: https://doi.org/10.1016/j.envsci.2021.03.018 provides examples of conceptualisation and operationalisation of nature-based solutions within the EU's climate adaptation action also on the water sector.

[104] European Parliamentary Research Service with the Directorates-General for Internal Polices (IPOL) and External Policies (EXPO) study (2023). Future shocks. Anticipating and weathering the next storms: https://www.europarl.europa.eu/RegData/etudes/STUD/2023/751428/EPRS_STU(2023)751428_EN.pdf

[105] Sustainable water use in agriculture: CAP funds more likely to promote greater rather than more efficient water use, (2021). European Court of Auditors Special report: https://www.eca.europa.eu/Lists/ECADocuments/SR21_20/SR_CAP-and-water_EN.pdf

[106] More information on the CAP reform through the following webpage: https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en

[107] Pe'er G, Bonn A, Bruelheide H, et al., (2020). Action needed for the EU Common Agricultural Policy to address sustainability challenges. *People and Nature*. https://doi.org/10.1002/pan3.10080

of cohesion policy and infrastructure to combat extreme droughts in Europe; promoting vertical farming, which requires less water and pesticides.[108]

By integrating water stress and drought policy objectives into other key areas, the EU and its Member-States could significantly improve coherence and accelerate implementation, enhancing sustainable water management across the EU.

3.5.3. Other actions and activities at EU level

In addition to EU policy and legislation, there are additional efforts at the EU level and beyond to address issues related to water availability, use, scarcity and drought. According to most of the interviewees, improving cooperation among EU member states, ideally through sharing knowledge and exchanging best practices, is considered essential to addressing these challenges according to most of the interviewees. Additionally, and according to the interviewed stakeholders' opinion, knowledge and information sharing among the EU member states are particularly important for addressing the impacts of droughts at an early stage (through an early warning system and risk management), as they are more complex compared to the impacts of floods due to their associated cascading effects. The EU has various projects and programmes to enable the creation and sharing of knowledge on droughts and water scarcity. For example, as part of the WFD there is a Working Group that maintains an inventory of practices of Member States.

In October 2023, the European Economic and Social Committee (EESC)presented a call for an EU Blue Deal.[109] The EU Blue Deal includes a comprehensive set of recommendations for a sustainable water policy for Europe as a strategic priority. It is based on a set of opinions covering the social, economic, environmental, and geopolitical aspects of water. It also addresses water challenges related to agriculture, industries, infrastructures, and sustainable consumption. In July 2024, the EESC has renewed its call for a dedicated EU Blue Deal in the form of a new opinion on water resilience and industrial development, adopted just ahead of the European Commission President Ursula von der Leyen's announcement of a Water Resilience Strategy.[110] The new Commissioner-designate for Environment, Water Resilience and a Competitive Circular Economy is tasked with working on this strategy acknowledging that the EU's industrial future is contingent on water.

The EU also funds various research and innovation projects through the Horizon and LIFE programmes. to develop knowledge and provide tools to implement policy actions. These include, for example the Horizon project Transformational and Robust AdaptatioN to water Scarcity and ClimatE chaNge under Deep uncertainty (TRANSCEND)[111] on adaptation policies to water scarcity or the Horizon project ANYWHERE[112] dealing with early warning of weather-relate hazards, including droughts. A larger overarching funding programme is the Water4All Partnership[113], which aims to fund research on water challenges and enable transnational collaboration on water R&I. In addition, the partnership aims to share knowledge specifically on innovative solutions to water challenges and build capacity among policymakers to implement these solutions.

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[108] 2023 European Parliament resolution on ensuring food security and long-term resilience of the EU agriculture (2022/2183(INI)): https://oeil.secure.europarl.europa.eu/oeil/popups/ficheprocedure.do?lang=en&reference=2022/2183(INI)

[109] Declaration for the EU Blue Deal (2023). European Economic and Social Committee: https://www.eesc.europa.eu/sites/default/files/files/qe-04-23-852-en-n.pdf

[110] Europe's Choice. Political guidelines for the next European Commission 2024-2029: https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf

[111] More information about the project through this webpage: https://cordis.europa.eu/project/id/101084110

[112] The official website of the project: http://anywhere-h2020.eu/

[113] More information about the partnership through the official website: https://www.water4all-partnership.eu/

In more details, Table 1 provides an overview of the available tools, actions and information systems related to droughts and water scarcity.

Table 1: Tools, Actions, and Information Systems for Droughts and Water Scarcity

Tools/actions	Purpose
EU Civil Protection Mechanism	EU response to droughts with short-term emergency measures
European Drought Observatory	Providing the latest information and maps on droughts across the EU
Global Drought Observatory	Providing the latest information and maps on droughts worldwide
European Drought Observatory for Resilience and Adaptation (EDORA)	Enhancing drought resilience and adaptation as well as cooperation throughout the EU
European Droughts Risk Atlas	Simulating the impact of temperature increases using machine learning
European Droughts Impacts Database	Providing data on the impact of droughts between 1977 and 2022
European Droughts Centre including a European Drought Impact Report Inventory (EDII) and European Drought Reference (EDR) database	The European Drought Centre is a virtual knowledge centre with the aim to coordinate drought related activities in Europe to better mitigate the environmental, social and economic impact of droughts. The EDC promotes collaboration and capacity building between scientists and the user community and thereby increases preparedness and resilience of society to drought
European Centre for medium-range weather forecast	Provides two different types of weather forecast: an extended range forecast, with lead times of up to 45 days, which is issued twice a week, and a seasonal forecast, with season is important to trigger actions for mitigating negative impacts on human activities and environmental processes. Decision-makers and end users require adapted and robust forecast indicators that are capable of informing about the onset, possible duration, intensity and end of drought conditions
EIT Water Scarcity Programme	Supports innovative solutions to alleviate water scarcity in Southern Europe, are being implemented to boost knowledge, foster entrepreneurship, and promote strategies that minimise water waste, enhance efficiency, and bolster resilience to climate change

3.5.4. Encountered inspiring policy practices at regional level

Although the EU has several water policies, its mandate to develop such policies is limited. Each member state is responsible for its own water regulations, management, and governance, which are based on national traditions and tailored to address regional water system challenges. National policy practices in one member state can serve as inspiration for policy actions in others and influence EU-level policy options. Here are some examples of inspiring national policy practices encountered during the study.[114]

- **Integrated strategic plan for water and climate change**: Spain has developed a Global Water Strategy[115] and Strategic Orientations on Water and Climate Change[116] in which it addresses many challenges in terms of water stress and water management in Spain in the

[114] Please note that this section does not intend to provide an overview of all EU Member States' water policies/actions nor suggests that Member States not listed do not have any inspiring water policies.

[115] DGA (2023). Global Water Strategy of the Kingdom of Spain. Madrid: Directorate-General of Water, MITRERD.

[116] DGA (2022). Strategic Orientations on Water and Climate Change. Executive Summary. Madrid: Directorate-General of Water, MITRERD.

light of climate change. The strategy is associated with significant investments and modernisation of the water sector in Spain. Actions include investments in desalination plants, demand reduction measures, protection of water bodies and increased circularity of the water cycle to enhance water security; improving drought risk management; recovery of natural sites and the use of nature-based solutions; investments in adopting innovations and digitalisation in the water sector; funding of research on hydrology and modelling; and improve participation of all stakeholders in water governance.

- **National plan to modernise irrigation:** The National Irrigation Programme (MAPA 2002) was born in Spain as the policy response to a severe drought event in the mid-1990s that had a drastic impact on the entire national economy, especially on agriculture. The plan aimed to modernise 1.1 million irrigated hectares in the period 2002–2008, by improving large transport infrastructures, collective distribution networks and on-farm equipment. A second prolonged drought (2005–2008) triggered the second and the third modernisation waves, known as the Shock Plan for Irrigation Modernisation.[117]
- **Subsidy programme for grey water reuse:** Cyprus has taken conservation measures at household level by encouraging the re-use of "grey water" (i.e. from washing and washing machines) for watering gardens and flushing toilets[118], reducing per capita water consumption by up to 40%. In 2007, government subsidies covered 75% of the cost of the system.[119]
- **Water quantity plan to address worst-case scenarios**: the water operator VIVAQUA[120] in Brussels (Belgium) has developed a Water Quantity Plan based on a risk analysis of the adequacy between its drinking water production, supply, infrastructure, and water demand, also considering the impact of climate change. VIVAQUA manages 26 catchment sites in Brussels and Wallonia. The Water Quantity Plan revealed potential risks of insufficient production capacity during specific periods if certain events occur together. The plan is based on a worst-case scenario; a dry winter (with little or no aquifer recharge), followed by a dry spring and summer (leading to severe low river water levels), and heatwaves during periods of high consumption in Brussels (May-June and September). The worst-case scenario has led to identifying measures to ensure reduced risk and ensure additional water abstraction in times of water scarcity: increased production of current catchments, rehabilitate old catchments and make new catchments for peak demand, optimise catchments and manage aquifer recharge (i.e. by storing water in aquifers with an underground lock). [121]
- **National knowledge institute**: In the Netherlands the knowledge institute Deltares develops applied research on water and the subsurface. It has a large range of expertise and operates internationally, although the Dutch government is their main client. Their projects focus on providing solutions for policymakers or practitioners. These projects allow them to extend their knowledge base and provide opportunities for innovation. One example of the solutions they developed is a global river flood and drought forecast

[117] Berbel, J., et al. (2019). Effects of the irrigation modernization in Spain 2002-2015. Manuscript, https://digital.csic.es/bitstream/10261/207337/3/WARM-D-18-00706_final.pdf

[118] Sofroniou, A. and S. Bishop (2020). Water Scarcity in Cyprus: A Review and Call for Integrated Policy. In: Tewodros Tena (Eds.). Water: Ecology and Management. Hyderabad, India: Vide Leaf.

[119] European Commission (2007). Addressing the challenges of water scarcity and droughts in the EU, COM(2007) 414 final, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0414:FIN:en:PDF

[120] More information about VIVAQUA through the official website: https://www.vivaqua.be/en/

[121] Robert. T. (2024). Our Water Quantity Plan. Webinar Resilience in Action. VIVAQUA, https://www.aquapublica.eu/sites/default/files/article/file/Annex%20C%20-%20Presentation%202%20-%20VIVAQUA.pdf

service.[122] Another initiative developed by a consortium of institutes is the Dutch Drought Portal that monitors meteorological and hydrological drought.[123]

- **Blue Deal Flanders**: To tackle water scarcity and drought, the Government of Flanders launched the Blue Deal. A programme that addresses challenges of water scarcity and drought through a range of initiatives including infrastructure investments, policy and regulation, innovation, research, monitoring, communication and awareness campaigns. The initiatives are aimed at water retention, reducing consumption and use, and increasing reuse.[124]
- **Interregional drought management centre**: The Drought Management Centre for South-Eastern Europe (DMCSEE) located in Slovenia is a collaboration initiative between several countries. This centre is an initiative of the national hydrometeorological services of thirteen countries in South-Eastern Europe and funded by World Meteorological Organization and the UN Convention to combat desertification. The DMCSEE's mission is to coordinate and facilitate the development, assessment and application of drought risk management tools and policies in Southeastern Europe. [125]
- **Assigning protected groundwater bodies:** France decided to include various groundwater bodies in its 2022-2027 River Basin Management Plan. In these reserved aquifers abstractions are in principle only allowed for drinking water. The RBMP[126] states that specific management plans should be developed with other stakeholders to regulate additional abstractions and preserve the quantitative balance of the aquifer.[127]
- **Tax credits for sustainable investments of farmers:** Italy provides tax credits for private investments by farmers to increase the sustainability of their farm. This includes investments in reducing water use. The tax credits have been used extensively with €2.1 billion invested by farmers in 2022.[128]
- **Water quality management:** Germany sets a precedent with its successful management of Lake Constance's water quality through comprehensive pollution reduction strategies, showcasing a model for sustainable water use with new technologies.[129]
- The German Drought Monitor provides daily information on drought and soil moisture throughout Germany.[130] Updated daily, the maps show you the drought status of the whole soil, including the subsoil, and the topsoil, which reacts more quickly to recent precipitation, and the water available to plants in the soil.

[122] https://www.deltares.nl/en/about-us

[123] https://droogteportaal.nl/droogteportaal/web/

[124] https://bluedeal.integraalwaterbeleid.be/about-blue-deal

[125] https://www.dmcsee.org/

[126] International Commission for the Protection of the Rhine (ICPR) (2022). Internationally Coordinated Management Plan 2022-2027 for the International River Basin District of the Rhine, https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/BWP-HWRMP/EN/bwp_En_RMBP_2021_01.pdf

[127] Rinaudo, J.-D., et al. (2020). Groundwater Management Planning at the River Basin District Level: Comparative Analysis of the Adour-Garonne and Loire-Bretagne River Basins. In: Sustainable groundwater management: a comparative analysis of French and Australian policies and implications to other countries, https://hal.science/hal-02532156

[128] Kazim, A. (2023). Climate change forces Italy's farmers to focus on water. Financial Times, 19 October 2023.

[129] European Patent Office (2024). Innovation in water-related technologies, https://link.epo.org/web/publications/studies/en-innovation-in-water-related-technologies.pdf

[130] https://www.ufz.de/index.php?en=37937

4. In the short term: future of water availability and use in the EU in 2030

4.1. Short term trends that affect water availability and use

This section describes trends that affect water availability and use in Europe in the short term (2030). Environmental and climatological trends; social, demographic and economic trends; technological trends; and political, ethical and legal trends are discussed. Trends considered here are external factors that influence the context and conditions that determine water availability and use in the short term. These are trends that are clearly foreseeable and often more concrete than megatrends for the long-term (section 5.1), although they do in part overlap or share similarities.

4.1.1. Environmental and climatological trends

Climate change

There is an overwhelming scientific consensus that human activities are the primary driver of the rapid climate changes observed in recent decades. Activities like burning fossil fuels, industrial processes, land use, land use change and forestry release large amounts of greenhouse gases, such as carbon dioxide and methane, into the atmosphere, trapping heat and causing global temperatures to rise.

EU countries are legally committed to fighting climate change by shifting to a climate-neutral economy with net-zero greenhouse gas emissions by 2050.This goal from the commitment to the Paris Agreement which all EU member states have signed and ratified. In the meantime, climate policies in Europe are aimed at reducing greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990 levels to reduce the adverse effects of climate change. According to the JRC, GHG emissions in the EU are on the linear track to reaching the -55% goal in 2030. However, the JRC also indicates that more effort is needed in the years to come to keep this linear track and reach the target in 2030.[131] Nevertheless, this policy goal is likely not enough to limit global temperature increase to 1.5°C above pre-industrial levels, as ambitioned in the Paris Agreement.[132] Climate change will thus be an important trend to consider in the short and medium- to long-term.

Climate change directly affects water availability and indirectly influences water use. The implications of climate change differ across the EU Member States depend on the extent to which climate mitigation goals will be achieved. Climate change projections indicate that the areas exposed to drought, as well as the frequency, duration, and intensity of droughts are likely to increase in multiple regions in Europe.[133] Taking precautionary measures and managing water use and consumption during prolonged droughts is becoming a major challenge in Europe.[134] With the

[131] JRC (2023). EU Climate Action Progress Report 2023, https://climate.ec.europa.eu/eu-action/climate-strategies-targets/progress-climate-action_en

[132] Climate Analytics (2022). 1.5°C pathways for the EU27: accelerating climate action to deliver the Paris Agreement, https://ca1-clm.edcdn.com/assets/1-5pathwaysforeu27-2022.pdf

[133] Prudhomme et al. (2013): Hydrological droughts in the 21st century, hotspots and uncertainties from a global multi-model ensemble experiment, www.pnas.org/cgi/doi/10.1073/pnas.1222473110

[134] WISE Freshwater (2024). Exposure of European ecosystems to drought, https://water.europa.eu/freshwater/europe-freshwater/freshwater-themes/drought?activeAccordion=&activeTab=acd63a02-23fb-4eae-aa3c-2697524ac903

increasing impact of climate change, pressure on the availability of clean freshwater in sufficient quantities is expected to increase.[135]

Climate change is expected to aggravate the structural problems that already lead to water scarcity in some European countries. The last few decades some of the hottest and driest years of the last two centuries have been recorded, and the annual average temperature in Europe has already increased to 1.6-1.7 °C above the pre-industrial level.[136] Climate change is projected to cause seasonal reductions in water availability in most parts of Europe, except in north-eastern areas. The strongest impact is expected in Southern and South-western Europe, with river discharge reductions in summer of up to 40% in some basins, under a 3 °C temperature rise scenario. Large parts of Western and Central Europe will also be affected, albeit to a lesser degree. Changes in aquifers' recharge follow roughly the same pattern.[137]

Climate change can influence both average conditions and the frequency and severity of droughts. The temperature rise increases potential evapotranspiration and, in many cases, actual evapotranspiration, causing more frequent and extreme droughts. The temperature rise intensifies heavy precipitation, attenuates snowpack build-up and triggers early snow melting. These effects have led to a decrease in annual precipitation in parts of southern Europe and decreasing river discharges, leading to increasing water stress.[138] Due to climate change there will be a higher frequency of substantial damages, and increasingly irreversible losses, in freshwater ecosystems.[139]

4.1.2. Societal, demographic and economic trends

The EU is expected to see a slight increase in population due to migration

Eurostat projects that in 2030 the population in the EU has slightly increased to over 452 million people. The projected population growth in 2030 is rather limited, with an expected growth of +0.3%. The main reason for this modest population growth is migration, as the population in Europe is ageing and birth rates have been declining in Europe. However, there are significant regional differences in population dynamics. Southern and Eastern Europe are experiencing depopulation, while Western and Northern Europe are seeing steady growth, partly driven by mainly driven by EU internal economic migration augmented by non-EU migrants. .

A larger population would generally use more water than a smaller population to support basic needs such as drinking, cooking, cleaning and personal hygiene. According to most recent Eurostat data, however, the median water consumption per inhabitant in the EU has decreased by 8% in the period 2000-2022.[140] If this water use efficiency trend continues at a somewhat similar pace, the total

[135] European Commission (2007). Report from the Commission to the Council and the European Parliament on the implementation of the Water Framework Directive (2000/06/EC), the Environmental Quality Standards Directive (2008/105/EC amended by Directive 2013/39/EU) and the Floods Directive (2007/60/EC), https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:0970:FIN

[136] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[137] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[138] Ibid.

[139] United Nations (2024). The United Nations World Water Development Report 2024: Water for Prosperity and Peace. Paris: UNESCO, https://unesdoc.unesco.org/ark:/48223/pf0000388948

[140] Eurostat (2024). Water statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_statistics#Water_uses

household water use in the EU further decrease despite a slightly growing population, signifying a decoupling of population size and water use.

During the Three Horizons workshops, the experts discussed that a larger population would pose challenges such as distribution and increase of land use (e.g. agricultural and urban). These challenges require political attention regarding spatial planning or potential cascade schemes to determine which sectors should be prioritised in terms of water use/consumption in times of severe water stress.

Finally, as discussed during the Three Horizons workshops, the trend of an aging population can also have implications for water availability, such as an increased risk of pharmaceuticals entering the (waste) water circuits and the need for more thorough drought and heat policies, as older people are usually more sensitive to droughts heat waves.

The EU economy is expected to grow at a low rate

The IMF projects that the EU will experience an economic growth of approximately 1,5% by 2030.[141] This growth is modest and lower than the projected economic growth rates for Asia and North America. As economic growth typically leads to increased production, it also requires more resources, including water. However, it's important to note that water usage tends to rise at a slower rate than economic growth.[142] This indicates that while a slight increase in water consumption can be anticipated as the economy grows, implementing greater water efficiency measures may help to separate economic growth from water usage.[143] Implementation of water efficiency measures varies between EU Member States due to differences in economic conditions, water infrastructure development, and the impacts of climate change.

Water use and consumption is influenced not only by economic growth but also by water pricing, although the price elasticity of water is relatively low.[144] In the EU, water prices are based on the principle of full cost recovery. This means that users should cover not only the costs of producing drinking water but also its environmental and resource costs through their water tariffs.[145] However, water taken from private wells or through self-service (for instance, in agriculture) is often not priced the same way as drinking water. It is frequently unmetered and sometimes subject to taxes, with variations occurring among EU Member States.[146] The price of water is different across EU Member States and the structure of the pricing as well. The price of water varies across different EU Member States, as does the structure of pricing. Due to the full cost recovery principle, water prices are expected to rise in the future, driven by increasing production costs and the heightened monetary value of water due to scarcity caused by climate change.[147]. This rise in prices may lead to a slight decrease in overall water consumption.

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[141] IMF Datamapper (n.d.). Real GDP growth, https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/EU/EURO/EUQ

[142] UNEP (2015). Options for decoupling economic growth from water use and water pollution. Report of the International Resource Panel Working Group on Sustainable Water Management.

[143] EEA (2022). Water resources across Europe – confronting water stress: an updated assessment. https://www.eea.europa.eu/en/analysis/publications/water-resources-across-europe-confronting

[144] OECD (1999). The Price of Water. Trends in OECD Countries. Paris: OECD.

[145] WAREG (2023). 3 – Water Pricing Principles in the EU, https://www.wareg.org/articles/european-water-pricing-principles/

[146] Berbel, J. and A. Expósito (2020). The theory and practice of water pricing and cost recovery in the Water Framework Directive. Water Alternatives 13(3): 659-673.

[147] Onillon, A. and B. Fribourg-Blanc (2023). Economic models for water management and pricing in Europe: Synthesis, OiEau, March 2023.

A more circular economy and society

Circularity is becoming a key solution in our economy and society to address resource scarcity and the demand for sustainable products. This trend stems from growing public concern about environmental impact and mass consumption, as well as a desire to live more sustainably. Additionally, it is fuelled by government incentives. Many policies in Europe promote a circular economy, which aims to keep products and materials in use at their highest economic value for as long as possible.[148] This is achieved through maintenance, repair, reuse, refurbishment, remanufacturing, recycling and composting. The goal is to decouple economic growth from finite natural resources and reduce waste.[149]

The concept of a circular economy has also been applied to the water sector, with the guiding principle of reducing water use by design. This involves developing processes that minimize water consumption. Rethinking water use encompasses three key strategies:[150]

- Decrease water use by avoiding the use of water, reducing the use of water or replacing water as a resource;
- Optimise water use by reusing water, recycle used water and cascading water[151] (using output water from one process as input water for the other);
- Retain water by storing water (conservation) or recover water (cleaning water).

Increased urbanisation and human mobility

Urbanisation is a trend that began to emerge in Europe in the 20th century and is expected to continue growing through 2030 and beyond. In 2022, approximately 75% of EU citizens lived in cities, and this figure is projected to rise to 84% by 2050[152]. Increased urbanisation may lead to local discrepancies between water demand and availability, potentially resulting in local water scarcity.[153] Furthermore, increased human mobility-such as mass tourism and workforce mobility, may further intensify local water demand.[154]

Both urbanisation and human mobility place greater pressure on urban water supply systems. Cities require extensive water infrastructure and often experience increased water demand during heatwaves, which are becoming more frequent due to climate change and extreme weather events

Water-sensitive urban design is gaining traction as a sustainable solution to the increasing demand on urban water supplies. This approach focuses on managing urban water resources more effectively

[148] UNEP (2024). Water as a Circular Economy Resource. Foresight Brief. February 2024.

[149] Ellen MacArthur Foundation (n.d.). What is a circular economy?, https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

[150] Morseletto, P., C.E. Mooren and S. Munaretto (2022). Circular Economy of Water: Definition, Strategies and Challenges. Circular Economy and Sustainability (2(4)), https://doi.org/10.1007/s43615-022-00165-x

[151] For concrete examples in circular water use see: Socio-economic study on the value of the EU investing in water, (2024).WaterEurope Project No: 70118415: https://watereurope.eu/wp-content/uploads/2024/10/Water-Europe-Socio-Economic-Study.pdf

[152] ESPAS (2019). Welcome to 2030: The Mega-Trends. In: Challenges and Choices for Europe. https://ec.europa.eu/assets/epsc/pages/espas/chapter1.html

[153] A. Frérot (2009). The European Union and the Challenge of Water Scarcity. Foundation Robert Schuman, https://www.robert-schuman.eu/en/european-issues/126-the-european-union-and-the-challenge-of-water-scarcity

[154] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

by incorporating strategies such as stormwater harvesting, wastewater reuse, and rainwater collection. It also emphasizes reducing our reliance on potable water. Moreover, water-sensitive design improves stormwater management and increases the permeability of urban surfaces, which helps to reduce surface runoff, enhance groundwater recharge, and prevent water wastage. As a result, this approach not only supports the sustainability of ecosystems but also can help to decouple urbanisation and water use and cities to adapt cities adapt to climate change.[155]

Changes in consumption patterns

Changes in consumption patterns have significantly impacted water usage. Modern lifestyles, characterised by higher living standards and increased consumption of water-intensive products (such as meat and textiles), place greater demands on water resources. The average water footprint of an EU citizen is estimated to be 4.385 cubic meters per day when taking both direct and indirect water consumption into account.[156]

As consumer preferences shift towards a higher consumption of energy and water-intensive goods, the pressure on available water resources increases. This issue extends beyond just water resources within the EU; many products available in the EU are produced in other countries. However, changes in consumption patterns will also influence water use related to products manufactured within the EU.

4.1.3. Technological trends

The EU is committed to fostering innovation to address the challenges of water scarcity. It focuses on improving various aspects, including better monitoring of the Earth and its climate, effective data management, enhanced socio-environmental modelling, advancements in hydrological practices such as drought forecasting, and the development of technologies that increase technical water efficiency. Additionally, the EU aims to create better tools for controlling water demand and promoting alternative water sources[157]. Innovations like the development of urban and agricultural infrastructure and improvements in water use efficiency are vital for adapting to changing climate conditions and ensuring the sustainability of water resources. [158].

Digitalisation and the use of Artificial Intelligence (AI)

Digitalisation provides solutions to reduce water use and consumption, but at the same time digitalisation also leads to increased water use. Increased digitalisation and the further adoption of AI will thus affect water use and consumption in the future.

Digitalisation offers solutions to reduce water usage and consumption, but it also leads to increased water use. As digitalisation continues to grow and the adoption of AI expands, the impact on water use and consumption will become more significant. On the positive side, digitalization can help minimize water use through effective data analysis. Information gathered from satellites, weather stations, and sensors provides insights into water availability, use patterns, and impacts on water-

[155] Climate Adapt (2023). Water sensitive urban and building design. https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-sensitive-urban-and-building-design

[156] Feng, B., et al. (2021). A quantitative review of water footprint accounting and simulation for crop production based on publications during 2002–2018. Ecological Indicators (Vol. 120, p. 106962), https://doi.org/10.1016/j.ecolind.2020.106962

[157] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[158] European Patent Office (2024). Innovation in water-related technologies., https://link.epo.org/web/publications/studies/en-innovation-in-water-related-technologies.pdf

related sectors. By leveraging this data, timely decisions can be made to address water scarcity effectively. Predictive models that use data and AI can assist in developing optimal water management strategies tailored to potential scenarios and anticipated conditions[159][160]. For example, when a drought is predicted months in advance[161,162], it becomes possible to implement effective drought management measures. AI, using real-time data from sensors, can also enhance the efficiency of water allocation, reducing waste. The creation of a digital twin— a digital replica of the actual regional water system— can be invaluable for exploring solutions to hypothetical conditions or optimizing the overall water system. Additionally, sensors can predict maintenance needs and detect leaks, which helps prevent water waste. Smart metering and advanced irrigation systems can contribute to reduced water consumption and improved efficiency. In summary, digitalization and AI provide valuable real-time insights into water resources, demand, and systems, enabling better water management in challenging conditions.

Digitalisation has adverse effects on water use. It not only contributes to increased overall water consumption but also requires substantial resources. Data centres, which are essential for digitalization, consume a significant amount of electricity and, consequently, a lot of water is used to produce this electricity. Additionally, data centres need water for cooling their servers. The rising adoption of cloud services and artificial intelligence (AI) has further heightened the demand for computing power and, thus, for more data centres. As both cloud services and AI are expected to grow in the future, we can anticipate an increase in water use and consumption as well. Despite the importance of water consumption by data centres, this issue has received far less attention than their energy consumption and $CO2$ emissions. However, the water use of these facilities is significant, particularly on a local or regional scale.[163]

The direct water use and consumption of data centres is primarily due to evaporation in their cooling systems. In 2023, Google's hyperscale data centres, which range from 10 to 100 MW and are used for cloud services and AI by major tech companies, each consumed an average of 760 million m^3 of water annually. This amount is equivalent to the yearly water usage of a city with approximately 20,000 residents. Nearly 80% of the water used in Google's data centres is consumed, with a significant portion—80%—being potable water[164] The water usage of data centres has risen substantially in recent years. For instance, between 2021 and 2022, the water consumption of Google's data centres increased by 20%.[165] This rise is largely attributed to the growing demand for AI technologies.

AI will significantly increase water consumption in the ICT sector. The training and operation of generative AI models, such as GPT-3, require substantial server capacity. The initial training of GPT-3 in U.S. data centres resulted in the consumption of approximately 700 cubic meters of freshwater in total due to on-site evaporation.[165] Additionally, each inference made by AI is linked to water usage in data centres. In European data centres, approximately 500 mL of water (equivalent to a small bottle) is consumed for every 17 to 70 inferences of GPT-3.[165] This figure on water consumption

[159] Kamyab, H. et al. (2023). The latest innovative avenues for the utilization of artificial Intelligence and big data analytics in water resource management. Results in Engineering (20), https://doi.org/10.1016/j.rineng.2023.101566

[160] McIntosh, R. (2024). Water AI: 8 Ways AI in Water Management Creates a Better Future. Insights. Sand Technologies, https://www.sandtech.com/insight/water-ai-8-ways-ai-in-water-management-creates-a-better-future/

[161] Sutanto, S.J., van der Weert, M., Wanders, N., Blauhut, V. and Van Lanen, H.A.J. (2019). Moving from drought hazard to impact forecasts. Nature Communications. https://doi.org/10.1038/s41467-019-12840-z

[162] Hauswirth, S.M., Bierkens, M.F.P., Beijk, V. and Wanders, N. (2021). The potential of data driven approaches for quantifying hydrological extremes. Advances in Water Resources, https://doi.org/10.1016/j.advwatres.2021.104017

[163] Mytton, D (2021). Data centre water consumption. Clean Water (4, 11), https://doi.org/10.1038/s41545-021-00101-w

[164] Google (2024). 2024 Environmental Report. Google, https://www.gstatic.com/gumdrop/sustainability/google-2024-environmental-report.pdf

[165] Li, P. et al. (2023). Making AI Less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models. Preprint on ArXiv, https://arxiv.org/pdf/2304.03271

includes both operational water used for cooling servers (scope 1) as well as water associated with electricity generation (scope 2). With the expected growth rate of AI, it is estimated that the global water withdrawal for AI may reach 4.2-6.6 billion m^3 in 2027.[165] For reference, this amount is more than 4-6 times the annual water withdrawal of Denmark.

Energy transition: using different energy technologies

The energy transition is set to influence water use and consumption within Europe's energy sector. Transitioning to renewable energy sources can lead to a reduction in water consumption and lessen the strain on regional water systems. However, the impact will largely depend on the specific energy technologies and sources employed. Traditional thermoelectric power generation uses significantly more water throughout its lifecycle compared to wind and solar power—approximately 10 to 75 times more. In contrast, it uses notably less water than biomass and hydropower, estimated to be about 2 to 25 times less. The operational water use of thermoelectric power generation is also influenced by the cooling mechanisms implemented. For instance, using dry (i.e., air) cooling systems can considerably decrease operational water consumption. Furthermore, the incorporation of Carbon Capture and Storage (CCS) technologies alongside thermoelectric power generation that relies on fossil fuels can increase water consumption by 29 to 77%.[166]

The energy transition in most EU countries is likely to result in the replacement of fossil fuel thermoelectric power plants with energy technologies that consume less water. As a result, water consumption for energy generation is expected to decrease. By 2050, a reduction in water consumption for energy generation is predicted across Europe, except in countries that currently use and are expected to increase their hydropower capacity in the future, such as Sweden, Austria, and Hungary).[167]

Technological solutions to address water scarcity

By 2030, technologies designed to combat water scarcity will likely focus on improving water use efficiency, minimising water waste, and enhancing freshwater availability. Additionally, new crop varieties may be developed to be more resilient to climate change and to require less water for growth. Some of these technologies are already available today but are expected to see increased adoption and further development in the coming years.

Such technological solutions include:

- **Smart irrigation systems**: by using weather data and sensors to measure soil moisture optimal irrigation schedules are created to deliver no more water than needed to the irrigated crops. In combination with drip irrigation, in which water is directly provided slowly to the roots of plants, this results in a further reduction of water use in agriculture.[168, 169]

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[166] Yin, Y., P. Behrens, A. Tukker and L. Scherer (2019). Water use of electricity technologies: a global meta-analysis. Renewable and Sustainable Energy Reviews (115), https://doi.org/10.1016/j.rser.2019.109391

[167] Lohrmann, A., M. Child, and C Breyer (2021). Assessment of the water footprint for the European power sector during the transition towards a 100% renewable energy system. Energy (233), https://doi.org/10.1016/j.energy.2021.121098

[168] Hassan, F. (2023). Innovative Water Technologies Solutions To Global Water Crisis. H2O Global News, 5 September 2023, https://h2oglobalnews.com/innovative-water-technologies-solutions-to-the-global-water-crisis/

[169] Lakhiar, I.A., et al. (2024). A Review of Precision Irrigation Water-Saving Technology under Changing Climate for Enhancing Water Use Efficiency, Crop Yield, and Environmental Footprints. Agriculture (14(7)), https://doi.org/10.3390/agriculture14071141

- **Water efficient devices**: new devices, such as washing machines, dishwashers, shower heads, toilets, are often more energy and water efficient, using less electricity and water than before.[170]
- **Desalination**: different technologies can be used to obtain freshwater from salt or brackish water, these processes are called desalination. Desalination is already used today in the EU, mostly in Southern Europe: of all 2178 desalination plants [171]in the EU, 41% is in Spain, 19% in Greece, 18% in Italy, 4% in Germany and 3% in France. The desalination capacity in Europe has grown significantly in the last two decades. Worldwide, the desalination capacity is increasing and is expected to enter an expansion phase in Europe, which will likely result in more desalination plants in the EU in 2030 as well. However, there are some concerns about the adverse environmental impacts of on marine ecosystems and energy consumption associated with desalination.[172]
- **Crop adaptation**: The development of crops more resistant to water scarcity has made significant improvements through research and innovation programmes like the EU-funded IDRICA project where researchers have succeeded in modifying crops like sorghum to be more resistant to drought without affecting their growth.[173] Additionally, entrepreneurs and researchers in coastal areas are currently exploring the cultivation of salt-tolerant crops. This would decrease demand for freshwater and provide a solution for production in a saline environment.[174]
- **Smart metering of water use**: smart water meters collect real-time water use data and share that with users and water companies, making use of sensors/IoT and (big) data technologies. The data help consumers to get better insights in their water use and contribute to reduced consumption – the introduction of smart water meters in Singapore led to a 5% reduction of consumption. The data also help water companies and consumers to detect leaks early and thus saving water[175].
- **Water leakage detection systems and predictive maintenance**: wireless sensors can be used to monitor the water flow in pipes of water supply networks. Changes in the water flow can signal leaks, which helps in addressing leaks timely and locating leaks more quickly. Based on data collected on the water system and using (AI) models, the need for maintenance can be predicted, resulting in avoiding leakages and thus saving water.[176] The problem of water loss due poor water infrastructure maintenance and in particular leakages was thoroughly discussed during the Three Horizons workshops. During these discussions, experts emphasized the need for technological solutions such as detection systems and AI to address leakages and maintenance issues.[177]
- **Grey water reuse**: Grey water refers to wastewater from sources such as showers, baths, hand basins, and washing machines, excluding water from toilets and kitchens. Recycling

[170] US Department of Energy (2021). Consumer Guide to Home Water Efficiency, https://www.energy.gov/sites/default/files/2021-08/ES-Home%20Water%20Efficiency_080421.pdf

[171] The capacity of reservoirs is also an important factor to consider next to their number.

[172] EU Blue Economy Observatory (n.d.). Desalination. European Commission, https://blue-economy-observatory.ec.europa.eu/eu-blue-economy-sectors/desalination_en#10

[173] IDRICA (2019). Growing importance of making plants drought-resistant. https://projects.research-and-innovation.ec.europa.eu/en/projects/success-stories/all/growing-importance-making-plants-drought-resistant

[174] STOWA (2024). Salt-tolerant crops. https://www.stowa.nl/deltafacts/zoetwatervoorziening/delta-facts-english-versions/salt-tolerant-crops

[175] Global Infrastructure Hub (2020). Smart Metering for Water Efficiency, https://www.gihub.org/infrastructure-technology-use-cases/case-studies/smart-metering-for-water-efficiency/

[176] Hassan, F. (2023). Innovative Water Technologies Solutions To Global Water Crisis. H2O Global News, 5 September 2023, https://h2oglobalnews.com/innovative-water-technologies-solutions-to-the-global-water-crisis/

[177] Insights from the Three Horizons workshops in Maastricht (30-10-2024) and Faro (07-11-2024)

this water for non-potable uses like toilet flushing and irrigation can significantly reduce freshwater consumption. Several mediterranean countries, such as Malta and Cyprus have implemented initiatives to promote greywater recycling to combat water scarcity. Greywater circuits were mentioned by several experts during the Three Horizons workshops as a solution for water scarcity as well. It was pointed out however that in some EU-member states (i.e. the Netherlands) there are legal restrictions prohibiting the reuse of grey water.[177]

4.1.4. Agricultural trends

Agriculture accounts for approximately one-third of water use and half of water consumption in the EU, with much of this demand concentrated in regions already facing significant water scarcity. Studies suggest that, due to current regulations, the total area of agricultural land in Europe is expected to decline slightly by 2030. However, climate change is extending the growing season, increasing drought conditions, and consequently leading to a greater need for irrigation. Reforms under the Common Agricultural Policy (CAP) have, to date, limited the expansion of irrigation and encouraged its modernisation.[178]

By 2030, several climatological and demographic trends will shape water use and demand in agriculture. Discussions during the Three Horizons workshops highlighted the sector's crucial role in water consumption and the pressures it faces due to climate change. The agricultural sector is expected to continue dominating water consumption, particularly in Southern Europe, where climate change is intensifying droughts and worsening water scarcity. This region will be disproportionately affected due to its reliance on irrigation and existing vulnerabilities in water resources.

At the European level, there is a growing emphasis on promoting efficient water use in agriculture. The reforms of the Common Agricultural Policy (CAP) for 2023–2027 prioritize sustainable farming practices through the introduction of eco-schemes.[179] These initiatives provide farmers with direct payments for adopting practices such as crop diversification, organic farming, and soil management, all of which are anticipated to reduce water consumption. Furthermore, under the Circular Economy Action Plan, the EU also aims to improve water management by advocating for policies that promote efficient water use in agriculture, especially in regions facing water scarcity.[180]

Several technological advancements are promising solutions for agricultural water challenges. Smart irrigation systems are designed to optimize water delivery based on real-time data, significantly reducing water use. Research into drought-resistant crops offers potential for long-term sustainability by decreasing the water requirements of agricultural production. Additionally, smart metering and water leakage detection systems enhance efficiency and reduce water loss, while greywater reuse for irrigation could lessen the strain on freshwater resources. However, the adoption of these technologies has been slow. Experts attribute this lag to several factors, including the high costs associated with these technologies, which can be prohibitive for small or less financially resilient farms. Implementing new technologies often requires changes in farming methods, necessitating retraining or adjustment periods, which further delays widespread adoption. Regional disparities, particularly in Southern Europe where water scarcity is most severe, also

[178] Rouillard, J., (2020). Tracing the impact of agricultural policies on irrigation water demand and groundwater extraction in France. https://link.springer.com/chapter/10.1007/978-3-030-32766-8_24

[179] European Commission. (2024) Eco-schemes explained. https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/eco-schemes_en#eco-schemes-explained

[180] European Commission, (2020). A new Circular Economy Action Plan. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

present unique challenges. Issues such as fragmented land ownership and differing levels of technical infrastructure complicate the uniform application of policies.

The agricultural sector's role in water consumption is likely to grow as climate change exacerbates regional water scarcity. While policy frameworks like the CAP and technological innovations seek to improve water efficiency, significant barriers remain. Addressing these challenges requires coordinated action, targeted funding, and stronger integration of water management strategies into agricultural practices to ensure sustainability and resilience by 2030.

4.1.5. Political, ethical and legal trends

Changing political climate: more resistance to green policies

In recent years, several European countries have experienced a rise in electoral support for right-wing and populist parties, which tend to be more critical of actions aimed at addressing climate change.[181] This growing resistance to green policies across Europe can largely be attributed to the costs associated with climate action for different groups in society and a widespread perception of excessive regulation stemming from climate goals.[182, 183]

Europe's changing political climate may have significant implications for climate change actions and environmental policies across the continent. Water availability and various water-related challenges are closely linked to climate change. Increased resistance to climate policies may, therefore, exacerbate water challenges in Europe.

This shifting political landscape could divert focus and resources away from addressing water scarcity issues. This situation is particularly concerning, as experts are calling for increased funding and resources to tackle challenges related to water scarcity and droughts, which require transboundary cooperation and intersectoral collaboration.[184]

However, resistance to green policies may change as the effects of climate change become more evident and people begin to experience water scarcity firsthand. In many countries, public discussions around climate change are often less focused on water scarcity and more centred on other impacts of climate change, such as heatwaves, flooding, and sea level rise. Additionally, unpopular measures to combat climate change, such as investments aimed at reducing greenhouse gas emissions in sectors like agriculture, may place further pressure on farmers who are already dealing with water scarcity issues.

In recent years, geopolitics has become increasingly fragmented, leading to greater competition and friction among nations. National interests have taken precedence, resulting in diminished international cooperation and rising[185] The Brexit example highlights this trend, demonstrating that such developments can reduce collaboration even within the EU. The intensifying competition and friction on the global stage have prompted Europe to rely more on itself, sparking discussions and policies aimed at achieving strategic autonomy within the EU.

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[181] Coi. G. (2024). Mapped: Europe's rapidly rising right. Politico, 24 May 2024, https://www.politico.eu/article/mapped-europe-far-right-government-power-politics-eu-italy-finalnd-hungary-parties-elections-polling/

[182] Dirkx, M. and J. Wettengel (2024). Right-wing populists challenge Europe's climate efforts. Clean Energy Wire, 7 June 2024, https://www.cleanenergywire.org/news/right-wing-populists-challenge-europes-climate-efforts

[183] Reuters (2023). Resistance to green policies around Europe. Reuters, 10 August 2023, https://www.reuters.com/sustainability/resistance-green-policies-around-europe-2023-08-10/

[184] Insights from the Three Horizons workshop in Maastricht (30-10-2024).

[185] ESPAS (2024). Choosing Europe's future. Barry, G. (editor). Luxembourg: Publications Office of the European Union, https://data.europa.eu/doi/10.2760/180422.

As water sources often cross-national boundaries, cooperation is essential to ensure water availability across the continent. Conflicts over water resources are prevalent worldwide, and tensions related to water scarcity exist even in Europe .[186] Global friction in combination with climate change may further aggravate such tensions. During the Three Horizons workshops, several experts emphasised the need for more structured transborder cooperation, particularly in regions where different areas depend on the same water sources.

Additionally, conflicts pose significant risks to water availability. The safety of the European continent is threatened by aggressive actions, such as Russia's invasion of Ukraine. This war has revealed the vulnerabilities of water systems within the EU. Ukraine, which heavily relies on surface water for its supply, has faced severe challenges due to the destruction of water infrastructure, including the breach of the Kakhovka dam. This destruction has negatively impacted access to drinking water for many Ukrainian citizens and hindered agricultural irrigation.[187, 188, 189]

Nature-based solutions for water challenges in spatial planning

In recent years, governments have increasingly focused on addressing societal challenges by implementing nature-based solutions (NBS) in spatial planning. Although research and adoption of these solutions are still somewhat limited due to the difficulties in their implementation and operationalisation, experts extensively discussed this trend during the Three Horizons workshops as an innovative approach to tackling water-related issues.

Already, many interesting examples exist of current NBS implementations in spatial planning. In Germany, under the "Emscher Restoration Project",[190] NBS are implemented to restore the Emscher river and its floodplains, while in the Danube Delta, wetlands are being restored with the aim to enhance flood regulation, water purification and biodiversity.

Additionally, an example of NBS in spatial planning, is the concept of Sustainable Urban Drainage Systems (SUDS). SUDS is a solution for urban water drainage that creates a more natural urban water cycle by retaining, filtering, and slowly draining water.[191] SUDS consist of an underground network of pipelines and above-ground green spaces that can naturally drain and retain a part of the water for soil health and use. SUDS improve the water cycle, increase environmental health and biodiversity, address risks associated with extreme rainfall and improve water retention and infiltration. Additionally, they increase human well-being by adding green spaces to cities that add comfort and decrease city heat.[192]

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[186] Weise, Z. (2024). Brussels warns of water conflict danger in the EU. Politico, 6 March 2024, https://www.politico.eu/article/water-fights-will-come-if-europe-doesnt-act-climate-brussels-warn/

[187] EU4 Environment (2024). The toll of two years of war on water: Damage and needs assessment in Ukraine's water sector, https://www.eu4waterdata.eu/en/blog-news/34-ukraine/334-the-toll-of-two-years-of-war-on-water-damage-and-needs-assessment-in-ukraine-s-water-sector.html

[188] WAREG (2023). Protection of water resources of Ukraine: from crisis to recovery, https://www.wareg.org/articles/protection-of-water-resources-of-ukraine-from-crisis-to-recovery/

[189] Niinistö, (2024), former President of the Republic of Finland/Special Adviser to the President of the European Commission "Safer Together Strengthening Europe's Civilian and Military Preparedness and Readiness: https://commission.europa.eu/document/5bb2881f-9e29-42f2-8b77-8739b19d047c_en

[190] European Commission (2024). The Emscher Restoration: A Contribution to Climate Adaptation: A New River Basin for a Blue-Green Future: https://climate-adapt.eea.europa.eu/en/mission/external-content/pdfs/mission-story-emscher-restoration_final-1.pdf/@@download/file

[191] Davis, M., & Naumann, S. (2017). Making the Case for Sustainable Urban Drainage Systems as a Nature-Based Solution to Urban Flooding. http://dx.doi.org/10.1007/978-3-319-56091-5_8

[192] Brears, R. C. (2018). Blue and Green Cities: The Role of Blue-Green Infrastructure in Managing Urban Water Resources. Palgrave Macmillan. https://doi.org/10.1057/978-1-137-59258-3

In the city of Amsterdam, these NBS are incorporated in the city sewage plans since 2016[193] and implemented in different forms, of which WADIs[194] is one. By utilizing natural processes like water absorption, filtration, and storage, cities and regions are enhancing their resilience to floods, water scarcity, and climate change. At the same time, these solutions improve residents' quality of life and support biodiversity.

4.2. Implications for water scarcity in the short term

4.2.1. Evolving demand and supply for water

The identified trends for the short term can affect both the demand for water (i.e. the use and/or consumption of water) as well as the supply of water (i.e. the availability of water) in different directions. Table 2 shows whether trends will have an increasing or decreasing effect on the demand or supply of water. Trends that contribute to increasing demand for water or decreasing supply of water have the potential in aggravate water scarcity in the short-term future.

Table 2: increasing and decreasing trends in water supply and demand

	Demand for water (use & consumption)	Supply of water (availability)
Increasing trend	➢ Increasing EU population due to migration ➢ Slowly increasing economic growth (depending on decoupling) ➢ Increased urbanization and human mobility (local effects) ➢ Digitalisation and the use of AI (cooling of data centres)	➢ Climate change: regionally and seasonally more short and heavy precipitation events leading to flooding or drought event (depending on the EU region) ➢ Technology: desalination
Decreasing trend	➢ Pricing of water (depending on increase of costs to abstract water) ➢ Increased circularity ➢ Digitalisation and AI for water management and water users ➢ Energy transition from thermoelectric to renewable energy (excl. hydropower) ➢ Technology: smart irrigation systems, water efficient devices, smart metering, predictive maintenance and leakage detection, crops demanding less water, introduction of salt-tolerant crops, run –off mitigation through dam construction ➢ Nature-based solutions, green engineering	➢ Climate change: regionally and seasonally less precipitation, higher evaporation rates and intrusion of saltwater into freshwater aquifers ➢ Energy transition towards more hydropower (evaporation from water reservoirs i.e. dams) ➢ Resistance to green policies (reducing action towards climate mitigation and water quality) ➢ Global friction (competition for water sources and conflicts)

Source: Technopolis Group, 2024

Water demand and supply in the EU is facing a critical moment due to demographic, economic, and environmental changes. With the growing threat of climate change, increased urbanization, shifts in consumption patterns, and industrialization, the balance between water supply and demand is under significant pressure. The overall impact of these trends is difficult to predict, particularly concerning demand.

[193] https://www.waternet.nl/siteassets/ons-water/omgevingsprogramma-riolering-2022-2027.pdf https://repository.officiele-overheidspublicaties.nl/externebijlagen/exb-2016-8325/1/bijlage/exb-2016-8325.pdf

[194] This originally Arabic word, is used in Dutch as an acronym for 'runoff by drainage and infiltration' https://weerproof.nl/maatregelen/wadis/

Stakeholders consulted for this study, however, indicate that the changing climate will likely result in a seasonal decrease in water availability on the supply side and that water scarcity poses a serious risk in the short-term future.

4.2.2. Expected issues in water scarcity in Europe

Climate change is an important factor contributing to water scarcity in Europe, even in the short term. It is evident from observations of rising global average air and ocean temperatures, widespread melting of snow and ice, and an increase in global average sea levels.[195]

In many regions, climate change poses an additional threat to existing human-induced factors, particularly in the dry Mediterranean climate zone. In this area, river flows are expected to decrease throughout the year in the 2030s, which will worsen the effects of high water abstraction for irrigation. Similarly, in the continental climate zone, significant withdrawals of water for electricity production and irrigation are likely to further reduce river flows from spring to autumn. Overall, summer precipitation is anticipated to decline significantly across large parts of Europe, especially in Southern and Eastern Europe.[195]

Climate projections indicate a north-south pattern in water availability across Europe. Southern European countries, which already experience significant water scarcity, are expected to see further decreases in water availability. This will exacerbate existing vulnerabilities, particularly affecting marginalized communities in countries such as Spain, Portugal, Greece, and Italy. Relying solely on mitigation efforts is insufficient to prevent these adverse impacts of climate change. It is essential to implement adaptation and innovation strategies as effective solutions.[195]

Input from Three Horizon workshops showed, however, that mainstreaming sectoral and regional policies will be a significant challenge. While there are several overarching directives and regulations such as the Water Framework Directive and the EU Green deal that addresses water scarcity and droughts, the experts from the workshops concluded that there are no hard transboundary policies in place (e.g. priority sequence for water use in times of water scarcity) to regulate competition between member states and to improve cooperation. Furthermore, according to the experts, the policies that do exist are fragmented and placed under different frameworks and are reactive (i.e. reacting to new developments and situations regarding water scarcity) rather than pro-active.

[195] Schneider, C., C. L. R Laizé, M. C. Acreman, and M. Flörke (2013). How will climate change modify river flow regimes in Europe? Hydrology and Earth System Sciences (Vol. 17, Issue 1, pp. 325–339), https://doi.org/10.5194/hess-17-325-2013

5. In the medium- to long-term: future of water availability and use in the EU in 2050

5.1. Medium- to long-term trends that affect water availability and use

Central to this section is the exploration of so-called "mega-trends," which refer to widespread, long-term changes in social, economic, environmental, political, or technological realms.

Mega-trends are notable for their longevity, stability and impact over time. Unlike short-term trends, which are often more specific, domain-focused, and easier to influence or predict, mega-trends are broad and span multiple domains, industries, and societal issues.[196] They frame the contextual environment within which organizations or issues operate, as opposed to the transactional environment shaped by short-term trends. Importantly, mega-trends cannot be influenced by single organizations, regardless of their size or power, as they are deeply ingrained in global systems. However, predicting their specific consequences remains challenging, as many intervening factors can arise between now and 2050, adding a layer of uncertainty despite their overarching nature.

For the purposes of this study, we focus on key climatological, economic, demographic, societal, and environmental mega-trends expected to shape Europe by 2050. These include resource scarcity, changing security paradigms, demographic transformations, growing consumption patterns, and widening inequalities. Each of these trends carries significant implications for water availability and use, influencing how Europe will manage its water resources. A crucial question for this project is how these mega-trends will impact water scarcity and what role water scarcity will play in uncertain futures shaped by these transformative forces.

5.1.1. Environmental and climatological trends

Climate change scenarios and water scarcity in Europe

The IPCC uses emission scenarios to model the climatological effects of varying levels of greenhouse gas emissions over time. The scenarios are modelled to represent a certain range of global mean temperature increases, assuming a certain level of climate mitigation policy outcomes. These scenario's range from limiting global warming to below 2°C (scenario RCP2.6) to exceeding 4°C (scenario RCP8.5) by 2100 compared to pre-industrial levels by the JRC. These scenarios are widely used by climate scientists and have also been used by the JRC.[197]

The JRC has applied various climate change models to predict water related effects of climate change under a moderate emission mitigation policy scenario (RCP4.5) and a high-end emission (i.e. no mitigation/worst-case) scenario (RCP8.5). The results of these models were then presented for a time window centred around the year that global mean temperature exceeds 1.5°C, 2°C and 3°C, as shown in Figure 14. Further analysis focused on projections for 2050. Depending on the pace of climate change, any of these global mean temperature increases may represent the situation of 2050, although in 2020, the JRC did not consider 3°C global warming realistic for 2050.

[196] Be aware that short and mid-long-term timeframes are relative. For certain organizations the year 2030 might be long term whereas for other types of organizations it might be short term.

[197] Bisselink, B. et al. (2020). Climate change and Europe's water resources. JRC, doi:10.2760/15553, JRC118586.

Projected impacts of rising temperatures on water scarcity

The JRC's climate change models indicate that even a modest rise of the global mean temperature to 1.5°C will increase the number of days per year with water scarcity (as indicated with the WEI+ index), particularly Southern Europe. Similarly, the median streamflow is projected to decrease in various parts of Southern Europe, while in large parts of Northern, Western and Central and Eastern Europe the median streamflow will increase. In the latter regions, some parts will face more days of water scarcity as well, while in other parts a small decrease is projected.

More severe climate change (i.e. higher increases in global mean temperature to 2°C or 3°C) will further increase water scarcity in already affected regions. In a scenario where global temperatures rise by 3°C in 2100, the number of people in the EU living in areas experiencing water stress for at least one month each year could increase from 52 million currently to 65 million[198] Not only Southern Europe, but also Western Europe will see more days of water scarcity, even though median streamflow will not decrease in this region of Europe.

Increased drought severity

As a result of climate change, droughts are projected to become considerably more severe over the 21st century. By 2080, climate change could have lowered minimum flows by up to 40% in the Iberian Peninsula, southern France, Italy and the Balkan region.[199] Water use will aggravate streamflow drought conditions by 10–30 % in southern, western and central Europe.

In Southern Europe, as well as parts of Western, Central, and Eastern Europe, annual and summer precipitation have decreased, while temperature, and evapotranspiration have increased. These changes have already contributed to more frequent and intense droughts. Climate change is expected to aggravate these trends further, especially if the global mean temperature rises to 3°C above pre-industrial levels.

Water availability in Europe

Climate change is projected to significantly change the annual and seasonal water availability across Europe in the second half of the century. It will alter the water flow in rivers and interact with previous human made changes to river flows, such as canalisation and dams. Current projections indicate that summer flows are decreasing and projected to decrease further in most of Europe, including regions where annual flows will increase.[200] In summer, the strongest warming is projected to occur in the Iberian Peninsula and other parts of Southern Europe. In winter, warming will affect the most North-Eastern parts of Europe and Scandinavia.[201, 202]

Climate change is expected to aggravate the existing pressures on freshwater resources in Europe, the most so in Southern Europe, which already faces severe water stress, but also in parts of Western

[198] European Commission (2020). Climate change impacts and adaptation in Europe. JRC Science Policy Report. Luxembourg: Publications Office of the European Union, doi:10.2760/171121, JRC119178.

[199] Forzieri, G., et al. (2014). Ensemble projections of future streamflow droughts in Europe. Hydrology and Earth System Sciences (Vol. 18, Issue 1, pp. 85–108), https://doi.org/10.5194/hess-18-85-2014

[200] Stahl et al. (2012). Filling the white space on maps of European runoff trends: estimates from a multi-model ensemble, Hydrol. Earth Syst. Sci., 16: 2035-2047, doi:10.5194/hess-16-2035-2012.

[201] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment, https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

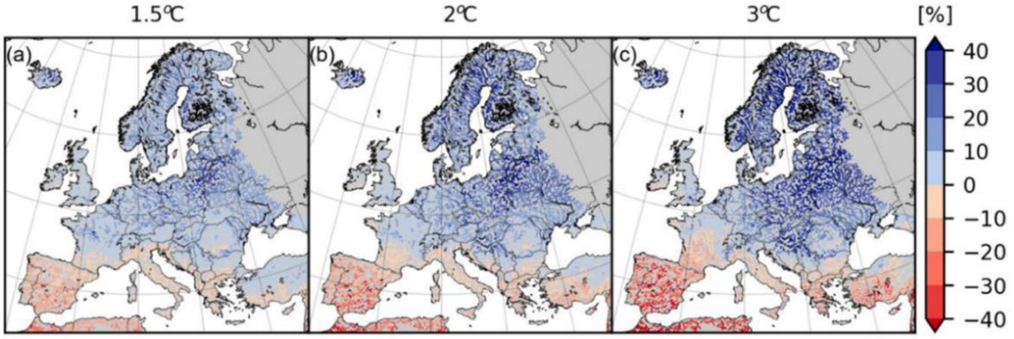
[202] European Commission (2000). Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document No. 24 - River Basin Management in a Changing Climate.

and Central Europe.[203] Groundwater depletion is already evident in various aquifers across Europe, especially in the Mediterranean and the Black Sea. Climate change contributes partly to the depletion due to slower groundwater recharge, but it is over-abstraction remains the primary driver. Over-abstraction and reduced groundwater recharge is driven further by climate change (e.g., increased irrigation needs due to higher evapotranspiration). These trends are expected to increase the stress on aquifers in the above areas.[204]

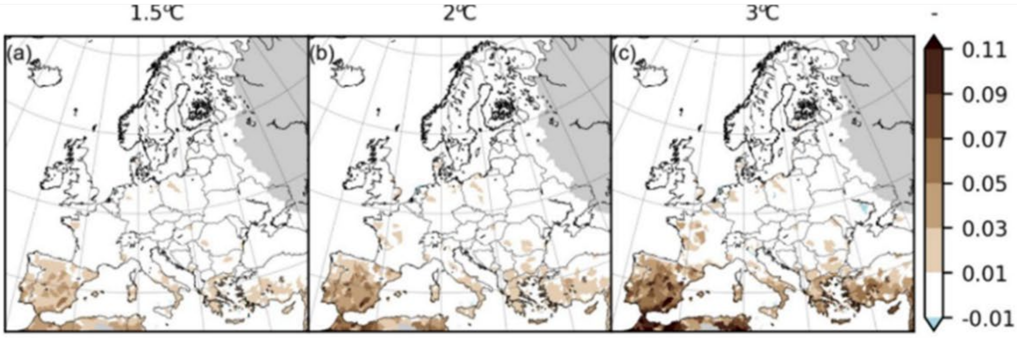
[203] EEA (2021). Water resources across Europe. Confronting water stress: an updated assessment., https://www.eea.europa.eu/publications/water-resources-across-europe-confronting

[204] Psomas, A., et al. (2021). Comparative study on quantitative and chemical status of groundwater bodies. Study of the impacts of pressures on groundwater in Europe, EEA, https://forum.eionet.europa.eu/nrc-eionet-freshwater/library/2021-impacts-pressures-groundwater-europe/eea-comparative-study-quantitative-and-chemical-status-groundwater-bodies

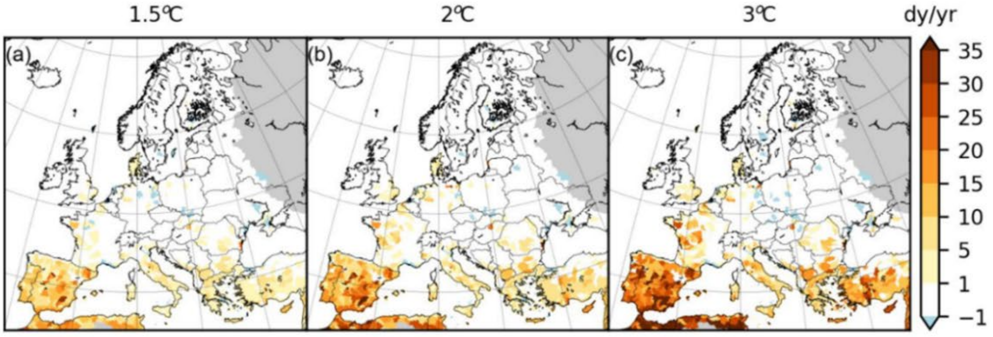
Figure 14: Projections from climate change models for relevant water indicators under different levels of climate change as modelled by the JRC



A. Projected change in median streamflow compared to 1981-2010 for different levels of climate change



B. Projected change in average WEI+ compared to 1981-2010 for different levels of climate change

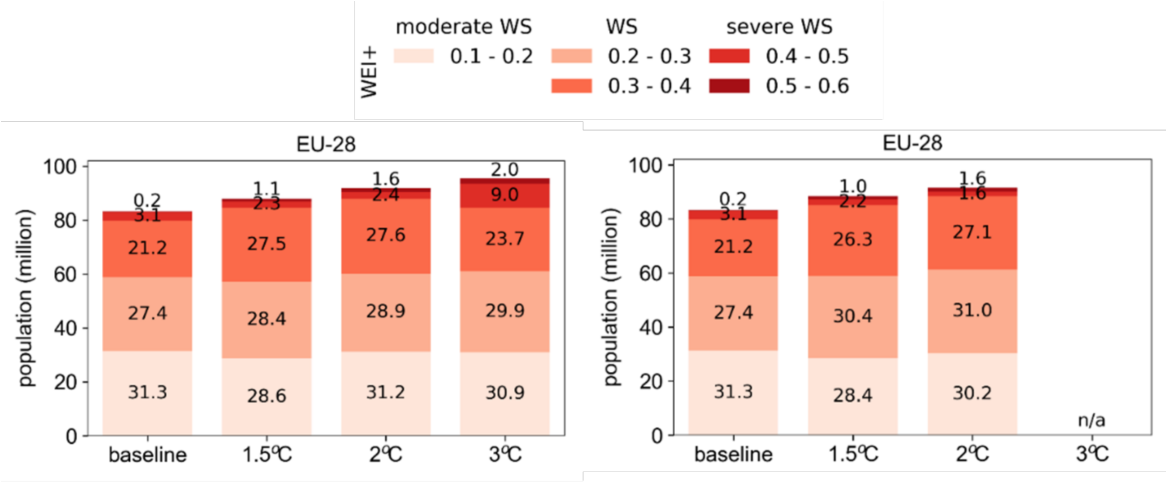


C. Projected change in water scarcity days (WEI+ > 0.2) in a year compared to 1981-2010 for different levels of climate change

Source: Bisselink, B. et al. (2020). Climate change and Europe's water resources. JRC, doi:10.2760/15553, JRC118586.

These projections show that climate change is a strong driver for water scarcity in the future. Considering only the effect of climate change, the number of people living in the EU under water scarcity conditions, will increase significantly. Figure 15 shows that the further the global mean temperature increases, the more people will live under severe water scarcity conditions. When social-economic developments are also included in these models, however, the number of people living under severe water scarcity will reduce, due to the assumption that these regions will become uninhabitable and populations will decline.

Figure 15: Projections for people living with water scarcity in the EU28 modelled by the JRC



A. Projected number of people living in different levels of water scarcity due to climate change alone under different levels of climate change

B. Projected number of people living in different levels of water scarcity due to climate change alone and socio-economic developments (population, land use and water demand changes) under different levels of climate change

Source: Bisselink, B. et al. (2020). Climate change and Europe's water resources. JRC, doi:10.2760/15553, JRC118586.

Aggravating resource scarcity

Further depletion of resources such as water, arable land, and minerals is expected by 2050 due to population growth, industrial activity, and environmental degradation.[205] This trend is exacerbated by climate change, which is expected to reduce the availability of critical resources, including freshwater, in several regions, particularly Southern Europe. This scarcity will also extend to energy resources, crop yields, and raw materials, making resources increasingly scarce and expensive.

Aggravating resource scarcity will have large implications for water availability in Europe. As climate change intensifies, regions already facing water stress will experience more competition for declining resources. Agriculture, energy production, and industry sectors could face stricter allocation limits. Additionally, current reliance on non-renewable water sources, such as fossil groundwater, could further exacerbate long-term scarcity and environmental degradation.

5.1.2. Societal, demographic and economic trends

Changing security paradigm

The European security paradigm is shifting from traditional military concerns to include emerging threats, including resource conflicts, cyber threats, and climate change-induced instability.[206] For Europe specifically, this includes addressing issues like transboundary water disputes, disruptions to critical infrastructure, and migration driven by resource scarcity and environmental degradation. The nexus of security and sustainability will become central to policy discussions, with water security emerging as a critical element of national and regional stability.

Water scarcity could increasingly become a security issue in Europe, with water infrastructure being a valuable target and water availability potentially even leading to disputes between regions and nations sharing transboundary water resources. For example, river basins such as the Danube or

[205] JRC 2021, Aggravating resource scarcity. https://knowledge4policy.ec.europa.eu/aggravating-resource-scarcity_en

[206] JRC 2023, Changing security paradigm https://knowledge4policy.ec.europa.eu/changing-security-paradigm_en

Rhine could become flashpoints if cooperative agreements fail under the pressure of reduced water availability.

Urbanisation, migration, demographic imbalances, and inequalities

By 2050, Europe will experience several demographic and societal shifts driven by urbanisation, migration, and growing inequality between regions and populations.[207][208][209] Urbanisation will continue to intensify, with almost 84% of Europeans expected to live in cities. [210] This trend reflects broader (global) patterns of rural-to-urban migration as people seek better economic opportunities and access to services. At the same time, migration from within and outside Europe—caused by economic inequality, political instability, and climate change—will affect the European demography. These forces will place pressure on urban areas to expand infrastructure, services, and resources, particularly water systems, to sustain their growing populations.

The concentration of people and economic activities in urban areas will increase existing pressures on water supplies. Cities need large and reliable water supplies to meet the needs of residents and industries. At the same time, as described in the previous chapter and due to increased efficiency, population size and water use are not directly coupled, indicated by a decreasing trend in the water consumption per inhabitant. Urban expansion nonetheless requires a large and reliable water supply in highly concentrated areas. This further strains resources, poses possible security concerns and complicates resource management, particularly in already water-scarce areas.

Demographic imbalances further complicate this. Many parts of Southern and Eastern Europe are expected to lose working-age populations due to migration.[211] The divide between well-resourced and under-resourced areas is expected to grow between regions, which could fuel social tensions and affecting access to water and other essential services.

The intersection of urbanisation, migration, and regional inequality presents a complex challenge for water resource management. As wealthier regions adapt to changing demographics through innovation and investment, poorer regions will become more vulnerable to water scarcity. These disparities could increase social tensions, undermine public health and security, and have a negative effect on local economies.

Growing consumption patterns

Consumption patterns are expected to keep growing towards resource-intensive goods and services, particularly in regions where living standards improve.[212] The demand for water-intensive products, such as meat, textiles, and consumer goods, continues to grow and places additional strain on resource systems, even as technological advancements and sometimes cultural movements aim to reduce per capita consumption.

Growing consumption impacts water scarcity by increasing the demand for water across sectors. Agriculture and industry, already major water consumers, will face intensified pressures to produce more with limited resources. A transition to circular water use systems, where water is reused and

[207] JRC 2023, Continuing urbanisation. https://knowledge4policy.ec.europa.eu/continuing-urbanisation_en

[208] JRC 2023, Increasing significance of migration. https://knowledge4policy.ec.europa.eu/increasing-significance-migration_en

[209] JRC 2023, Widinging inequalities. https://knowledge4policy.ec.europa.eu/diversifying-inequalities_en

[210] JRC 2020, Urbanisation in Europe. https://knowledge4policy.ec.europa.eu/foresight/topic/continuing-urbanisation/urbanisation-europe_en

[211] JRC 2022, Increasing demographic imbalances. https://knowledge4policy.ec.europa.eu/increasing-demographic-imbalances_en

[212] JRC 2023, Growing consumption. https://knowledge4policy.ec.europa.eu/growing-consumerism_en

recycled where possible, and policies that balance economic growth with sustainable resource management will play a big role in balancing growing consumption with resource limits.

5.1.3. Technological trends

This section covers technological trends in relation to water scarcity, focusing on tools to enhance efficiency and reduce waste. It specifically covers agricultural developments such as precision agriculture, drought-resistant crops, and advanced wastewater treatment for managing surface and groundwater levels and improving resource efficiency. While technological trends may inherently increase water use due to rising energy demands and infrastructure needs, these solutions highlight the potential for mitigating those impacts effectively.

Accelerating technological change and hyperconnectivity

By 2050, Europe is expected to increase its use of digital innovation for societal challenges like climate adaptation and mitigation and resource management.[213] Hyperconnectivity—the integration of digital systems, devices, and data—is being integrated in governance, infrastructure, and research. Emerging technologies such as artificial intelligence (AI), Internet of Things (IoT), and digital twins are introduced into different sectors, helping with decision-making and increasing efficiency.

In the context of water scarcity, technological change also offers both solutions and challenges. Technologies like IoT-enabled smart water management systems and digital twins can optimise water distribution and reduce losses that currently occur due to leaks or inefficient use. For instance, real-time monitoring of water networks can help minimise waste and improve water allocation during droughts. At the same time, the increasing reliance on digital infrastructure, such as AI-powered water models, introduces vulnerabilities to cyberattacks that could disrupt water supply systems. Additionally, as the European energy demand grows, water use for cooling purposes could rise.

Technological solutions to address water scarcity

Technological solutions offer innovative solutions to address water scarcity, but often come with challenges in terms of feasibility, environmental and financial costs. Some of the solutions below are currently in (or close to) the phase of practical implementation, while others remain very theoretical. During the Three Horizons workshops, some of these solutions have been discussed by the experts.

- New genomic techniques (NGT) involve the genetic modification, such as CRISPR-Cas9 and gene editing, to alter the DNA of organisms. NGTs are already being applied in agriculture and medicine. NGT applications that offer solutions for water scarcity include the development of drought-resistant and/or water-efficient crops, salt-tolerant crops, and bioremediation, with which plants and microbes are altered to clean contaminated water sources. Challenges for NGTs are unintended consequences and strict regulations, as genetic modification could have unforeseen effects. This leads to public resistance, ethical and safety concerns and strict regulations for NGTs.
- Advancements in full water recycling systems involve treating wastewater to a level where it can be reused for drinking, agriculture, and industrial processes. These systems use advanced filtration technologies, such as reverse osmosis and ultraviolet treatment, to ensure water quality. While promising, and already widely in use in some countries, these systems face challenges including high energy requirements and the need for reliable regulatory frameworks.
- Advancements in water storage technologies for retaining water such as aquifer recharge, water injection, and infiltration methods. For instance, on farmland, water storage enables farmers to store water when it is plentiful and make it available when it is scarce. This

[213] JRC 2023, Accelerating technological change and hyperconnectivity. https://knowledge4policy.ec.europa.eu/accelerating-technological-change-hyperconnectivity_en

reduces scarcity and ensures long-term availability of water. Challenges for this technology are the impacts on local ecosystems and requirement of careful monitoring to prevent contamination.

- Fog harvesting is the collection of water droplets from fog using large mesh nets or panels on which water condenses and is then collected in storage tanks. The technique is currently used successfully in dry regions with coasts or mountains that experience consistent fog conditions. The scale and geographic reach of this solution is currently quite limited as it requires predictable weather conditions and the amount of water harvested is limited.
- Cloud seeding is a technique that is used to increase cloud formation and rainfall by dispersing silver iodide or salt into the atmosphere. This is currently used in certain country with dry regions (China, UAE, US). The impact of this technology raises environmental concerns for existing ecosystems and ethical and geopolitical concerns.
- Iceberg harvesting is a technological solution that remains largely theoretical as the costs and concerns seem to outweigh the benefits. It involves towing icebergs from polar regions to areas experiencing water scarcity for freshwater use. The costs, technology and environmental impact associated with the transportation of icebergs, however, is extensive.
- Desalination is a process that removes salt and other impurities from seawater or brackish water to produce fresh, potable water. It is a commonly used technique to overcome the freshwater scarcity. The two primary desalination methods are reverse osmosis (RO) and thermal desalination. Reverse osmosis, the most widely used technique, employs semi-permeable membranes to filter out salts and contaminants under high pressure. Thermal desalination, including multi-stage flash (MSF) distillation and multi-effect distillation (MED), relies on heating water to produce vapor, which is then condensed into freshwater. While desalination offers a promising solution to water scarcity, challenges such as high energy consumption, environmental impact, and economic feasibility can potentially limit this technology. New frontiers in research focus on using renewable energy sources such as wind, solar, and biomass for desalination. In these cases, seawater treatment plants operate similarly to traditional plants, with the main difference being that they use renewable energy instead of fossil fuels.[214]

5.1.4. Agricultural trends

The agricultural sector is expected to remain the largest consumer of freshwater in Europe, placing a large strain on available water resources.[216] Climate change will only intensify this pressure, as growing seasons will extend and droughts will increase, leading to higher demands for irrigation. Inefficiencies in agricultural water use will become increasingly unsustainable, increasing competition with other sectors.

Changes in land use

The EEA predicts that the total area of land used for crop cultivation will remain stable until 2040. The way agricultural land is used, however, will undergo significant changes.[215] Some agricultural areas may become unfit for farming due to increased droughts or reduced soil quality. At the same time, areas previously considered unsuitable due to harsh conditions, may now become viable for agriculture as the climate changes. With technological solutions such as the introduction of drought-resistant crops and advances in irrigation, as mentioned in the previous section, these areas may

[214] Curto, D., Franzitta, V., & Guercio, A. (2021). A Review of the Water Desalination Technologies. *Applied Sciences*, *11*(2), 670. https://doi.org/10.3390/app11020670

[215] EEA (2021). Water resources across Europe – confronting water stress: an updated assessment. https://www.eea.europa.eu/en/analysis/publications/water-resources-across-europe-confronting

now be considered for cultivation. Precision farming techniques are also expected to improve, with specialised crops adapted to water scarcity and harsh soil conditions.

Food demand and production

Global food demand is expected to grow significantly by 2050 due to population growth, rising incomes and changing consumption patterns. Meeting this growing food demand will require a 70% increase in global food production. The growing food demand and increased consumption of meat and dairy products, is expected to put further strain on agricultural systems and water resources, particularly for feed production. Although a countermovement with dietary shifts towards plant-based food, may mitigate some of this pressure, the global consumption trend is increasing.

At the same time, climate change will threaten global food production in the medium- to long-term, also affecting Europe. By 2050, grain maize yields in the EU could have decreased by 1% to 22%, driven by changes in daily temperature, precipitation, wind patterns, humidity, and global radiation. In Southern Europe, wheat yields may face an even sharper decline, potentially dropping by up to 49%.[216] These changes will challenge existing agricultural systems, particularly in regions already under stress from resource and water scarcity.

In Europe, the growing global food demand and the threat of climate change to food production create pressure on the agricultural sector. These challenges will likely result in more intensive farming systems, increased reliance on agricultural technology, and a shift towards more sustainable practices essential to deal with limited resources.[217] Sustainable farming methods – such as conservation agriculture, agroecology, agroforestry, and circular water systems – could improve resource efficiency, reduce the water use of agriculture, and increase the resilience of agricultural ecosystems.[218]

5.1.5. Political, ethical and legal trends

Political, ethical, and legal trends in Europe are likely to be shaped by expanding economic and power influence of East and South, increasing influence of new governing systems, and the rise of populism.

Shifting geopolitical balance

By 2050, Asia expected to account for over half of the global economic output.[219] The rapid economic growth of e.g. China, India signifies a continuation of the shift of global economic power towards the East and South. At the same time, Africa has an emerging workforce which could provide new opportunities for partnership.[220] This change will shape European economic strategies and its global position. Strategic autonomy and regional trade blocs are likely to be central to Europe's approach, especially with geopolitical tensions and supply chain disruptions.[221]

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[216] JRC (2020). Analysis of climate change impacts on EU agriculture by 2050. JRC Technical Report. JRC PESETA IV project – Task 3, https://joint-research-centre.ec.europa.eu/system/files/2020-05/pesetaiv_task_3_agriculture_final_report.pdf

[217] FAO, 2018. The future of food and agriculture Alternative pathways to 2050. https://openknowledge.fao.org/server/api/core/bitstreams/2c6bd7b4-181e-4117-a90d-32a1bda8b27c/content

[218] EC 2024, Sustainable agricultural practices and methods. https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/sustainable-agricultural-practices-and-methods_en

[219] JRC 2023, Expanding influence of East and South. https://knowledge4policy.ec.europa.eu/expanding-influence-east-south_en

[220] JRC 2022, Africa's growth potential. https://knowledge4policy.ec.europa.eu/foresight/africas-growth-potential_en

[221] JRC 2022, Increasing fragmentation of globalisation. https://knowledge4policy.ec.europa.eu/foresight/increasing-fragmentation-globalisation_en

This shift in geopolitical balance is expected to increase water scarcity challenges in Europe even more. As emerging economies demand more agricultural and industrial goods, Europe could face higher pressures on its water-intensive industries to remain competitive. Additionally, the fragmentation of globalization may put a strain on transboundary water management systems, which challenges the equitable distribution and effective collaboration on water use.

Rise of populism

The current rise of populist movements in Europe is expected to continue up to 2050 and increase political instability, as populism often prioritises short-term goals over long-term sustainability.[222] Populist governments may deprioritize environmental protections or resist transnational agreements, and increase competition for limited water resources. At the same time, as populism emphasises national strategic autonomy, European countries could move away from collective action on transboundary issues like shared water resources, which complicates cooperation necessary for effective water management. Strategic autonomy, while aimed at improving national resilience, could spark conflict over shared water systems and reduce resources allocated to European collaboration.

New governance systems

At the same time, new governing systems are expected to continue to shape Europe's decision-making processes and public engagement and opinion.[223] The rise of non-state actors, digital platforms, participatory governance mechanisms, and automated systems is expected to change public administration and could improve and streamline (water) governance. At the same time, these developments could also increase polarization and misinformation, and feed into political instability.

5.2. Four scenarios for water availability and use in 2050

In this study, we have developed four contextual scenarios that describe potential future societies in the EU in 2050. These scenarios provide the future contexts in which policies should take effect to deal with water scarcity. They help to understand what policy options could be effective in the future, or what long-term policy action should be taken already now to avoid certain risks that might emerge from future societal contexts. It is also important to clarify that the scenarios presented are not intended to predict or represent the future political landscape, including specific political regimes or parties, within individual Member States or the European Union (EU) as a whole. Instead, these scenarios are designed to illustrate broader socio-economic trends and conditions that could shape the future. Their purpose is to provide a framework for understanding the potential evolution of social and economic factors, rather than offering a forecast of political developments.

In all scenarios we consider climate change and water scarcity as a given. This is a perspective that clearly emerged from all stakeholder and expert consultations: climate change is not an uncertainty, even though its future impacts in the water sector are not completely predictable. The global response to climate change under the Paris Agreement and citizens' collective efforts, may reduce the effects of climate change. Nevertheless, the EU is predicted to face a significant change in water scarcity by 2050, leading to more days of water scarcity per year in especially Southern Europe. Water scarcity will thus be a situation with which various EU Member States and regions will have to deal in 2050. Therefore, water scarcity are assumed in each scenario but are not determining the future context in which to deal with water scarcity.

[222] ESPAS 2018. https://ec.europa.eu/assets/epsc/pages/espas/chapter2.html

[223] JRC 2022. Increasing influence of new governing systems. https://knowledge4policy.ec.europa.eu/increasing-influence-new-governing-systems_en

5.2.1. Scenario axes from two critical uncertainties for the future

The four scenarios are crafted from two critical uncertainties about the future that have emerged during the study's stakeholder interactions and are closely linked to some of the trends that we have identified and of which some can already be witnessed today. Each of these critical uncertainties provides an axis for the scenario framework as depicted in Figure 16. These critical uncertainties are:

- **Cooperation versus competition**: this critical uncertainty relates to how citizens, companies and governmental institutions generally relate to each other. Do they see each other as competitors competing for scarce (water) resources or as potential partners with whom to negotiate or cooperate leveraging complementary efforts and group dynamics? It is important to note that competition is not inherently negative. In fact, competition can stimulate 'productive conflict' leading to significant effective and efficient improvements in water use/consumption. Competition can have a strong dynamic effect. Cooperation primarily refers to the tendency to seek cooperation for organising various activities or for finding solutions, whether public and private. Cooperation uses complementary and group efforts. While cooperation is a good starting point, it is also essential to recognise that it also perpetuates the status quo. Establishing collaborations may take considerable time and might emphasise preserving existing dynamics and trends in water use and consumption.
- **Openness to change: high versus low:** this critical uncertainty revolves around how open societies are to change. Societies that embrace change generally view it as an opportunity for improvement, with stagnation seen as a form of decline. In contrast, societies which are less open to change, often seek salvation in restoring 'former times'. As a result, water users/ consumers tend to be hesitant and sceptical about change and transitions (especially in terms of their behaviour) believing that it is better to take a step back and cherish what they already have than changing anything significantly.

The two scenario axes relate to trends in the contextual environment that have been identified as relevant and unclear in terms of their direction for the future.

The relationship between cooperation and competition is influenced by several emerging trends. These include growing inequalities, which tend to strengthen competition; the rising influence of countries in the global East and South, presenting both opportunities for cooperation and competition; increasing resource scarcity, which can drive either competition or collaboration; and heightened consumption, which fuels economic competition and international trade.

Additionally, the Draghi report[224], about the future of European competitiveness, has sparked discussions about enhancing Europe's competitiveness and achieving strategic autonomy. These factors could promote internal cooperation within the EU while also intensifying external competition. Changes in the US' political landscape, particularly with elections' results and Trump's re-election, suggest a shift toward increased international competition and the potential for new trade barriers. Overall, these trends indicate that the dynamics of cooperation and competition are evolving, leading to uncertainties regarding their future trajectory in the medium- to long-term.

The other axis, openness to change, relates to trends such as increasing populism, which is often associated with resistance to change, alongside accelerating technological advancements and hyperconnectivity – changes that can be perceived both positively and negatively. There is also a growing concern about resource scarcity, which calls for some form of change. Meanwhile,

[224] The future of European competitiveness – A competitiveness strategy for Europe, September 2024: https://commission.europa.eu/document/download/97e481fd-2dc3-412d-be4c-f152a8232961_en?filename=The%20future%20of%20European%20competitiveness%20_%20A%20competitiveness%20strategy%20for%20Europe.pdf

discussions about the green transition and its pace and ambition are prevalent in the EU. Where Europe regulates change, the US appears to be moving towards deregulation. Different approaches are taken to deal with change which depend on whether change is expected to come from markets or from governments. Openness to change is influenced by the urgency of the need for change, its pace and level of trust in innovation and the belief that the future will generally be better than the past. These trends and signals indicate that societies can exhibit varying levels of openness to change, which can differ in nature. Consequently, there is significant uncertainty regarding the medium- to long-term future.

Table 3: summary of characteristics associated to the extremes of the scenario axes

Axis	Associated characteristics
Cooperation	➢ Member States have a strong willingness to cooperate in the water sector and find solutions for addressing water scarcity collectively ➢ EU institutions play a significant role in fostering collaboration, and both collaborative regulation and action at the EU level are highly valued and accepted. ➢ There are low barriers to international trade in this context. ➢ Citizens expect governments to act against water scarcity in collaboration with relevant public and private sector actors. ➢ The private sector seeks alliances and partnerships to address societal issues, such as water scarcity, and to expand their markets. ➢ There is a focus on long-term solutions to tackle water scarcity, emphasising a slower pace for change to avoid mistakes.
Competition	➢ Member States tend to prioritise their own national water issues and solutions, often overlooking the consequences that their actions may have on other regions. The role of the EU institutions is limited to establishing rules that ensure fair competition and promote essential collaboration among EU Member States and different sectors affected by water scarcity. ➢ Many countries are increasing barriers to international trade, choosing to protect their own markets and solutions. Citizens expect business to provide solutions for water scarcity, while they also look for government support to stimulate water innovation across various sectors including agriculture, energy, and households. ➢ The private sector is eager to be the first to introduce new water-saving innovations and products. Competition can drive businesses to use less water to reduce costs. ➢ There is a focus on short term results, with a fast pace to change. Failures are often accepted as a natural part of the transition process.
High openness to change	➢ Societies are increasingly open to change and are seeking new, more radical approaches to address water scarcity. ➢ Innovations and policies are focusing on more innovative methods for managing water scarcity. ➢ Citizens and businesses are also willing to change their behaviour and adapt to current and future circumstances ➢ Societies have a strong belief in better and more favourable future conditions, that can be influenced by human action, such as innovation and behavioural change.
Low openness to change	➢ Societies tend to resist change and often seek to maintain past practices regarding water scarcity or look for incremental (technical) solutions. ➢ Innovation and policies are focused on finding solutions that do not require major changes in citizens' behaviour and economic sectors. ➢ This approach aims to preserve the "status quo" in the management of water scarcity, while still requiring introducing technical solutions or workarounds to avoid doing things radically different.

Source: Technopolis Group

5.2.2. Four future scenarios

The scenario axes result in four contextual future scenarios for water availability and use in 2050. These four scenarios are named and provided in the scenario framework in Figure 16.

Figure 16: Scenario framework with two axes and four scenarios

Source: Technopolis Group, 2024

The following section elaborates on each scenario, placing it in the context of water scarcity. It takes a forward-looking perspective, examining the current and short-term situations regarding water scarcity, how these conditions may inform future interventions and how the water scarcity reality in the years 2020 and 2030 could shape potential interventions and policy decisions.

For each scenario, we make the context of water scarcity more explicit by including examples from the agricultural sector. This is important because agriculture is the largest consumer of water and is likely to face the most significant impacts of climate change, particularly in the long-term future.

Scenario 1: Conserve and protect! (low openness to change & competition)
The essence of this scenario is that actors withdraw strongly into their 'own arena' and that the time-honoured law of the strongest rules over the other is no longer regarded as a taboo. People are often expected to prove themselves to others and cannot simply assume that everyone has each other's best interests at heart. For many, this feels like a more 'natural state' than the present. However, some believe there is now a better balance between freedom and responsibility. Indeed, even when distributing scarce natural resources, such as water, the right to access them is not unlimited and must be upheld by measures such as using them sparingly.. With the increasing problem of water scarcity in the 2020s and 2030s in the E.U., citizens and organisations started to think more about how to better deal with water scarcity without having to completely change their way of operating or lifestyle. . Political forces that were sceptical to change gained the upper hand and that did not automatically mean a return to the pleasant times of former times. On the contrary, this 'revolution' also meant that old (neo-)liberal values were back and competition was no longer an inappropriate term word, not even with regard to water. The time-honoured price mechanism could also be added to the arsenal of policy options on how to deal with water scarcity. In this scenario, water is considered to be something that is both precious and valuable. Politicians, policymakers and other parties involved in the water system often have the diamond-water paradox in mind, i.e., the (apparent) contradiction that, although in terms of survival, water is almost always more useful than diamonds, the same number of diamonds in the market fetches a much higher price. As a result, people do not hesitate to put a price tag on the use of water in order not to consider water as 'normal' (anymore). At the same time, they want to convey the message that economy and restraint in the use of water is the best way to address the water scarcity problem. Nevertheless, a moral appeal remains difficult to work with because people often start from their own interests and do not accept in advance that these own interests can also be shared interests with regard to water. The 'sceptical to change-urn' also ensures that national-focused tendencies are prominent again, which is not entirely in line with the cross-border nature of the water scarcity problem and its possible solutions.

In this scenario, water scarcity is considered as a problem that benefits both from moderation in use and consumption and from a distribution that meets the different needs of actors in which the price mechanism plays an important role. In this scenario, everyone has access to (sufficient) water resources, but one must first ask oneself how to organize it as good as possible before appealing to society/organisations. New technologies are not excluded, but they are also not at the forefront and must also be sustainable from a commercial point of view. That is why new technologies are also judged on the extent to which they use water or save water.

In this scenario, the agricultural sector is no longer as protected as it used to be. This sector has also to learn to deal with the commercial rules and it also has to pay a 'fair' price for water that is considerably higher than it was before. But the agricultural sector now also has the possibility to pass this on in the prices it asks for its products. This does put pressure on exports outside the E.U. (and causes problems within the E.U. as well), so that this sector also has an incentive to use water more sparingly. Efficient water management has become an essential part of this sector (alongside other sustainability requirements). The emphasis on (lower) prices has resulted in the margins being too small to invest much in new technology and innovation. The stakeholders involved in the sector avoid taking too much risk and water management has mainly become a commercial business case: only if it saves costs they want to invest. That is why the emphasis is on process innovations.

Scenario 2: Let the game begin! (high openness to change & competition)

The essence of this scenario is that actors are constantly trying to push each other to greater heights and achievements. Change is important, if not the most important thing in society. Change is the only constant, is an important motto. People are mainly and almost constantly looking for the differences between them, where it is a competition who is the first to come up with something new. Both in society and in the commercial world, it's all about realising and benefiting from 'first-mover advantages'.

With the increasing problem of water scarcity in the 2020s and 2030s, people and organizations have concluded that continuing to do the same thing is the same as not doing it, and thus not an option. The problem of water scarcity was exacerbated by the fact that governments and organizations could not (or did not want to) find consensus and therefore no decisions were made or that they were taken too late. Organizations therefore took matters into their own hands and tried to solve water scarcity problems from their own interest and position. Collaboration was hereby not the priority. They preferred to go their own way and the idea was to let as many flowers bloom as possible and let the market and society choose what the best solution would be. The road to solving water scarcity therefore became risky and uncertain, but the general idea was that it was better than standing still.

In this scenario, the problem of water scarcity is not seen as something that can be solved with existing approaches. The water ecosystem now consists of new actors and potential solution providers because the trust at the organizations that caused the problem is declining and they do not seem in a position to provide suitable solutions in the foreseeable future. These 'new entrants' do not hesitate to experiment with new technologies and new business models to ensure that there is sufficient supply of water and that it is distributed in a way that does justice to the specific needs of citizens and companies. The 'water market' is therefore increasingly resembling that of other services that were previously regulated by governments, such as telecom and energy. In these dynamic times, which are also seen by many as panting and stressful, businesses have no trouble crossing national borders, especially at least if it offers new market opportunities. Innovation is paramount, although the many risks that businesses take also lead to many hypes that are not always of direct value for solving the water scarcity problem.

Water has become much less of a 'public good' (i.e. available to every citizen and business without reducing its availability to all others). Access to water for all remains the norm, but in this scenario it is seen as a commercial challenge. The government, both regionally, nationally and internationally, supports many initiatives and experiments that attempt to solve water scarcity. This can also involve local and social initiatives. After all, may the best win!

In this scenario, the agricultural sector has become a very innovative sector. They have joined forces across international borders so that they no longer lose out to the large food companies. The agricultural sector has become a very important and innovative link in the 'food chain'. Of course, the intensive competition in the agricultural sector also relates to how to deal with water scarcity. Investing in new techniques for managing water is no longer a free choice but a necessity. The challenge here is both to be the first in the market to come up with new crops and to ensure that those new crops consume less water. That is why the emphasis is on product innovations.

Scenario 3: We can do this! (high openness to change & cooperation)

The essence of this scenario is that actors see change and progress primarily in the form of a collective action. Everyone realizes that acting on your own makes no sense. Society is strongly interconnected, and the different actors understand and respect each other's point of view and interests. Improvement, change and progress are determined jointly and the implementation of all kinds of plans is also tackled jointly. There is little or no room for individual action because the only way to bring change is by mobilizing large groups of actors. This can take some time, but if the actors starts moving, change will actually take place.

With the increasing problem of water scarcity in the 2020s and 2030s, people and organizations increasingly realized that this is a shared problem and that old solutions no longer suffice, but that new solutions must be found. And precisely because this is a shared problem, the conviction also came that the solution also requires collective action. It was considered unacceptable that knowledge and solutions would not be shared. The time when actors and countries thought they could solve this problem themselves was now far behind them. Nobody owns water, the water belongs to all of us and so we have to work together, there is no alternative. And of course, this was a difficult switch because it required a different way of thinking and transcending your own interests requires a lot of mutual trust and therefore a lot of time. They had to learn that water binds us.

In this scenario, water is not considered something that you can own and use without considering other users/consumers' needs. Just as we borrow the earth from our ancestors and have to pass it on to our children, water is also seen as something that we only use temporarily. Commercial initiatives, such as exploiting a water resource for profit, related to water are not allowed, both nationally and internationally. Of course, it is not always easy to develop new activities, but if a critical mass is reached, new initiatives can go very quickly. Governments are doing a lot to raise awareness of the water scarcity problem and that the solutions largely lie in different behaviour, new technologies and more attention to nature. Education also plays an important role in this. Initiatives and investments in the environmental sector with water consideration receive a lot of attention and positive policy incentives.

In this scenario, the water scarcity issue gets the attention it deserves. Water sector is seen as one of the most important, if not the most important, sector where transition needs to be realized. The fact that everyone should have sufficient access to water is not up for discussion, of course. With almost every major commercial and social investment, organizations are legally obliged to indicate the impact they have on the water level and how to minimize the negative impact on water. And it is precisely this mandatory nature of these laws and guidelines that forces organizations to come up with truly new solutions. Innovation does not arise from freedom but rather from limitations, that is the lesson learned.

In this scenario, the agricultural sector has become an innovative sector. They operate and work together on a mainly regional scale. have joined forces across local and regional borders so that they no longer lose out to the large food companies because they can better meet the specific (local or regional) needs of consumers. Farmers are eagerly sharing knowledge in both the area of new crops and regarding water scarcity and this area and are jointly trying to make the transition to growing crops that require much less water than traditional crops. The interdependence in the agricultural sector is greater than ever, which ensures both more cooperation and innovation.

Scenario 4: All together now! (low openness to change & cooperation)

The essence of this scenario is that actors understand that the most effective way to do something about the water scarcity problem is to collectively take a step back. The realization is that if we are frugal, collaborate among each other and do not expand water use/consumption in new activities , the water scarcity problem is manageable. In principle, there is enough water (and other raw materials) for everyone, so let's live and work together according to that. By working together and controlling our wishes, we ensure that the water system becomes more efficient because it is not unnecessarily burdened. Sharing is multiplying, is often said in this scenario.

With the increasing problem of water scarcity in the 2020s and 2030s, people and organizations have realized that things could no longer go on like this. The sky may be the limit, but when the water is up to our lips, as a society you have to recognize that it can't go on like this. Less is indeed more. After several emergencies due to water shortages and scandals with all kinds of dubious investments in the water sector, it has been decided to simply no longer allow such initiatives. Governments have completely taken back the initiative and reversed many legislation and other directives. Because the water scarcity problem has worsened, there was a lot of support for this policy turn. The management and supply of water has apparently proved to be too important to be left to market parties who have their commercial interests above social interests. There has been a kind of 'calm' in the sector that is mainly used to properly analyse the problem of water scarcity and first investigate which solutions are effective and socially responsible without making the mistake of making all kinds of hasty decisions again.

In this scenario, the solution to water scarcity is mainly sought in adjusting behaviour or reducing the use and consumption of water to earlier levels. Of course, that is difficult because the European population has grown, but there are actually not many other initiatives either dealing with water scarcity. Whatever solution is proposed, it starts with changing our behaviour and our relationship with water use and consumption. We can no longer consider water as something that is infinite and to which we have a kind of 'natural right'. We also have to earn these rights, as it were, and be aware that we are jointly responsible for them and that it is a shared responsibility to deal with them properly. National Governments are constantly looking at which administrative level the water scarcity problem can best be solved. The main candidate seems to be the local and regional level because people find it easier to address each other's behaviour at that level and people are also more aware of the adverse effect of water scarcity on the natural environment and the daily lives of people and organisations.

In this scenario, water scarcity is mainly seen as a direct result of bad behaviour from the recent past where wasting water was too much ignored. The solution is not a flight forward, but rather to return to earlier times when we used water much more wisely and therefore more economically and efficiently. Water conservation is at the heart of every policy initiative and every financial and technological investment. Water is also seen as an integral part of wider environmental ecosystem and it is believed that taking good care of the environmental ecosystems those natural systems will also have positive consequences for water management. Going back to nature also means that we solve the water scarcity problem to a large extent.

In this scenario, the agricultural sector did not seek the solution to water scarcity (and other sustainability and financial) problems in increasing production and distribution scale. The limits of nature have been recognized, especially those of the water ecosystem. Savings, protection and reuse have become the magic words in water management by the agricultural sector. The agricultural sector is self-regulating and tries to make the water shortage manageable by breathing old techniques into life. Information and education are especially important means of this. Suitability in the water ecosystem is an important condition for the initiatives that this sector develops.

5.2.3. Summary overview of the four scenarios

Table 4: summary overview of the four scenarios

	Low openness to change	High openness to change
Competition	Scenario 1: Conserve & protect! ➢ Actors are withdrawn in their 'own arena' ➢ Dealing better with water scarcity without really changing our way of life and operating ➢ Conservative political tendencies made a return to (neo) liberal values: the market is in dominant play ➢ Competition for water as a valuable source with dynamic pricing as a mean of regulation ➢ Economics and restraint are accepted approaches to deal with water scarcity ➢ Nationalist tendencies are prominent, limiting EU Member States and cross-border cooperation ➢ All have access to sufficient water ➢ Water saving is important	Scenario 2: Let the games begin! ➢ Change is the only constant: change is important and highly valued ➢ Strong innovation: high competition for new water saving solutions and for being front-runners ➢ Doing things differently than before is key in dealing with water scarcity ➢ Water users/consumers take initiatives to solve water scarcity from their own interest and position to move faster ➢ Let all flowers bloom and let the market choose what works best ➢ New actors in water ecosystem (or 'water market') from the belief that those who created problems will not solve them

		➢ Experiments with new technologies, nature-based solutions and business models ➢ Access to water for all is the norm, but is an (international) commercial challenge
Cooperation	Scenario 4: All together now! ➢ Most effective way to deal with water scarcity is to take collectively a step back ➢ Water scarcity is manageable if we don't do new things and are water-efficient ➢ Working together and controlling our wishes (reduce our use/demand) ➢ Sharing is multiplying, less is more ➢ Avoidance of new and risky water use commercial activities or innovations ➢ Government is taking back control on water management, societal interest is put first ➢ Risk averse, analyse the problem and implement effective and socially responsible solutions only ➢ Adjusting behaviour: reducing consumption, new relation with water ➢ Local and regional level considered the right level to deal with water scarcity, as this is close to the people ➢ Water scarcity is result of bad behaviour ➢ Return behaviourally to older times and more wise water use, more aligned with the natural environment and ecosystems	Scenario 3: We can do this! ➢ Change and progress is a collective action ➢ Cooperation is key in tackling water scarcity ➢ Old solutions no longer suffice, seeking for new solutions ➢ Nobody owns water, commercialisation of water is not allowed ➢ All actions from the water users/consumers are taken beyond the own interest ➢ Solutions lie in the change of everybody's behaviour, technology and collective environment/nature ➢ International orientation to dealing with water scarcity ➢ Everybody should have sufficient access to water ➢ Government and society at large is responsible for water ➢ Water users/consumers are legally obliged to report on their use/consumption of on water and how they take action to minimise their negative impact on water quantity ➢ Regulation drives organisations to develop innovative solutions for water scarcity (innovation does not arise from freedom, but from regulation)

6. Policy options for the future

6.1. Overview

The study has indicated, through desk research, stakeholder consultations, and Three Horizons workshops, several issues that deserve attention. These findings highlight the complex nature of water management, especially as the EU seeks to address increasing concerns about water availability in the future. Addressing the indicated issues could enhance the EU's capacity to manage water scarcity and ensure sufficient water availability for the future. Tackling all the issues raised during the different activities of the study may not be feasible. Addressing water scarcity is not a "one-size-fits-all" solution; it requires interventions across various policy domains – including technological, societal, environmental, economic, and regulatory dimensions. Additionally, regional disparities must always be considered.

With this in mind, we have developed two sets of policy options aimed at addressing some of the identified issues regarding water scarcity. We aim to propose solutions that maximise impact while ensuring these options are pragmatic and likely to be implemented, whether for the short-term or the long-term. The first set of policy options is intended for short-term implementation (by 2030) and offers emergency responses to the current challenges of water scarcity and droughts. The second set focuses on medium- to long-term strategies that address the structural challenges of water scarcity. These options are designed using the future scenarios developed in the study and aim to mitigate or reduce the effects of water scarcity, ensuring that adequate access to water is maintained.

Although the short-term and long-term policy options are applied on a different time horizon, this does not mean that they are by definition independent of each other. For example, the long-term policy options must be started in the short term because the difference with short-term policy options is that they need more time to be developed and implemented and to be effective. Think of policy options that have to do with infrastructure that have a longer cycle than short-term policy options that relate to, for example, implementing financial incentives. One possibility is that short-term policy options may even influence the implementation of long-term policy options. For example, the application of 'smart metering' can mean that the more effective use of water necessitates smaller enlargements of the water infrastructure. There could even be a form of 'path dependency' in which short-term policy options make the implementation of long-term policy options almost impossible. This must be considered when assessing the portfolio of short-term and long-term policy options.

The goal of the policy options is to ensure water availability across the EU by addressing the immediate challenges posed of water scarcity and the longer-term structural issues. The proposed policy options seek to balance urgency with feasibility, and regional disparities with the need for coordinated action.

6.2. Policy options for the short term (2030)

The proposed policy options for the short term (2030) are not linked to the future scenarios, as these describe the medium- to long-term contextual future. Rather, the short-term policy options aim to address the pressing issues towards 2030 related to acute water shortages and the adverse effects of drought on critical sectors identified in this report. Our analysis has therefore focused on identifying policy options that can have a more immediate and tangible impact. These are policies designed to be effective rapidly in cases of urgent water scarcity, rather than long-term strategies that require extended periods to implement or to have effect.

In this context, the policy options we recommend for the short term are primarily geared toward emergency response measures. The urgency of the current water scarcity status in some EU regions necessitates swift and decisive actions that can mitigate the immediate effects of drought and water shortages in key economic sectors, as these have been presented in the report. While long-term sustainability and resilience remain important, as there is a need to shift from a crisis management to a risk management approach when dealing with water scarcity, the focus here is on actions that can deliver quick relief and address critical needs without delay. These options are tailored to enable a more rapid response to water scarcity, ensuring that the affected sectors can continue to function and maintain stability in the face of the present challenges due to climate change.

The tables below explain the rationale behind the proposed policy options, the objectives of these options, the suggested interventions, and the anticipated impacts, along with qualitative assessment criteria. Annex A, Table 7 offers a detailed explanation of the qualitative assessment.

6.2.1. Policy option A

Policy option A: "Develop and implement strategies and measures to reduce water use/consumption in times of water scarcity"	
Time horizon	Short-term (2030)
Rationale	As water availability diminishes, tensions have emerged between different water users and sectors, including agriculture, industry, and urban centres, all competing for limited freshwater resources. These tensions between water supply and demand will intensify as droughts increasingly threaten the capacity of key economic sectors to maintain their operations. The growing water scarcity situation leading to diminishing water supplies due to climate change, highlights the urgent need for coordinated, equitable water management strategies that address the impacts of climate change while ensuring sustainable access to water for all stakeholders. This policy option takes an equitable approach to water use and consumption, where reductions in water use and consumption are applied fairly but proportionally to use and consumption levels. This would follow a principle akin to the "polluter pays" model, in which the largest water users or consumers bear the greater responsibility for reducing their water use or consumption. By targeting those sectors that have the most significant impact on water consumption, this approach ensures that the burden of managing water scarcity is distributed in a manner that is both efficient and fair. Additionally, this policy option emphasises the need for measures that are not only effective but also adaptable to different levels of water scarcity (per region/ MS level), allowing for a flexible and dynamic response to varying levels of drought or water shortages. In doing so, it seeks to prevent over-exploitation of water resources while maintaining economic stability across the sectors most reliant on water, thus safeguarding both the environment and the economy in times of crisis.
Objective	This policy option aims to introduce practical, swiftly implementable measures that can offer immediate and effective responses to water shortages, particularly those impacting key economic sectors. Its primary objective is to reduce water use and consumption to alleviate strain on resources. Recognising the potential for water shortages to create competition for water between different sectors – such as agriculture, industry, and municipal use – this policy option aims to ensure a fair distribution of water use reductions across all sectors.
Policy intervention(s)	Examples of more specific policy interventions that fit this policy option: • **Installation of smart metering in water-intensive sectors, aquifers, and private wells**. Smart-metering system enables real-time monitoring of water

	usage and availability. Smart meters provide critical, up-to-date data on water levels, withdrawal rates, and usage patterns, allowing for more accurate and efficient water management. For water-intensive sectors, smart metering can help monitor water consumption in real-time, identifying inefficiencies and potential wastage. This data-driven insight allows businesses to implement water-saving measures, reduce operational costs, and meet regulatory requirements, especially during droughts or water shortages. Aquifers and private wells equipped with smart meters offer a more precise understanding of groundwater conditions. Continuous tracking of water levels and withdrawal rates helps prevent over-extraction, protects the sustainability of water resources, and ensures that withdrawals remain within environmentally safe limits. Smart meters play also a crucial role in data collection, especially for tracking both water returns and withdrawals. This provides a more comprehensive understanding of not only where water is sourced, but also where it ends up, allowing for an accurate assessment of the net water balance. This information could also be invaluable for authorities and regulators to manage shared water resources more effectively, especially in regions prone to water scarcity. • **Seasonal/context-based water pricing/taxation schemes**. If designed well, this policy intervention can act as both a financial instrument and an environmental tool to address shortages and encourage sustainable water use. National governments or local authorities can apply higher water prices for/taxation over water use/consumption during peak demand, during dry or summer months of (anticipated) drought conditions. When water supply is higher and demand lower, prices can be reduced, allowing users to meet their needs without imposing financial burdens. During times of drought or severe water shortages, temporary surcharges or taxes may be introduced to limit excessive water use and raise revenue for managing the crisis. Once the crisis subsides, rates return to normal. A sector-based differentiation can also apply, so the basic water needs, such as drinking and hygiene, are charged at lower rates, while higher levels of use—such as for irrigation or industrial processes—are taxed more steeply. It is important to highlight that given difference between water use and water consumption with regards to the amount and purpose of water extracted from natural sources, as well as its eventual return to the environment, water use pricing encourages efficient use of water resources, while water consumption pricing directly targets conservation by penalising permanent losses from the water cycle. • **Require water-intensive sectors to have a drought insurance in regions with a high risk of water scarcity**. Droughts can cause major disruptions to sectors that rely heavily on water (agriculture, manufacturing, energy production, etc.). Having drought insurance would protect these sectors financially if water shortages reduce their operational capacity or cause production delays. This system can eventually replace the traditional approach of governments providing ad-hoc compensation to sectors for economic damages due to droughts. Insurance schemes could shift some of these financial burdens from governments (taxpayers) to private insurers The public-private insurance system can combines indemnity- and index-based products for drought-related damage across the water-intensive sectors. This policy intervention could likely cover losses related to decreased productivity (agricultural sector), increased water procurement costs, or operational interruptions (thermoelectric plans/manufacturing sector) caused by drought.
Expected impact(s)	• Improved alignment of water supply and demand during periods of water scarcity.

<table>
<tr><td></td><td colspan="4">Enhanced data availability and quality through smart metering of water-intensive sectors, aquifers and private wells, enabling a more accurate forecasting and better informed, data-driven decision-making during periods of water scarcity
Reduction of unnecessary water use and water consumption(depending on the respective sector needs, as elaborated in Section 4.1), supporting sectors and businesses in overcoming challenges during prolonged droughts.
Stabilisation of economic activity in regions with a high risk of water scarcity. With the insurance coverage, the water-intensive sectors can maintain operations or recover more quickly after a drought, reducing the economic ripple effects in the broader society.
More efficient water use and water consumption (depending on the respective sector needs, as elaborated in Section 4.1) during times of water scarcity. Higher prices during dry periods or in water-scarce regions can motivate water users and water consumers to adopt water-saving technologies and practices.</td></tr>
<tr><td rowspan="6">Qualitative assessment of criteria
(see Annex A for details of qualitative assessment)</td><td>Dimension/ criterion</td><td>Comparative score</td><td>Dimension/ criterion</td><td>Comparative score</td></tr>
<tr><td>Costs</td><td>-1</td><td>Risks, challenges and uncertainties</td><td>-1</td></tr>
<tr><td>Benefits</td><td>+1</td><td>Coherence EU policy</td><td>+1</td></tr>
<tr><td>Feasibility</td><td>0</td><td>Ethical & societal impact</td><td>-1</td></tr>
<tr><td>Effectiveness</td><td>+2</td><td>Regulatory impact</td><td>-1</td></tr>
<tr><td>Sustainability</td><td>+2</td><td></td><td></td></tr>
</table>

6.2.2. Policy option B

Policy option B: "Integrated EU-wide water strategy and legislative framework to mitigate water scarcity impacts"	
Time horizon	Short-term (2030)
Rationale	In its 2024 work program and State of the Union address, the European Commission announced plans for a non-legislative initiative on water resilience. This initiative aims to secure access to water for people, nature, and the economy, while also addressing issues like flooding and water shortages. In the political guidelines for the next European Commission (2024-2029), presented to the European Parliament on July 18, 2024, by European Commission President Ursula von der Leyen, who was elected for a second term, emphasised the need to improve Europe's water security. The new European Water Resilience Strategy will focus on water efficiency, scarcity, pollution, and risks related to water. It will also aim to boost innovation in the water industry and promote a circular economy approach. This initiative recognises the seriousness of water scarcity in the EU and the pressing need for solutions. However, the fact that it is non-legislative raises concerns about its practical impact. There is a risk that water governance may remain unchanged, missing a key opportunity to address immediate water-related risks while also establishing a strong, long-term policy framework. Without binding measures, the initiative may fall short of driving the necessary changes to effectively mitigate water challenges in both the short and longer term.

Objective	This policy option focuses on the timely establishment of a robust (legislative) framework for water resilience, with specific measures to be implemented during the current mandate of the newly appointed European Commission. As a comprehensive and holistic approach, this strategy will not only target water management and sustainability but also create synergies with other policy areas and mainstream water issues in other policy domains, including agriculture, climate adaptation, energy, biodiversity, and circular economy. By doing so, it aims to strengthen the EU's capacity to respond to water-related crises, while fostering innovation and economic growth within water-dependent sectors. Moreover, the strategy's implementation will encourage the adoption of complementary policies that align with broader EU goals, including the European Green Deal and the Climate Adaptation Strategy.
Policy intervention(s)	Examples of more specific policy interventions that fit this policy option: • Revision of the Water Framework Directive (WFD) with priority focus on water quantity and the introduction of digital water management systems at the MS level. The revision could introduce stricter standards for managing water quantity, along with mechanisms for monitoring and allocating water resources more sustainably. It may also emphasize a more integrated approach to water management across regions (also transboundary), particularly by combining the management of surface and groundwater resources. The introduction of a digital water management would enhance the monitoring and reporting for compliance with water quality and quantity standards set out by the WFD and will provide a framework for the interoperability of digital systems across the EU Member States ensuring consistent reporting and data sharing. • **Provision of a Drought Directive as counterpart of the Floods Directive(2007/60/EC).** The Floods Directive provides a framework for managing flood risks through flood risk assessments, mapping, and the implementation of flood risk management plans. Similarly, a Drought Directive would aim to mitigate the impacts of droughts, ensure sustainable water management, and promote resilience in EU Member States facing increasingly frequent water shortages. A Drought Directive would require Member States to conduct assessments of drought risks, to create drought vulnerability maps and to prepare and implement Drought Management Plans. It could also establish guidelines for prioritising water use during droughts, focusing on essential purposes (e.g. drinking water, key ecological functions) while imposing restrictions limiting water use for non-essential purposes (e.g., irrigation, recreational activities). • Provision of additional funding targeting water scarcity through EIB investments and loans focusing on improving water infrastructure, developing and implementing nature-based solutions (NBS). EIB could allocate funds for the modernisation of water supply systems, the expansion of water recycling and reuse systems, (sustainable) desalination technologies and building or enhancing infrastructure that supports drought resilience, such as reservoirs or groundwater recharge systems. NBS that can be financed by the EIB could include wetland and floodplain restoration, reforestation, promotion of agroforestry, soil restoration and conservation. Provision of additional funding, through the European Innovation Council, for start-ups and SMEs to scale up their high-TRL innovations that have potential to reduce water scarcity in the short term and in various sectors. Innovations which are closer to market adoption and commercialisation have the larger potential to deliver tangible, short-term solutions to water scarcity challenges. Examples of these technologies could include water-efficient technologies for agriculture (e.g., precision irrigation, water-saving crop varieties), advanced water purification and (sustainable) desalination technologies, smart water management systems that use IoT, AI, and data analytics for real-time water monitoring

	and demand management. Funding to start-ups and SMEs should help them to de-risk investments and to bridge the commercialisation gap.			
Expected impact(s)	• Improved monitoring of water scarcity across the EU • Harmonised framework on efficient use of water across the EU Member States • Improved water management and infrastructure across the EU Member States to mitigate water scarcity • Improved preparedness, risk and crisis management in times of water scarcity and drought • Boosting innovation in water technology solutions and NBS tackling water scarcity and droughts across EU Member States. • Enhanced transboundary cooperation in managing shared water resources • Enhanced coordinated action between Member States to address drought risks and water shortages.			
Qualitative assessment of criteria (see Annex A for details of qualitative assessment)	Dimension/ criterion	Comparative score	Dimension/ criterion	Comparative score
	Costs	-2	Risks, challenges and uncertainties	-1
	Benefits	+1	Coherence EU policy	+2
	Feasibility	+1	Ethical & societal impact	0
	Effectiveness	+2	Regulatory impact	-1
	Sustainability	+2		

6.3. Policy options for the medium- to long-term (2050)

Policy options for the medium- to long-term are inspired by the future scenarios for 2050 (see section 5.2). Each of the policy options links to multiple scenarios. These policy options are developed to address structural changes to address water scarcity and to improve the resilience of the water system in the EU towards 2050. This means that the impacts of these policy options take more time to reach effect, but does not mean that one should wait with implementing these policy options or suggested policy interventions that are linked to each of these policy options. The policy options help to prepare for potential futures or to mitigate undesired implications emerging from future context (for example a future which tends towards less cooperation, while cooperation is considered important to address cross-border water scarcity challenges).

The tables below explain the rationale behind the proposed policy options, the objectives of these options, the suggested interventions, and the anticipated impacts, along with qualitative assessment criteria. Annex A, Table 8 offers a detailed explanation of the qualitative assessment.

6.3.1. Policy option C

Policy option C: "Do things differently - Innovate and prepare for radical change"	
Time horizon	Medium- to long-term (2050)
Link to scenario(s)	This policy option is relevant in the following scenario(s): • Scenario 2: Let the games begin! (competition & high openness to change) Scenario 3: We can do this! (cooperation & high openness to change)
Rationale	This policy option acknowledges that water scarcity requires to deal differently with water and adopt a more proactive approach to water scarcity. It accepts a future in which water is scarcer and thus requires to radically change how we use water in our societies and economies and to develop solutions that can be considered radical, both technological, societal, economical as well as nature-based solutions. As water scarcity will be rather regional and seasonal, and have stronger impacts on sectors like agriculture, the impacts may be more painful for certain regions and economies, therefore policies should be in place to tackle these challenges in a just and collaborative manner within the EU (to also avoid painful competition between regions in scenario 2).
Objective	This policy option aims to reduce the implications of (regional) water scarcity in the EU by preparing and supporting EU societies and economies for radical changes in how we value and deal with water and for radical solutions to enable sufficient water for societal well-being and economic prosperity. Technological, social and nature-based innovations are required to make this transition. EU policies and strategies should help to ensure that over time the EU is ready to deal radically different with water when water scarcity will be more prevalent due to climate change.
Policy intervention(s)	Examples of more specific policy interventions that fit this policy option: ➢ **Integrated EU water strategy**: water should be a key priority at EU level and approached more integrally to address the many challenges with water that climate change will bring. Such a strategy should cover for instance water quantity, water quality, water governance and cross-boundary water management. Such a strategy should set priorities that are transferred/addressed in all other polices (mainstreaming such as in the Green Deal), including industrial, agricultural, R&D&I, regional, environmental and climate policy. ➢ **EU wide water scarcity campaign to change behaviour of citizens and businesses** (stronger linked to scenario 3): a long running campaign across all EU Member States should raise awareness for water scarcity and should contribute to changing the societal and economic value of water in the EU. It should change behaviour in water use among citizens, but also among businesses. Like being green, being blue should be the norm and demanded by customers and society at large. Water scarcity should by all be recognised as a problem to which society and economy should adapt. It should highlight actions that citizens and businesses could take to reduce their water use and should be aligned with incentives (e.g. other actions) to promote such a behavioural change. This blue transition should also help businesses and the economy to remain competitive in a more water scarce future. ➢ **Adopt socially equitable dynamic water pricing and taxation across the EU** (stronger linked to scenario 3): regulations or directives could be developed to ensure that water pricing is dependent on the availability of water and that taxation is progressive with volumes of water used. Water pricing should be socially equitable: all citizens should still be able to afford essential water use (which should be defined and which is fairly price inelastic). Dynamic pricing may be coupled to water use that is not considered essential (which is more price elastic) and applied in periods that water is expected to become scarce. To be more proactive, such a price mechanism should be used to avoid water scarcity in the first place which requires better monitoring of water sources and better

<table>
<tr><td></td><td>prediction of water scarcity to determine dynamic water pricing. This policy intervention would introduce a market (i.e. price) or tax mechanism to regulate demand of scarce water resources.
➢ EU strategy aimed at a just structural economic reform to match water availability in regions: as in the future some regions will deal with more severe water scarcity than others, higher investments in radical water solutions/innovations are needed in these regions. In addition, some highly-water consuming activities might no longer be sustained in regions that deal with more frequent/severe water scarcity. Therefore, the economic structure in such regions will need to change, such as agriculture specialising in crops that use less water or that are salt or drought tolerant (which can be engineered crops). Specialisation and (free) trade among regions across Europe should reduce implications. In addition, water scarcity may set natural limits to the growth of populations in certain regions. To help regions transform, a strategy could be in place that support regions with investments in more radical solutions that reduce water scarcity (e.g. nature-based solutions, water management systems or technological innovations) or to attract different industries and reskill citizens in those regions to these industries. Like in the Green Deal, these transitions should be just and regions would be (like with regional and cohesion policy) supported by the EU with this strategy.
➢ R&I programmes and investment programmes to develop and adopt radical solutions to address water scarcity: radical solutions to address water scarcity could be technologies – such as a genetically engineered salt/drought tolerant crops, sustainable desalination, atmospheric water capture, smart rainfall enhancement, smart precision irrigation – nature-based solutions – wetland restoration, reforestation, etc. – and changes to water management. These require research, innovation and investments to ensure that these solutions are developed and implemented in sufficient scale in 2050.</td></tr>
<tr><td>Expected impact(s)</td><td>• Higher value of water (as a scarce resource) in society and economy
• Less water use/consumption and higher reuse of water
• Avoidance of a shortage of essential water for citizens
• Strategic autonomy in water as a strategic and essential resource
• Restructured, strong and future proof regional economies and sectors in the EU
• Specialised regions in the EU to their available water resources
• Strong EU position in innovations for (technological and nature-based) water solutions globally</td></tr>
</table>

<table>
<tr><td rowspan="6">Qualitative assessment of criteria
(see Annex A for details of qualitative assessment)</td><td>Dimension/ criterion</td><td>Comparative score</td><td>Dimension/ criterion</td><td>Comparative score</td></tr>
<tr><td>Costs</td><td>-2</td><td>Risks, challenges and uncertainties</td><td>-2</td></tr>
<tr><td>Benefits</td><td>+2</td><td>Coherence EU policy</td><td>+1</td></tr>
<tr><td>Feasibility</td><td>-1</td><td>Ethical & societal impact</td><td>-1</td></tr>
<tr><td>Effectiveness</td><td>+2</td><td>Regulatory impact</td><td>-1</td></tr>
<tr><td>Sustainability</td><td>+2</td><td></td><td></td></tr>
</table>

6.3.2. Policy option D

Policy option D: "Business as usual - Regulate and innovate to preserve"	
Time horizon	Medium- to long-term (2050)
Link to scenario(s)	This policy option is relevant in the following scenario(s): • Scenario 1: Conserve & protect! (competition & low openness to change) • Scenario 4: All together now! (cooperation & low openness to change)
Rationale	In a future where societies are less open to change, radical change is unlikely to be accepted and Member States will try to keep business as usual. Resistance to another impactful transition would result on keeping business as usual or incremental changes in terms of water use and consumption, even if this may pose risks in times of extreme or prolonged water scarcity. If societies and economies want to only take minor steps in changing water use and behaviour, and changing pricing mechanisms are not accepted, (self)regulation and innovation are the key solutions to reduce demand and improve supply. This would include regulating water use/consumption, changing water infrastructure and management, and finding solutions to increase the supply of water (for instance from other regions or through innovative technologies or nature-based solutions) or to use water more efficiently (e.g. water efficient processes).
Objective	This policy option aims to reduce the implications of (regional) water scarcity for citizens and businesses in the EU by setting regulations that requires Member States and businesses to increase water efficiency and water reuse and by developing and adopting demand and supply innovations that enable to keep using and consuming water as we are used to. Technological, social and nature-based innovations are required to enable business as usual to the extent possible. EU policies and strategies should help to ensure that over time the EU is ready to have regulations in place and implement solutions that – even with water scarcity – should provide water for essential use (which would need to be defined).
Policy intervention(s)	Examples of more specific policy interventions that fit this policy option: ➢ **Integrated EU water strategy**: even while holding on to business as usual, water should be a key priority at EU level and approached more integrally to address the many challenges with water that climate change will bring. Such a strategy would be a first step to further regulate water at EU and MS level. This strategy should cover for instance water quantity, water quality, water governance and cross-boundary water management. Such a strategy should set priorities that are transferred/addressed in all other polices (mainstreaming such as in the Green Deal), including industrial, agricultural, R&D&I, regional, environmental and climate policy. ➢ **Regulation/framework to ensure provision of water for essential use by Member States**: when trying to keep business as usual (i.e. not change behaviour and thus limit changes in demand to efficiency), water scarcity may be a temporal and regional risk for water supply to citizens and businesses. Adopting regulation that requires Member States to do all that they possibly can to supply sufficient water for essential use (which needs to be defined) to citizens at all times. This goes beyond providing access to water and ensuring good water quality. This requirement should drive innovation and investment in improved water management and supply, water efficiency and solutions that ensure that in times of water scarcity sufficient water is available for EU citizens to survive and live a normal life ('business as usual'). ➢ **Set water efficiency and reuse targets in regulation**: although behaviour is not really changed, more efficient water use can be realised through more efficient processes and more water efficient technologies and products (for which water efficiency labels could be required to help customers make informed decisions). In addition, reused water does not require citizens or businesses to change behaviour, but requires to adopt systems for water reuse. Setting targets in

<table>
<tr><td></td><td>regulation can require businesses or even Member States to ensure water efficiency is increased and more water is reused. This provides incentives for innovation, adoption and investments in processes, products and systems that are more water efficient or reuse water. With frequent water scarcity, investments may be taken by the private sector already to increase water efficiency and reuse as this is required for business continuity or to reduce costs. This regulation ensures investments are taken timely by public and private actors and by citizens – who may be supported with subsidies to invest in more water efficient products and reuse systems.
➢ R&I programmes and investment programmes to develop and adopt solutions to keep water use behaviour as-is: research and innovation can deliver solutions to water scarcity that can have impact in the medium- to long-term. R&I could be directed at technologies that increase the supply of water (to not change demand behaviour) or increase water use efficiency – this could include technologies such as sustainable desalination, atmospheric water capture, more water efficient variants of current crops, smart rainfall enhancement technology and smart precision irrigation. In addition, R&I could target nature-based solutions or water management to better store water in ecosystems during periods with high precipitation or reduce water run-off. Furthermore, investments could be directed at start-up businesses developing relevant solutions and at investing in improved water management, water infrastructure and new solutions to address water scarcity by governments (or public water management organisations).</td></tr>
<tr><td>Expected impact(s)</td><td>• Sufficient water available for citizens for essential use
• More reuse of water (by businesses, governments and citizens)
• Lower water use (without changed behaviour) due to efficiency regulation
• Improved water management and infrastructure in EU
• Strong innovation position of Member States or EU as a whole in water technology</td></tr>
<tr><td>Qualitative assessment of criteria
(see Annex A for details of qualitative assessment)</td><td>
<table>
<tr><th>Dimension/ criterion</th><th>Comparative score</th><th>Dimension/ criterion</th><th>Comparative score</th></tr>
<tr><td>Costs</td><td>-1</td><td>Risks, challenges and uncertainties</td><td>-2</td></tr>
<tr><td>Benefits</td><td>0</td><td>Coherence EU policy</td><td>+1</td></tr>
<tr><td>Feasibility</td><td>0</td><td>Ethical & societal impact</td><td>+1</td></tr>
<tr><td>Effectiveness</td><td>+1</td><td>Regulatory impact</td><td>-2</td></tr>
<tr><td>Sustainability</td><td>+1</td><td></td><td></td></tr>
</table>
</td></tr>
</table>

6.3.3. Policy option E

Policy option E "Ensure cooperation – Change governance and innovate for the future"	
Time horizon	Medium- to long-term (2050)
Link to scenario(s)	This policy option is relevant in the following scenario(s): • Scenario 3: We can do this! (cooperation & high openness to change) • Scenario 4: All together now! (cooperation & low openness to change) This policy option could help to avoid challenges in needed (cross-boundary) cooperation on water scarcity in the future, associated with the scenario(s): • Scenario 1: Conserve & protect! (competition & low openness to change) • Scenario 2: Let the games begin! (competition & high openness to change)

Rationale	Cooperation is important in some of the future scenarios, in which it may emerge naturally, but is less likely to emerge in the competition scenarios. Competition can be a strong driver for solutions, but cooperation on water scarcity is important, as water crosses national boundaries and involves many actors in society (incl. citizens, businesses and governments). To ensure some level of cooperation in the long-term, this policy option lays the foundations for cooperation on water scarcity in the EU by already starting stronger collaborations on water and by changing water governance approaches. Providing a framework for EU action on water and for collaborative innovation to address future challenges in water scarcity.
Objective	This policy option aims to reduce the implications of water scarcity through collaborative action across the EU, specifically by laying a framework for improved collaboration between regions, Member States and actors in the water domain.
Policy intervention(s)	Examples of more specific policy interventions that fit this policy option: ➢ **Integrated EU water strategy**: water should be a key priority at EU level and approached more integrally and collaboratively to address the many challenges with water that climate change will bring. Such a strategy should cover for instance water quantity, water quality, water governance and cross-boundary water management. Such a strategy should set priorities that are transferred/addressed in all other polices (mainstreaming such as in the Green Deal), including industrial, agricultural, R&D&I, regional, environmental and climate policy. This should lay a framework for collaborative action on water in a more integral approach, including an improved cross-border governance on integral water challenges in the EU and potentially a shared competence centre building upon and expanding further the existing Working Group under the WFD that maintains an inventory of practices of Member States. ➢ **Extent cross-boundary cooperation in WFD for all water sources to address water scarcity:** the current WFD can be enlarged to cover all water sources and pay more attention to water scarcity. This would improve cross-border cooperation and introduces a form of cross-border governance. As the challenge of water scarcity is projected to increase in the future, national drought management & water scarcity plans under WFD should be required for all Member States. ➢ **Sharing lessons on best practices in water governance and management across the EU**: regions and actors in the water sector can very much learn from each other in dealing with water scarcity. Sharing lessons on best practices in water governance, water management and addressing water scarcity in policy and practice can be valuable for all and is a form of cooperation, especially if this mutual learning is associated with a support mechanism in which regional experts and practitioners help other regions with expertise on their best practice. This could for instance be implemented as an interregional cooperation project funded under the Interreg Europe programme, in which interested regions can choose to participate. ➢ **Use EU regional & agricultural funding to strengthen regional economies while addressing water scarcity:** regional cooperation may require a certain level of equality and solidarity. Setting tackling water scarcity as one of the priorities in the European Regional Development Fund (ERDF) and by setting reducing water consumption and tackling water scarcity as a priority for (national) CAP Strategic Plans and the European Agricultural Fund for Rural Development (EAFRD) could contribute to making regional economies more resilient to climate change while addressing water scarcity. This is a form of financial cooperation: using a part of the EU contributions to address water scarcity in regions. With the right regional solutions, water scarcity across the EU could be reduced in the future. ➢ **R&I programmes and investment programmes to develop and adopt collaborative solutions for water scarcity**: innovation in collaboration can be sometimes faster than in competition, making use of the best knowledge, expertise and facilities available across the EU. R&I programmes could fund international collaborations on innovative (demand or supply side) solutions that address water scarcity from an economic, societal, technological or nature-

	based (ecosystems) perspective. Investment programmes could help bring these innovations to the market (e.g. by startups) or support the implementation of novel solutions.			
Expected impact(s)	• Strong/more cross-boundary cooperation on water scarcity • Enhanced knowledge on water scarcity solutions • Wider implementation of best practices in tackling water scarcity • Strong regional economies and agriculture despite water scarcity			
Qualitative assessment of criteria (see Annex A for details of qualitative assessment)	Dimension/ criterion	Comparative score	Dimension/ criterion	Comparative score
	Costs	0	Risks, challenges and uncertainties	0
	Benefits	0	Coherence EU policy	+2
	Feasibility	+2	Ethical & societal impact	+2
	Effectiveness	0	Regulatory impact	+2
	Sustainability	+2		

7. Conclusions

Climate change and water scarcity in Europe

Europe is confronted with excessive water use, despite an overall decline in water withdrawal since 2000. Local pressure on water resources has worsened, especially in regions already vulnerable to water stress. Poor water management practices, such as damming and drainage, have harmed freshwater ecosystems, reducing their resilience to climate events. Activities like river channelization and wetland drainage have further jeopardised soil health and agriculture. Climate change has exacerbated water scarcity, affecting 30% of Europeans annually. Water scarcity and droughts cause economic and ecological damage, and drought frequency is expected to increase due to climate change, posing challenges to balancing water needs for health, nature, and economic activities.

By 2050, climate change will intensify water scarcity across Europe, particularly in Southern, Western, Central, and Eastern regions. Projections show a rise in water scarcity days, especially in Southern Europe, despite possible increases in median river flow. As global temperatures rise, more people will face severe water shortages. However, population decline and socio-economic changes may slightly ease this burden.

The water-climate change nexus

Water availability and climate change are deeply interconnected, with climate change significantly altering precipitation patterns, increasing the frequency of droughts and floods, and affecting the overall distribution of water resources. This, in turn, has profound implications for agriculture, energy production, and industrial processes, as these sectors rely heavily on a stable water supply. Water is more than just a resource; it serves as a vital component for economic productivity, ensuring social well-being and maintaining environmental sustainability. Changes in water availability and quality can hinder agricultural yields, disrupt energy generation (particularly hydropower), and impede industrial activities while also exacerbating issues related to health, inequality, and livelihoods. As water becomes scarcer or more polluted, marginalised communities are often disproportionately affected, further emphasising the need for integrated water management strategies that address both climate resilience and social equity.

Key climate-related risks to water security

Climate-related risks to water security are complex and impact multiple sectors, including ecosystems, agriculture, tourism, and energy production. The list below summarizes the most important risks identified in the study, particularly through the analysis of the current and short-term horizon situation.

- **Decreased water quality and harm to ecosystems due to low river flow:** Lower river flow reduces the water's ability to dilute pollutants, leading to higher contamination levels. This disrupts aquatic ecosystems and harms natural habitats.
- **Water supply risks from water scarcity and poor quality:** Increased droughts and poor water management can lead to shortages and contaminated water. This threatens the availability of clean water for households, industries, and communities.
- **Agricultural threats due to water shortages and higher irrigation demands**: As water becomes scarcer, farmers face difficulties irrigating crops, leading to reduced yields. This can exacerbate food insecurity and increase the cost of agricultural production.
- **Tourism impacts, with reduced snow in winter and water shortages in summer**: Ski resorts suffer from shorter snow seasons, reducing winter tourism. In summer, water shortages can limit recreational activities, negatively impacting tourism-driven economies.

- **Energy supply risks as water-dependent power plants face decreased water reliability:** Power plants that rely on water for cooling, such as hydroelectric and nuclear plants, may experience operational challenges. Reduced water availability can lead to energy shortages and disrupt power generation.

These climate-related risks require urgent and integrated policy measures to ensure the sustainable management of water resources.

The need for collective action and fair access

Rising water scarcity across Europe, despite varying regional impacts, necessitates EU-wide solutions and stronger cross-border cooperation. As water shortages become more pronounced, unified strategies are essential to address the interconnectedness of water resources shared between the EU member states. Public awareness and education on water conservation are vital, as ensuring equitable access to water becomes increasingly challenging. In particular, measures such as water rationing and taxation, if not carefully managed, could deepen inequalities, much like the challenges seen in the energy sector's "just transition," where efforts to shift towards greener energy sources have sometimes exacerbated disparities. Achieving a fair distribution of water resources will require policies that prioritise vulnerable communities and promote sustainable water management practices across the continent, balancing both environmental sustainability and social equity.

Nature-based and digital solutions

Incorporating ecosystem services into water management is crucial as healthy ecosystems naturally contribute to water filtration, flood control, and climate regulation. By valuing these services, nature-based solutions such as local water conservation initiatives can be seamlessly integrated into regional planning to improve water resource management. Moreover, leveraging digitalisation and artificial intelligence can play a transformative role in addressing water scarcity. These technologies facilitate the sharing of data and enhance decision-making processes across different regions in the EU, where collaborative efforts are key to managing shared water resources efficiently and sustainably. As proposed across both short-term and long-term policy options, the role of EU funding through research and innovation is deemed crucial.

Data-driven water policy

However, the introduction of digital technologies in water management increases the need for comprehensive, accurate, and timely data at different levels. Real-time monitoring through sensors and IoT devices can enable quick responses to issues like leaks and pollution, allowing for informed decision-making that minimise water waste. Data-driven tools can optimize water resource management by using predictive analytics to forecast demand and employing precision irrigation systems that reduce water consumption. Moreover, data enhances water quality management. Sensors can trigger early warnings when contamination occurs, and smart filtration systems can automatically adjust to maintain safety standards. Infrastructure management also benefits from predictive maintenance and asset management strategies, which help prevent failures and inform investment decisions.

Data models simulate water availability and environmental impacts, helping to identify areas for conservation and enabling sustainable planning for future water use in the face of growing populations and climate change. Public engagement and transparency can also be improved through open data sharing, where citizen-driven platforms encourage water conservation by providing insights into personal usage. Additionally, integrating multiple data sources, such as hydrological and weather data, can offer a comprehensive view of water challenges, enhancing coordination among the respective stakeholders, institutions, and agencies.

The need for better data extends beyond the realm of digital technologies for water management. This study has faced numerous challenges related to data quality. One major issue is the discrepancies found among different data sources, and even within reports from the same organization. Another challenge is the annual variability in the data provided. Enhancing data reporting on water scarcity and droughts at the Member State, regional, and EU levels is essential for more informed policy-making.

Proactive water management policies

An integrated EU water strategy is though the cornerstone for effective water scarcity management. Water should be a top priority at the EU level and approached holistically to address the numerous challenges posed by climate change. This strategy should encompass various aspects, including water quantity, water quality, water governance, and cross-border water management. It must establish priorities that are reflected in all other policies, such as those outlined in the Green Deal, including industrial, agricultural, research and development, regional, environmental, and climate policies.

There is a need for an intersectoral water policy framework that prioritizes key sectors—such as agriculture, energy, industry, tourism, and transport—while also safeguarding ecosystems. This framework should promote the integration of these sectors into water policies, ensuring that their water needs are balanced with environmental protection. Shifting from reactive crisis management to proactive risk management is crucial. This involves early identification of water scarcity and drought risks. The approach should include the development of risk-based indicators, clear targets, and timelines to monitor progress, ensuring timely interventions that minimize the impacts of water shortages and enhance long-term resilience.

The European Economic and Social Committee (EESC) has renewed its call for a dedicated EU Blue Deal in September 2023, emphasizing the need for a new opinion on water resilience and industrial development. A year after, the European Commission registered a new European Citizens' Initiative (ECI) aimed at promoting a Water-Smart and Resilient Europe. The ECI emphasizes the need for a strategic and comprehensive action plan for water management in Europe. It advocates for the development and implementation of coordinated policies across all EU policy areas. Recently, the Commission also initiated a call for evidence on the 'Have Your Say' portal, providing stakeholders an opportunity to offer input that will help shape the future Water Resilience Strategy, which aims to tackle the most pressing water-related challenges facing Europe.

The critical role of research and innovation

Research and investment programs are crucial for creating and adopting innovative solutions to tackle water scarcity. Implementing transformative solutions will demand substantial research, innovation, and investment to ensure that these solutions are effectively developed and scaled by 2030 and 2050.

In addition, the European Institute of Innovation & Technology (EIT) has announced a call for proposals to establish a new sustainable innovation partnership aimed at strengthening Europe's water, marine, and maritime sectors and ecosystems. This call invites consortia of organizations and industry leaders involved in water-related education, research, and business to present their vision and strategy for EIT Water. As a key component of Horizon Europe, the EU's research and innovation framework program, the EIT will implement an integrated approach that encompasses freshwater, marine, and maritime sectors and ecosystems. This initiative will support entrepreneurial education and skills development, foster innovation projects, and facilitate the creation and commercialization of new technologies, products, and services.

The initiatives mentioned above clearly demonstrate that water is at the centre of current EU policy. The call for a more comprehensive EU water policy highlights the importance of water issues within the broader EU environmental and climate agenda moving forward.

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Annex A Methods, framework, and resources

A.1. Literature review and quantitative data collection

The literature review established the foundation for the overall synthesis and analysis of the current study. Given its critical role in addressing all research questions and guiding other research activities, the review drew from a wide array of sources. These included EU policies, data from relevant agencies, academic research, future scenario studies, position papers from key stakeholders, and analyses from NGOs. The review encompassed publications from the last ten years, addressing water scarcity at the EU level and highlighting regional disparities.

The qualitative analysis included an extensive review of both academic and grey literature. In total, we analysed 256 documents of which 89 were found relevant for the study. These included academic papers, specific chapters of specific books, EU directives and regulations, publications and reports, strategies and strategic agendas, and certain libraries and repositories.

These documents were further analysed and codified in Atlas.ti using the codebook appearing in Table 5. The codebook includes 39 codes, distributed across seven (7) groups (time horizon, regionality, sectors, trends, water use & consumption, water availability/scarcity, policies & actions) that are linked to the different research questions and sections of the report. The rationale behind the codebook design was to cover all the areas addressed by the research questions, while at the same time having exclusion criteria in terms of topics, sectors, geographical focus, and time frame. This structured approach enabled us to develop an understanding of the current situation and future trends regarding water scarcity in the EU.

In addition to the literature review, we have conducted quantitative data collection to contribute to the description of the current situation of water availability and use across the EU. The collection of statistics enabled us to identify trends from past to present and to sketch the current situation. We consulted a total of 33 databases from nine (9) sources. We analysed 27 of them that contained relevant information for the study. This data fed the analyses presented in the different sections of the report by providing relevant figures, charts, and key statistics that substantiated the arguments and statements.

Table 5: Codebook used for qualitative analysis

Group	Codes
Time horizon	➢ Now/today ➢ Shor term/towards 2030 ➢ Long-term/towards 2050 ➢ Climate change scenarios/effects ➢ Inspiration for 2050 scenarios ➢ Inspiration for future policy scenarios ➢ Seasonality/Extreme events
Regionality	➢ Northern Europe ➢ Southern Europe ➢ Western Europe ➢ Central and Eastern Europe ➢ Regional disparity
Sectors	➢ Agriculture ➢ Electricity production ➢ Industry ➢ Household consumption ➢ Sectoral disparity

Trends	➢ Environmental trend ➢ Climatological trend ➢ Technological trend ➢ Societal trend ➢ Economical trend ➢ Ethical trend ➢ Political trend ➢ Legal trend
Use and consumption	➢ Water sources and abstraction ➢ Water use ➢ Water consumption ➢ Main users and consumers of water ➢ Data
Availability/Scarcity	➢ Water availability ➢ Water scarcity issues ➢ Impact/implications of water scarcity ➢ Droughts
Policies & Actions	➢ Water management and governance ➢ Current freshwater (scarcity) policies and actions ➢ EU policies and legislation ➢ Other EU activities/actions ➢ Inspiring policy practices at national/regional level

Source: Technopolis Group, 2024.

A.2. Workshops and interviews

Interviews with experts and stakeholders in the water domain across the EU

The purpose of the interviews was to enhance our understanding gained from the literature review and horizon scanning concerning the current situation, trends, future challenges, expected impacts, and potential policy actions for both the short and medium- to long-term. These interviews also filled in gaps in the qualitative and quantitative data we collected. The insights gathered from the interviews are presented in various sections of the report in an aggregated format. In total, we conducted 18 in-depth interviews with key stakeholders in the water sector. This group included NGOs, international organizations, policymakers, water users and consumers, stakeholders involved in water governance, management, and supply, as well as academic experts and representatives from research institutes. Table 6 provides an overview of the consulted stakeholders.

Regional Three Horizons Workshops

To generate and analyse the views and ideas of stakeholders and experts regarding the future of water scarcity (including water availability and usage), we organised two interactive workshops. The objectives of these regional workshops were to (1) validate findings primarily from the as-is analysis, (2) gather expert input on Three Horizons (including trends), and (3) provide direction for scenarios and policy options. To reflect the regional diversity of the water scarcity issue, the workshops were held in two different regions, each addressing the problem of water scarcity in its own manner.

We selected the North-South and Delta-Land regions, specifically the BE-DE-NL Delta and the Iberian Peninsula (SP/PT). These areas have distinct (hydrological) ecosystems and different approaches to drought management. The Iberian Peninsula, in particular, is experiencing severe drought and is expected to be significantly affected by climate change in terms of drought. The two workshops took place in-person: one in Maastricht, the Netherlands, on October 30, 2024, with 15 participants, and the other in Faro, Portugal, on November 7, 2024, with 14 participants. Holding the workshops in person facilitated greater interaction, involvement, and concentration among participants. Each workshop lasted half a day and included a mix of individual and group assignments. Individual assignments allowed participants to express their personal thoughts and views clearly, while group assignments encouraged collaborative discussions and collective output. The group discussions used the "World Café" method, where participants engaged in conversations about various developments at different tables throughout the workshop. This format ensured that all topics were adequately addressed and that discussions included multiple perspectives. Additionally, the workshops explored anticipated trends and developments related to water scarcity and its (social) context over the coming years. We focused on developments in society, technology, economy, environment, politics/legal matters, ethics, and demography (STEEPED). We distinguished between short-term trends (up to 2030) and long-term trends (up to 2050). The outcomes of these discussions helped us assess the degree of uncertainty surrounding long-term trends and identify which uncertain long-term trends are expected to have the most significant impact. The combination of long-term trends that are both sufficiently uncertain and relevant to water scarcity served as the foundation for the scenarios that were developed.

At the end of the workshop, participants received a summary report. The workshops were conducted in accordance with the Chatham House Rule, which ensures that the report and outcomes cannot be traced back to individual participants. This approach fosters a secure environment that allows participants to express themselves openly and share their knowledge and personal insights freely. Table 6 provides an overview of consulted stakeholders, including the Three Horizons workshop.

Validation and policy workshop

The validation and policy workshop had two main objectives. First, it aimed to validate the findings and preliminary conclusions from the study, as well as the medium- to long-term scenarios developed. This process strengthened the study's robustness and resulted in some modifications to the scenarios. Second, the workshop provided a platform to discuss potential policy options derived from these scenarios, ultimately leading to the selection of several relevant policy options as previously described.

We invited a group of experts, stakeholders, and policymakers to participate in the workshop, which took place on December 4th. Our expert panel also attended and contributed to the discussions.

The workshop was organised online via the Teams platform and lasted for two hours. The study team presented the key findings from their analysis of future water availability and usage in the EU, highlighting trends and impacts of the proposed medium- to long-term scenarios, followed by a plenary discussion. After this, the team presented a long list of policy options, which led to a policy options exercise in breakout groups. One group focused on short-term policy options, while two additional groups discussed medium- to long-term options. The workshop concluded with closing remarks that addressed the key themes that emerged from the breakout discussions. Table 6 provides an overview of consulted stakeholders, including the validation workshop.

Table 6 List of consulted stakeholders

Organisation	Type of involvement	country
Aachen University	Three Horizons workshop	Germany
Aggregates Europe – UEPG	Interview	EU-27
Águas do Algarve	Three Horizons workshop	Portugal

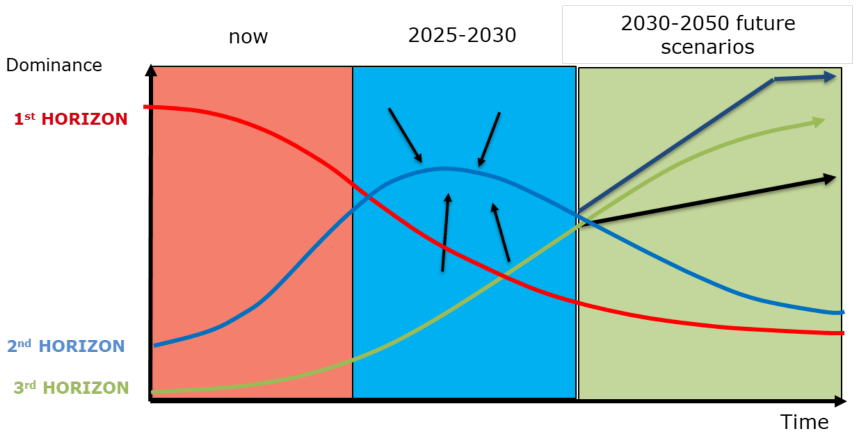
Algarve Regional Coordination and Development Commission (CCDR)	Three Horizons workshop	Portugal
Algarve Regional Coordination and Development Commission (CCDR) department for agriculture and fisheries	Three Horizons workshop	Portugal
Aqua Publica Europea	Interview	EU-27
Brabantse Delta	Three Horizons workshop	The Netherlands
CCVALG (Algarve Life Sciences Centre)	Three Horizons workshop	Portugal
Centro de Investigação Marinha e Ambiental (CIMA)	Three Horizons workshop	Portugal
Deltares	Three Horizons workshop	The Netherlands
EurEau	Interview & validation workshop	EU-27
Eurelectric	Interview	EU-27
European Commission – DG AGRI	Interview & validation workshop	EU-27
European Commission – DG CLIMA	Interview & validation workshop	EU-27
European Commission – DG ENV	Interview & validation workshop	EU-27
European Commission – DG RTD	Interview	EU-27
European Commission - Joint Research Centre (JRC)	Interview & validation workshop	EU-27
European Conservation Agriculture Federation	Interview	EU-27
European Economic and Social Committee (EESC)	Validation workshop	EU-27
European Environmental Agency	Interview	EU-27
European Water Association	Interview	EU-27
Federal Ministry for Environment, Nature Conservation and Nuclear Safety	Three Horizons workshop	Germany
French National Research Institute for Agriculture, Food and Environment (INRAE)	Interview	France
Municipality of Brabant	Three Horizons workshop	The Netherlands
Municipality of Limburg	Three Horizons workshop	The Netherlands
Municipality of Loule	Three Horizons workshop	Portugal
Rijkswaterstaat	Interview & validation workshop	The Netherlands

Technopolis Portugal	Three Horizons workshop	Portugal
Universite de Liege – Aquapole	Three Horizons workshop	Belgium
Universiteit Maastricht	Three Horizons workshop	The Netherlands
University Algarves (UALG)	Three Horizons workshop	Portugal
Vlaamse Milieumaatschappij	Three Horizons workshop	Belgium
Vrije Universiteit Brussel	Three Horizons workshop	Belgium
Wageningen University	Three Horizons workshop	The Netherlands
WaterEurope	Validation workshop	EU-27
Watermaatschappij Limburg	Three Horizons workshop	The Netherlands
Waterschap Limburg	Three Horizons workshop	The Netherlands
Wetsus	Interview	The Netherlands
World Wide Fund for Nature (WWF)	Interview & validation workshop	Global

A.3. Foresight methods and frameworks

The methodology applied in exploring possible futures related to water scarcity is a combination of three methodologies: horizon scanning, the scenario methodology, and Three Horizons. We decided to combine these three methods because exploring the future of water scarcity requires exploring the context of that topic and (therefore) taking into account multiple possible futures related to that topic. The division of the future of water scarcity into three-time horizons also argues for a methodology that does justice to this. The Three Horizons methodology mainly functions as an ordering framework for the various future trends and developments in the field of and relevant to water scarcity. In the 3rd time horizon of that model, we placed the four scenarios.

Figure 17: Three Horizons



The Three Horizons are shown in Figure 17 With this we want to show that the horizons exist separately as well as that they are related to each other. The further we look into the future, the greater the trends outlined will be uncertain, which justifies the decision to work with multiple scenarios in the third horizon.

Horizon scanning

Horizon scanning is a foresight method that focuses on exploring many different possible developments on a broad scale and long-term. In this foresight study it was decided to investigate the short term by doing desk research and expert-interviews horizon scanning.

The long-term developments were explored in the two regional workshops where we asked participants what relevant developments they see in various areas (demography, economy, social, technology, ecology, politics). To inspire them, we have shown a number of long-term developments in these two regional ones that we have found in other horizon scans (from the OECD, UN, WHO, JRC, among others):

- Demography: Migration, aging of society
- Economics: Increase global trade, rise of the green economy, changing nature of work
- Social: More individualism, widening inequalities, urbanisation
- Technology: AI, Quantum, genomics, accelerating technological development
- Ecology: Aggravating resource scarcity, climate change, decreasing biodiversity
- Political: Rise of populism, increasing demographic imbalances, expanding influence of East and South

Three Horizons Framework

The **Three Horizons Framework** is a foresight method used to explore and manage change over time by focusing on three different time horizons:

- **Horizon 1 (H1)**: Represents the current system, practices, and trends that are dominant but may be unsustainable or declining. In the context of water scarcity H1 represents the as-is situation and current trends in water scarcity in the EU covered in Chapters 3...
- **Horizon 2 (H2)**: Reflects to the short-term future (next 5 years) and the emerging innovations, disruptions, or transitional activities that challenge the current system and begin to shape the future. In the context of water scarcity H2 is covered in Chapter 5
- **Horizon 3 (H3)**: Envisions a long-term future, representing transformative change and-potentially-entirely new systems or solutions. In the context of water scarcity, H3 is covered in Chapter 6

The H3 framework helps stakeholders to identify short-term actions (H2) that can bridge the gap between the current challenges (H1) and a sustainable future (H3).

In this foresight study, we applied the Three Horizons methodology slightly differently. The first horizon was used both to map developments that show that the problem of water scarcity is a serious problem and to investigate a number of more neural but relevant developments. In addition, we used the third horizon not so much as a wishful image, but as the time dimension in which we positioned four scenarios that are relevant for the development of strategic policy on water scarcity.

Scenarios

The scenario method was used due to the long-term nature of water scarcity. Scenarios are narratives set in the future that explore how a future situation—specifically, water scarcity—could change if certain trends were to strengthen or diminish, or if various events were to occur. Scenario planning does not aim to predict what will happen; instead, it identifies a limited set of possible futures through a formal process. These scenarios serve as valuable reference points for evaluating current strategies or developing new ones. This method challenges assumptions about the future and instils confidence to act in the context of uncertainty.

The scenarios in this study are based on two 'critical uncertainties'—two trends that remain uncertain in terms of whether they will continue in a specific direction in the future. However, the impact of these uncertain trends is significant when considering the potential future of water scarcity. In this foresight study, the governance of water scarcity is treated as a dependent variable, with the selection of critical uncertainties situated within the contextual environment of the subject. The time horizon for the proposed scenarios is set between 2030 and 2050. The project team selected the 'critical uncertainties' from a range of uncertain trends identified through a literature review and discussions held during two regional Three Horizons workshops—one in Maastricht (the Netherlands) and one in Faro (Portugal). There are various methods for developing future scenarios. The most common approach involves identifying two trends that are both highly relevant and significant from a larger collection of trends and developments. Once these two extremes are identified, a 2x2 matrix is created, resulting in four quadrants, or scenarios. This study's comprehensive list of developments is based on the literature review and the outputs from the two regional Three Horizons workshops where participants brainstormed potential future developments that could impact water scarcity. The trends that are candidates for serving as scenario axes are termed 'critical uncertainties.' These are developments that are recognized as relevant, but their future directions cannot be predicted with certainty. Furthermore, differing opinions among workshop participants regarding the certainty of a trend are also considered a form of uncertainty. Thus, the lack of consensus does not necessitate a compromise, but rather highlights the trend's uncertain status. From the comprehensive list of trends generated through the horizon scan and workshops, two critical uncertainties were identified. In addition to the criteria of relevance and uncertainty, three other criteria were considered:

1. Orthogonality: The selected axes should not correlate with each other. For meaningful scenarios, the two axes must be independent, ensuring that all four quadrants provide distinct scenarios.

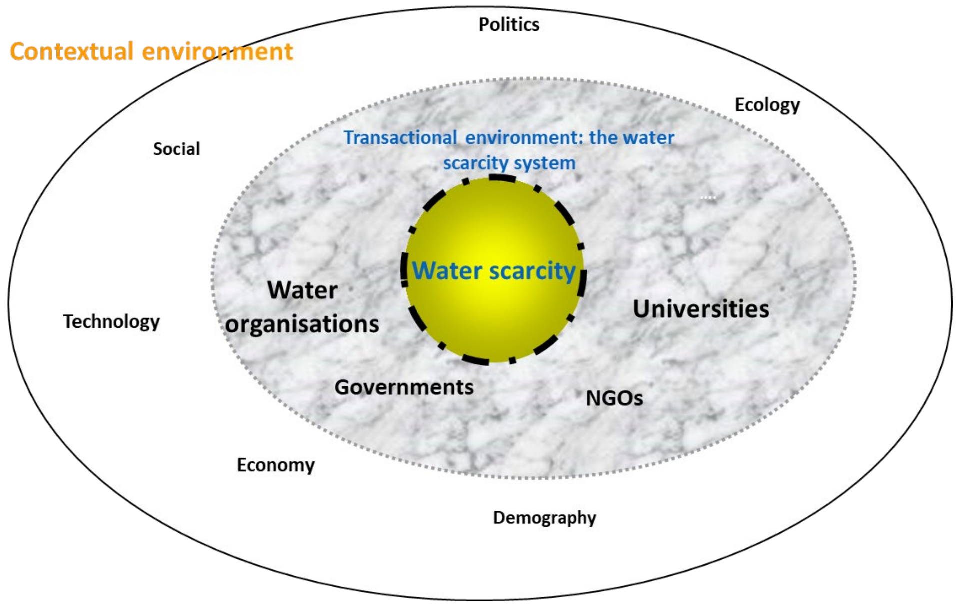
Equal Level of Detail: The axes must be comparable in terms of detail so that they are of similar magnitude and can be meaningfully integrated.

Contextual Relevance: The axes must be situated within the context of water scarcity issues, ensuring that no specific future scenario is chosen that would predict the future in a deterministic manner.

The scenarios that have been built are of course not an end in themselves. The scenarios describe possible future contexts in which water scarcity has a certain character and meaning. For example, in the scenario 'Let the games begin!' (see section 1.1.4) the problem of water scarcity is mainly considered from an economic perspective, so that the policy options that will be effective in that scenario must that take it into account and will therefore have a strong economic and financial character. The scenarios thus act as a kind of lens through which the view on relevant and effective strategic policy to address the problem of water scarcity looks different. This does not mean that an (the) E.U. policy-goal with regard to water scarcity is always different. The different scenarios only show (and inspire to) that in different futures different water scarcity policies are required to achieve the set policy goal. The policy should fit the scenario to realize the policy goal.

Figure 18 shows how the scenarios relate to policy related to water scarcity. The picture must be considered from the outside in. Water scarcity is surrounded by two 'spheres', as it were, that influence its future course. The transactional environment contains all actors who have a certain role with regard to water management in general and water scarcity in particular. The contextual environment is the 'shell' that contains all long-term developments. The strategic policy with regard to water scarcity is therefore determined, as it were, by these two shells that will have a different structure in each scenario. In the 'Let the games begin!' scenario (see section 1.1.4), economic and technological developments will have the upper hand and actors in that area will also be very important and the water scarcity policy must be in line with this.

Figure 18: Relationship between scenario's and water scarcity policy



Developing policy options

Based on information gathered from previous activities, including a literature review and stakeholder consultations, we initially created a comprehensive list of policy options. From this list, we developed five policy options in greater detail. We formulated two policy options aimed at addressing acute water shortages and the effects of droughts on key sectors in the short term (by 2030). Additionally, we established three policy options that focus on structural changes to enhance efficient water use, management, and the resilience of the water system for the medium- to long-term (2030-2050). These medium- to long-term options are linked to or derived from three contextual scenarios.

Starting with a broader range of policy options for both short- and medium- to long-term considerations (the latter derived from previously developed scenarios), we discussed these in the validation and policy workshop to prioritise and select the most relevant options. The feedback we received during these validation workshops was instrumental in refining and selecting the final policy options in collaboration with our expert panel.

The policy options were developed based on an analytical framework that considers the timeframe for implementation (short-term or medium- to long-term), associated contextual scenarios (relevant only for the medium- to long-term), the rationale behind the proposed options, their objectives, examples of potential interventions, and expected impacts. Furthermore, we analysed the proposed options against a set of qualitative criteria, detailing their costs, benefits, impacts, risks, and uncertainties.

Table 7 provides an overview of qualitative assessments of short term policy options and Table 8 provides an overview of qualitative assessments of medium- to long-term policy options.

Table 7: Qualitative assessment of short term policy options

Assessment dimension	Qualitative assessment	
	Policy option A: "Develop and implement strategies and measures to reduce water use/consumption in times of water scarcity"	Policy option B: "Integrated EU-wide water strategy and legislative framework to mitigate water scarcity impacts"
Costs	For EU and Member States costs are related to the development and implementation of new water pricing/taxation schemes, installation and maintenance of smart metering. At the same time new water pricing/taxation schemes could generate additional income for governments. These measures could also reduce costs for governments, which also holds for (commercial) drought insurances. Water intensive sectors will see an increase in costs due to changing pricing/taxation and required drought insurances and further investments to improve water efficiency. Comparative score: -1	For EU (incl. institutions such as the EIB) and Member States costs are related to the development and implementation of the revised WFD, Floods Directive and increased funding targeting improved water infrastructure the EIB. The latter will require funding in the order of several billion euros. No or limited additional costs are expected for the private sector or for citizens. Comparative score: -2
Benefits	Reduced water use/consumption and increased water efficiency in water-intensive sectors. Less use of water for non-essential purposes. Tax revenues for government or more income for public water companies to invest in better water management/supply and to address water scarcity. Improved data availability and insights on water quantity. Lower impact of water scarcity on society. Comparative score: +1	More holistic water management across EU, including both quantitative and qualitative aspects of water. Enhanced preparedness for droughts and water scarcity and better climate resilience. More innovations addressing water scarcity will enter the market (faster). Comparative score: +1
Feasibility	Willingness to accept different water pricing/taxation and to implement that in a practical and just manner (without harming affordability of water for citizens). Commercial feasibility (business case) for drought insurances with sufficient coverage and affordability. Comparative score: 0	Requires amendments/additions to the WFD and new directive on droughts. This requires political will and alignment of key stakeholders across the EU (which may be quite feasible as urgency for water scarcity is widely felt). (Re)allocation of funding to water scarcity related high-TRL innovations and business support and to investments in water infrastructure. Comparative score: +1
Effectiveness	Direct effect in reduced water use/consumption in water intensive sectors due to pricing/taxation. Indirect effect in increased water efficiency due to higher costs of water due to pricing/taxation. Indirect effects through better water data availability, which can be used for better water management (improved supply) or better	The combination of enhanced regulatory interventions with investments could have direct short-term effect on enhanced water security, improved resilience to climate change, and could promote sustainable water management practices/tools. Comparative score: +2

	prediction/preparation for drought/water scarcity. Comparative score: +2	
Sustainability	No adverse sustainability effects are anticipated. The interventions are expected to enhance digital water management and incentivise efficient water use in the longer term. Comparative score: +2	No adverse sustainability effects are anticipated, provided that sustainability is included as a requirement in investments and funding. Comparative score: +2
Risks, challenges and uncertainties	Data accuracy, misuse, and privacy concerns related to smart metering. Smart metering integration and compatibility and durability with regards to the existing water management systems. Ensure equitable distribution of taxes based on usage identification and prioritisation. Comparative score: -1	Lack of technical knowledge or capacity in certain Member States to implement NBS or modern water infrastructure. Prioritisation of investments given conflicting priorities among countries and sectors, such as agriculture, energy and urban planning. Comparative score: -1
Coherence EU policy objectives	Coherent with EU objectives is strengthened. However, further regulatory measures are required to ensure implementation of suggested interventions. Comparative score: +1	Coherent with the existing WFD, as well as with the European Climate Law, and relevant strategies such withing the context of the European Green Deal and the EU Climate Adaptation strategy. Comparative score: +2
Societal & ethical impact	Public resistance to different pricing/taxation in case sectors and/or consumers feel unfairly targeted. Equitable water pricing/taxation for citizens: how to ensure that essential water use is affordable for all? Lack of proactiveness in water storage/use efficiency due to heavy reliance to water insurance as a safeguard. Comparative score: -1	Disparities in investments and allocation of funding across Member States. Drought management involves multiple sectors (agriculture, industry, energy, etc.) and may require difficult trade-offs between competing interests, making it socially and politically challenging. Comparative score: 0
Regulatory impact	Need for clear regulatory framework for deployment of smart metering in certain sectors or private wells. Policymakers need to carefully define what constitutes "water-intensive" businesses and set appropriate thresholds for insurance requirements. Comparative score: -1	Requires considerable amendments and additions to the existing WFD both at EU and MS level. Requires the adoption of a new drought directive, leading to additional EU regulation to be transposed at MS level. Comparative score: -1

Table 8: Qualitative assessment of medium- to long-term policy options

Assessment dimension	Qualitative assessment		
	Policy option C: "Do things differently – Innovate and prepare for radical change"	Policy option D: "Business as usual - Regulate and innovate to preserve"	Policy option E "Ensure cooperation – Change governance and innovate for the future"
Costs	For EU costs are associated to the EU wide water scarcity campaign (order of millions of euros) and for R&I investments in radical solutions for water scarcity (or reallocation of existing investments, order of billion euros). For MS and EU costs are associated with developing and implementing socially equitable dynamic water pricing and taxation, as well as the integrated EU water strategy. The just structure economic reform of regions may be associated with transitional costs, subsidies and investments for EU, Member States and private sector. Private sectors and citizens may face additional costs due to dynamic pricing/taxation and required investments. Comparative score: -2	For EU costs are associated with R&I investments in solutions to keep water use behaviour as-is (or reallocation of existing funds, order of billion euros). For MS and EU costs are associated with the development and implementation of regulations to ensure the provision of water for essential use. This may require investments by Member States in their water supply infrastructure and water management. The private sector may face additional costs due to water efficiency and reuse targets, as well as requirements for water efficiency labels of their products. Enforcement and monitoring may result in additional costs at EU and/or MS level. Comparative score: -1	For EU costs are associated with extending the WFD and implementing the shared water competence centre. Furthermore, some additional EU funds would be needed or could be reallocated for R&I investments for collaborative solutions for water scarcity and for funding to strengthen regional economies while addressing water scarcity (in total of the order of several billion euros). For Member States, some small costs would be required for sharing lessons and best practices and for additional cross-boundary cooperation in the WFD. Comparative score: 0
Benefits	Better understanding of the real value of water, water scarcity and the need to be water efficient and reduce water use/consumption in society. Increased water efficiency, reduced water use and consumption. Better preparation of economy and society for a future with more droughts, water scarcity and climate change. Tax revenues for government or more income for public water companies to invest in managing water scarcity. Stronger EU position in radical water innovations. Comparative score: +2	Increased water efficiency and water reuse, reduced water use and consumption. Sufficient water for essential use (to citizens) to keep business as usual. Stronger EU position in water supply and water efficiency innovations. Comparative score: 0	Stronger EU-wide collaboration on addressing water scarcity (which is efficient). Additional regional and sectoral funding for Member States to tackle water scarcity. Stronger regional economies while addressing water scarcity. Reduction of water scarcity and/or improved approaches to deal with water scarcity. Stronger EU position in innovations to tackle water scarcity. Comparative score: 0

Feasibility	Willingness to accept different water pricing/taxation and to implement that in a practical and just manner (without harming affordability of water for citizens). The EU water scarcity campaign could help to improve this willingness. Feasibility depends on the acceptance and potential for regions to change their economic specialisation to the available water Depends on the successful development and implementation of radical innovations (incl. NBS). Comparative score: -1	Less of a transition and less change required by society and businesses. Feasibility depends on whether Member States can ensure provision of water for essential use and whether they accept this responsibility. Depends on the successful development and implementation of innovations (incl. NBS). Comparative score: 0	Most interventions in this policy scenario are extrapolations of current interventions or a smaller next step. Depends partly on the successful development and implementation of innovations (incl. NBS). Comparative score: +2
Effectiveness	Direct effect on reduced water use/consumption among all water users due to pricing/ taxation and changing economic specialisation to the availability of water. Direct effect on changed value for water in society. Indirect effect on increased water efficiency due to higher cost of water, campaign and innovation. Indirect effect on increased or improved water supply/reduced water scarcity due to successful radical innovations. Comparative score: +2	Direct effect on reduction of water use to essential use in times of water scarcity. Direct effect on increased water efficiency and water reuse. Indirect effect on increased or improved water supply/reduced water scarcity due to successful innovations. Comparative score: +1	Direct effect on cooperation to address water scarcity to improve measures and investments on water scarcity. More indirectly effect on reduced water scarcity, through collaborative interventions and the adoption of successful innovations in sectors and regions. Comparative score: 0
Sustainability	No adverse sustainability effects are anticipated. All actions should contribute to more sustainable use of water and ecosystems, partly dependant on the success and implementation of radical innovations. Comparative score: +2	No direct adverse sustainability effects are anticipated, although keeping up business as usual and requiring Member States to provide water for essential use in the future may result in further stressing the water ecosystem (perhaps not within the MS but in other regions) or unknown effects (what is the long-term systemic effect of for instance smart rainfall enhancement or desalination?). This may depend on the type of innovations that will be successfully adopted. Comparative score: +1	No adverse sustainability effects are anticipated, provided that sustainability is included as a requirement in investments and funding. Comparative score: +2

Risks, challenges and uncertainties	Ability of societies to radically change and acceptance of the private sector to engage in a just structural economic reform. Effectiveness of water scarcity campaign. Pace of implementation should be higher than increase of water scarcity to prevent substantial negative impacts of water scarcity. Success of radical innovations. Comparative score: -2	A risk might be that the efforts in keeping business as usual is in some regions not enough to avoid significant impacts of water scarcity. Acceptance of Member States to have the obligation and task to ensure provision of water for essential use. Pace of implementation should be higher than increase of water scarcity to prevent substantial negative impacts of water scarcity. Success of radical innovations. Comparative score: -2	A risk could be that collaboration and innovation might be not enough and too slow. Radical change and/or regulation might be needed to address water scarcity timely. Cooperation might be challenging as not all regions/ Member States face water scarcity as much as others and thus efforts in collaboration may be lower. Comparative score: 0
Coherence EU policy objectives	Coherent with existing EU policy objectives esp. those related to the Green Deal (just transition), WFD, Horizon Europe. More radical in approach than common at EU level and requires regulatory measures to ensure implementation of suggested interventions. Comparative score: +1	Coherent with existing EU policy objectives esp. those related to the Green Deal (just transition), WFD, Horizon Europe. Requires additional regulatory measures to ensure implementation of suggested interventions. Comparative score: +1	Coherent with existing EU policy objectives esp. those related to the WFD, Horizon Europe, CAP and regional policy. Requires no additional regulation and takes a common approach through many existing instruments. Comparative score: +2
Societal & ethical impact	Societal acceptance of radical change, dynamic pricing and just structural reforms (although the awareness raising campaign should help in increasing acceptance) Ethical implications of just structural economic reforms: change economic structures, crops, reliance on trade, limits to population growth set by availability of water. Equitable water pricing/taxation for citizens: how to ensure that essential water use is affordable for all? Take responsibility for climate change implications and prevent society from prolonged water scarcity. Comparative score: -1	Ethical question is whether governments should have the responsibility to provide citizens with essential water at all times and can refuse citizens to provide water for non-essential use in times of water scarcity. Or is this more or less implicitly already a role for governments (as part of their role in keeping citizens healthy and safe)? At what societal costs should governments still be required to do that (of we assume no changing pricing and taxation mechanisms)? Comparative score: +1	No ethical or societal concerns are anticipated with collaboration and (re)allocating regional or innovation funding in this policy option. Comparative score: +2
Regulatory impact	Policymakers need to carefully define what constitutes "essential water use".	Policymakers need to carefully define what constitutes "essential water use".	Requires little changes to regulations or directives, perhaps only the WFD. Most

	New regulations/directives should be in place to enable just structural reforms, socially equitable dynamic water pricing/taxation and potentially for an integrated EU water strategy. Comparative score: -1	This policy option strongly relies on regulation. New regulations/directives should be in place for water efficiency and reuse targets and for ensuring provision of water for essential use. The latter relates to the EU defining an essential task/ fundamental role for Member States and may be difficult to regulate. Comparative score: -2	changes are required at instrument/intervention level. Comparative score: +2

A.4. List of used data sources and databases

Table 9: Data sources and databases

Data source	Databases
Eurostat	➢ Water statistics ➢ Annual freshwater abstraction by source and sector ➢ Water Exploitation Index Plus (WEI+) ➢ Water resources: long-term average ➢ Freshwater abstraction by source (m3 per capita) ➢ Water abstracted by sector of use ➢ Renewable freshwater resources ➢ Water made available for use ➢ Population connected to public water supply ➢ Water use supply category and economical sector ➢ Water use in manufacturing industry by activity and supply category ➢ Water use balance ➢ Water abstraction by river basin district (RBD)
OECD.Stat	➢ Freshwater abstractions
FAO	➢ Aquastat
Water Information System for Europe (WISE)	➢ WISE – Water Information System for Europe ➢ Ecosystems exposed to drought conditions in Europe ➢ Exposure of European ecosystems drought
European Environment Agency (EEA)	➢ Water abstraction by source 2000-2019 ➢ Water abstraction by economic sector 2000-2019 ➢ Waterbase – Water quantity ➢ Projected change in meteorological drought frequency between 1981-2010 and 2041-2070 under two climate change scenarios ➢ Water scarcity conditions in Europe
World Meteorological Organisation (WMO)	➢ Freshwater fluxes into the world's oceans ➢ Basins and sub-basins
Stars4Water	➢ Global Water Watch
European Drought Observatory	➢ European Drought Observatory

Source: Technopolis Group, 2024.

Annex B EU Legislative framework and policy initiatives on water scarcity

Table 10: EU legislative framework and policy initiatives on water scarcity

EU Legislation (Regulations/Directives)	Policy Objectives
EU Water Framework Directive (WFD) 2000/60/EC	➢ Ensure a good quantitative status of groundwater bodies ➢ Achieve good ecological status of surface water bodies ➢ Identify significant pressures from abstraction ➢ Obliges EU Member States to develop River Basin Management Plans (RBMPs). If RBMP measures are insufficient to avoid water scarcity and drought, then the development of a Drought Management Plan (DMP) is required as a supplementary plan
Directive on the protection of groundwater against pollution and deterioration 2006/118/EC	➢ Establish criteria for the assessment of good groundwater chemical status ➢ Prevent or limit inputs of pollutants into groundwater
Directive on the assessment and management of flood risks 2007/60/EC	➢ Establish a framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods in the Community
Regulation on minimum requirements for water reuse (EU) 2020/741	➢ Facilitate the uptake of water reuse whenever it is appropriate and cost-efficient ➢ Creates an enabling framework for Member States who wish or need to practise water reuse ➢ Provides harmonised minimum monitoring requirements ➢ Includes risk management provisions to assess and address potential additional health risks and possible environmental risks
Directive on the quality of water intended for human consumption (EU) 2020/2184	➢ Addresses leakage in the water supply network ➢ Ensure the establishment of monitoring programmes in each MS checking that water intended for human consumption meets the requirements set by the Directive
EU Policy initiatives (EC Communications/ Strategies/ Guidance Documents)	**Policy objectives**
EC Communication "Addressing the challenge of water scarcity and drought in the EU" COM (2007) 414 final	➢ Encourage Member States to identify river basins which face quasi-permanent or permanent water stress or scarcity ➢ Improve drought risk management ➢ Improve knowledge and data collection
EC Communication "White Paper: Adapting to Climate Change: Towards a European Framework for Action" COM (2009)147	➢ Build a solid knowledge base on the impact and consequences of climate change for EU water resources as a basis for developing sound adaptation strategies for water
River basin management in a changing climate. Guidance document No 24, 2009	➢ Illustrate ways in which preparations can be made by the Member States for climate change within the second and third River Basin Management Planning (RBMP) cycles, including provision for floods and droughts

	➢ Provide guiding principles for adaptation and relates each to steps in RBMP. The principles are intentionally broad to be applicable across all Member States regardless of regional variations in potential impacts
EC Communication "Blueprint to Safeguard Europe's Water Resources" (2012)	➢ Put quantitative water management on a much more solid foundation (incl. identification of the ecological flow[225]) and address the issue of over-allocation at the river basin scale ➢ Recognise that water quality and quantity are closely related within the concept of 'good status' ➢ Develop water efficiency targets for river basins which are (or are projected to be) water stressed, based on water stress indicators developed in the Common Implementation Strategy (CIS) process and applied at river basin scale ➢ Implement Water Accounts at river basin and sub-catchment level[226] ➢ Identify and reduce of illegal abstraction/impoundments
Guidance document on the application of water balances for supporting the implementation of the WFD, 2015	➢ Support the development and use of water balances at the river basin and/or catchment scales in the context of the EU Water Framework Directive (WFD) implementation, as pre-requisite to sound and sustainable quantitative management of water resource
Ecological flows in the implementation of the WFD. Guidance document No 31, 2016	➢ Provide an EU definition of ecological flows and a common understanding of how it should be calculated, so that ecological flows may be applied in the next cycle of river basin management plans (RBMPs) due for adoption by the end of 2015
EC Staff Working Document "Fitness Check of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive" SWD (2019) 439 final	➢ Evaluate the Directives against their objectives ➢ Assess their relevance as they were at the time of the adoption and whether they still fit for purpose
EC report on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) Second River Basin Management Plans First Flood Risk Management Plans COM (2019) 95 final	➢ Presents the state of implementation of the Water Framework Directive2 (WFD) and the Floods Directive3 (FD) based on the Commission's assessment of the second River Basin Management Plans (RBMPs) and first Flood Risk Management Plans (FRMPs) prepared and reported by Member States for the period 2015-2021
EC Communication "A new Circular Economy Action Plan For a cleaner and more competitive Europe" COM/2020/98 final	➢ Monitor and support the implementation of the requirements of the Drinking Water Directive to make drinkable tap water accessible in public places, which will reduce dependence on bottled water and prevent packaging waste

[225] The amount of water required for the aquatic ecosystem to continue to thrive and provide services.

[226] They can tell water managers how much water flows in and out of a river basin and how much water can realistically be expected to be available before allocation takes place.

	➢ Facilitate water reuse and efficiency, including in industrial processes
EC communication "A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system" COM/2020/381 final	The Farm to Fork Strategy aims to accelerate our transition to a sustainable food system that should: ➢ Have a neutral or positive environmental impact, including the preservation of freshwater ➢ Help to mitigate climate change and adapt to its impacts ➢ Reverse the loss of biodiversity, including water pollution ➢ Ensure food security, nutrition and public health, making sure that everyone has access to sufficient, safe, nutritious, sustainable food ➢ Preserve affordability of food while generating fairer economic returns, fostering competitiveness of the EU supply sector and promoting fair trade
EC Communication "EU Biodiversity Strategy for 2030 Bringing nature back into our lives" COM/2020/380 final	➢ Promote sustainable water resource management ➢ Assist restoring freshwater ecosystems and the natural functions of rivers to achieve the objectives of the Water Framework Directive ➢ Provide technical support to the Member States review water abstraction and impoundment permits to implement ecological flows to achieve good status or potential of all surface waters and good status of all groundwater by 2027 at the latest, as required by the WFD
EC Communication "Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change" COM/2021/82 final	➢ Builds on the 2013 Climate Change Adaptation Strategy and focusing on develop and implement solutions ➢ Boost adaptive capacity, strengthen resilience and reduce vulnerability to climate change as well frequency and severity of climate and weather extremes, including droughts ➢ Help ensure climate-resilient, sustainable use and management of water across sectors and borders by improving coordination of thematic plans and other mechanisms, such as water resource allocation and water-permits ➢ Help reduce water use by raising the water-saving requirements for products, encouraging water efficiency and savings, and by promoting the wider use of drought management plans as well as sustainable soil management and land-use ➢ Help to guarantee a stable and secure supply of drinking water, by encouraging the incorporation of the risks of climate change in risk analyses of water management

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This study aims to offer an in-depth analysis of water scarcity, availability, and usage in the face of climate change. By employing a comprehensive foresight methodology that includes an extensive literature review, qualitative and quantitative data analysis, and broad stakeholder consultation, the research provides a detailed overview of current water availability and consumption within the European Union (EU). It highlights the current and projected trends related to water resources, identifying the pressures and challenges that climate change imposes on water supply and demand. The study also proposes a range of policy options, divided into short-term options (up to 2030) and medium- to long-term options (up to 2050), aimed at ensuring that both EU citizens and businesses have reliable access to adequate water resources. These policy options are geared towards sustainable water management, ensuring resilience to future climate-related water challenges.

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