RESILIENCE IN ACTION

EUROPEAN ASSOCIATION OF PUBLIC WATER OPERATORS

Public Water Operators' Strategies to Tackle Water Scarcity and Drought

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This document was authored by the Secretariat of Aqua Publica Europea, specifically Milo Fiasconaro and Marine Boulard. The design was executed by Liliana Baracova. Any mistakes or inaccuracies found within are solely ours.

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BERNARD VAN NUFFEL

President of Aqua Publica Europea
President of VIVAQUA

42 Degrees is a thriller novel written by Wolf Harlander, first published in Germany in 2020. The story unfolds in a dystopian future where a severe drought impacts Europe. Despite being foreseen by experts, public authorities are caught unprepared: major rivers run dry with devasting consequences. Electricity is cut off, plants cannot be cooled, wildfires break out everywhere, and Russia invades Ukraine to save it from the effects of the drought. European societies teeter on the brink of political turmoil.

This dystopian future eerily resembles our recent past. Harlander's account is powerful as it vividly illustrates how the gap between our civilisation and barbarism is as small as a week's worth of available drinking water. Europe can and must manage the risks associated with water scarcity, especially since – as in Harlander's novel – these risks are clearly anticipated in the latest Intergovernmental Panel on Climate Change (IPCC) reports.

If water is a common resource that cannot be "produced", then there is a shared responsibility to design and implement actions that ensure its long-term sustainable management. The collective dimension of this task also lies in the fact that, while technological progresses will certainly help, there are no 'easy technological fixes' to address water-related challenges, as argued by the European Commission in the evaluation of the Water Framework Directive. Stakeholder engagement and democratic decision-making are therefore key to define a shared path regarding how water resources are used and allocated.

In this framework, water operators have a crucial role to play. This publication collects examples of how members of Aqua Publica Europea are preparing to tackle droughts and water scarcity. From campaigns to reduce water consumption and the stewardship of big industrial users to the interconnection of water systems, water operators can do a lot to prevent and mitigate the risks of water scarcity. One of the objectives of this publication is to provide an overview of actions that operators can take, and thus contribute to building reference material for the sector across Europe.

But the publication also has the ambition to trigger a reflection about what can be done by water operators in cooperation with other authorities and stakeholders. Indeed, many of the most effective actions to increase our resilience – from Nature-based Solutions to water reuse – cannot be carried out by water utilities alone but require coordination with other institutions and actors.

Moreover, most of these actions, not to mention difficult decisions on restrictions during severe droughts, have political implications. Thanks to their public ownership, water operators can provide objective information and solid plans that can help balance different interests and needs. The biggest responsibility of water operators is then to contribute, with ideas and capacity, to the definition of that shared path towards a sustainable use of water resources mentioned above.

If water operators bear important responsibilities in contributing to the definition and implementation of drought risk management plans, the final decision on the course of actions necessarily lies with democratically elected institutions.

As an elected official myself (Deputy Mayor for Water Management & Public Works in one of Brussels' municipalities), I very well know the difficulty of making these decisions, hence the importance of underpinning them with solid evidence and participatory processes. However difficult or time-consuming these decisions might be, there is no alternative. Choosing not to decide invariably leads to over-exploitation, resulting in even harsher conflicts between users. At the same time, attempts to "de-politicise" decision-making (e.g., by relying on water markets for allocation) have proven completely unsuccessful, and unsurprisingly so considering the common nature and the multiple values attached to water. As pointed out by the UN Rapporteur for the right to water and sanitation, Pedro Arrojo, these attempts neither reduced conflicts nor over-exploitation.

Finally, the collective dimension of our water management also extends to national and European policymaking. As Aqua Publica Europea, we eagerly look forward to the new guidelines on water scarcity and drought risk management being elaborated by Member States and the European Commission in the framework of an Ad Hoc Task Group under the Common Implementation Strategy of the Water Framework Directive. From the work seen so far, we are confident that these guidelines will provide a consistent reference framework for water authorities across Europe. Equally important will be the streamlining of water-specific impact assessments in other relevant policies, such as the Common Agricultural Policy and others, which are key for the green and digital transition, but which also address sectors having a significant impact on water resources. We are confident that the new 'water resilience initiative', announced by President von der Leyen in her latest State of the European Union address, will focus on the key challenge of ensuring a sustainable water balance across users and sectors, this being an essential condition to reconcile environmental, social and economic sustainability.

As Aqua Publica Europea, we are committed to ensuring that the public water sector in Europe is prepared for the challenges ahead. We will continue to contribute our ideas and opinions to the evolution of national and European policies.

INTRODUCTION

Climate change poses one of the most significant and pervasive threats to both nature and societies. Its consequences are far-reaching, with an intensification of extreme weather phenomena such as droughts, floods, and heat waves. Water is closely interconnected with the environment and thus profoundly affected by climate change, which is altering the hydrological cycle and negatively impacting both water quantity and quality. In this context of heightened risks, water operators have been at the forefront of the fight against climate change.

It is in light of this growing concern that the General Assembly of Aqua Publica Europea (APE), uniting 70 European public water operators, set the issue of drought and water scarcity as one of the key priorities of the organisation. As a result, the idea of developing a publication showcasing the good practices of member operators in this domain emerged. The objective of this publication is twofold.

Firstly, it aims to shed light on the work of member operators, as well as on their approaches and strategies in addressing these issues. **Secondly**, it seeks to address the question of the scope of responsibility of public operators to identify (1) the actions that can and should be carried out by operators independently and (2) those that can only be implemented in cooperation with other authorities and stakeholders. Ultimately, by collecting and sharing these good practices, the publication aims to contribute to the debate on the most effective solutions and governance arrangements for ensuring the sustainable management of water resources in the face of climate change.

This publication also comes at a time when water quantity issues are gaining centre stage in the EU political debate. In this framework, we hope that this publication will contribute, at its own level, to ongoing efforts aimed at tackling this challenge and will provide valuable additional reference material from the perspective of public water operators.

Setting the scene

In its AR6 Synthesis Report on Climate Change 2023, the Intergovernmental Panel on Climate Change (IPCC) stated that “With every increment of warming, climate change impacts and risks will become increasingly complex and more difficult to manage. Many regions are projected to experience an increase in the probability of compound events with higher global warming, such as concurrent heatwaves and droughts, compound flooding and fire weather”[1].

The intensity of the widespread drought that hit Europe in 2022 already bears witness to this, and operators in the water sector have had to cope with severe episodes of water scarcity. Although the year 2023 has not yet ended, it is clear that issues of drought, heat waves, floodings and water scarcity will continue to have a considerable environmental and social impact.

It should also be noted that, while climate change has increased water stress-related phenomena, water scarcity issues would materialise regardless. While there are clear indications that domestic consumption is decreasing, some important economic sectors – including those that are key for the green and digital transition – are particularly water-intensive. This creates systemic challenges in how we can ensure sustainable development for future generations[2].

Against this backdrop, public water operators bear the responsibility to adopt a proactive stance and contribute to the development of solutions and approaches that can help our societies tackle these – quite literally – vital challenges.

Outline of the publication and methodology

The information presented in this publication is based on the drought management strategies and quantitative management plans of public water operators, members of Aqua Publica Europea[3]. APE collected data from 19 operators located in Belgium, France, Greece, Hungary, Ireland, Italy, Spain, and the United Kingdom.

While the European Commission has defined the concepts of drought and water scarcity[4], it should be noted that these definitions are not uniformly adopted at national level. This results in a variability in definitions, which is also reflected in our members' documents. Although the question of definition is noteworthy, we have chosen not to address it, as it does not impact the analysis of the various strategies and the conclusions that can be drawn regarding the objectives of the publication, as outlined in the introduction. Similarly, there is a level of variability in the way water scarcity and drought risk management is approached and developed, and in the scope of responsibility of water operators, both within and across different countries. This publication therefore seeks to identify the common elements in the risk management plans of APE members in order to develop a general framework that could be used as a reference across Europe, while its different elements can be applied and implemented according to local conditions.

The publication will begin by exploring the water scarcity and drought risk management methodology and its main components, as they appear in our members' documents. It will then examine the array of actions that operators can implement to combat drought and water scarcity, considering what falls within their remit and what falls outside the scope of their sole responsibility. Finally, the publication will conclude with some political considerations and future perspectives.

I. Water Scarcity and Drought Risk Management

I. WATER SCARCITY AND DROUGHT RISK MANAGEMENT

Water scarcity and drought risk management is a methodology used by water operators to guide their actions in times of drought and water scarcity. It establishes the best course of action against different drought scenarios to prevent and mitigate their impact. In other words, risk management for water scarcity and drought is very much a **proactive approach** in which operators – either independently or in coordination with other public authorities and stakeholders – address potential sources of vulnerability, anticipate impacts, and plan and implement preventive or mitigation measures. Anticipation, planning and communication are indeed key to maximise effectiveness of interventions and minimise disruptions for domestic users and other stakeholders. The result of applying this methodology is the creation of a **risk management plan**.

As explored in our members' reference materials, there are common features in risk management approaches, which are summarised in the following table as a four-step methodology. It is important to note that the concrete declination of this methodology may vary from one situation to another.

Additionally, in certain contexts, such as in Spain, several components of the risk management approach are defined at the national level and then implemented within each river basin[5].

In contrast, in other contexts, such as in Italy and Belgium, some key components of the risk assessment are defined at the regional or local level. These differences can have significant implications for the "governance" of drought management, which we will discuss in the conclusion, including the challenges it may entail. Nevertheless, water operators typically play a role in all stages of the process, albeit to varying degrees depending on the national or local governance framework.

In the following pages, we will provide lighthouse examples of how APE members approach the steps of the risk management methodology, without discussing whether those steps should be carried out by the operator alone or in coordination with authorities and stakeholders. This point will be addressed later in the conclusion.

THE FOUR STEPS OF A WATER SCARCITY AND DROUGHT RISK MANAGEMENT METHODOLOGY

1 Conducting a risk assessment

- Identify the hazards, vulnerabilities, and risks in the relevant areas

2 Participatory production/elaboration

- Include relevant stakeholders in the development of the water scarcity and drought risk management plan to maximise results

3 Developing the risk management plan

- Monitoring
- Define indicators to assess the development of drought and water scarcity
- Establish drought and water scarcity scenarios
- Identify measures to be implemented

4 Evaluating

- Evaluate the effectiveness of implemented measures
- Evaluate the economic impact of the measures

1 Conducting a risk assessment

The initial step in the creation of a water scarcity and drought risk management plan (DRMP) is to identify vulnerabilities and risks. This process involves examining not only the water supply system, but also the environmental conditions of the geographical area under the operator's responsibility.

For the water supply system, a crucial aspect is to acquire a solid understanding and mapping of the available resources. This means having a detailed description of these resources, including volumes, flows, and information on abstraction points. The resources will then be classified according to their quality and quantity.

Ideally, the analysis underpinning the risk assessment should also include projections on future water balances that integrate the expected impact of climate change on water resource availability, of demographic and economic evolution on water demand, etc. This long-term analysis based on statistical models is indeed essential to increase the structural resilience of the system, as it facilitate the implementation of adaptation measures that require significant time and resources. In short, this long-term planning should help address not only the risk of acute drought but also of more structural water scarcity.

The risk assessment should also include a description of the operating rules of the water supply system under normal conditions and of the demand. The latter, especially in its expected evolution over time, is particularly relevant for long-term water quantity plans.

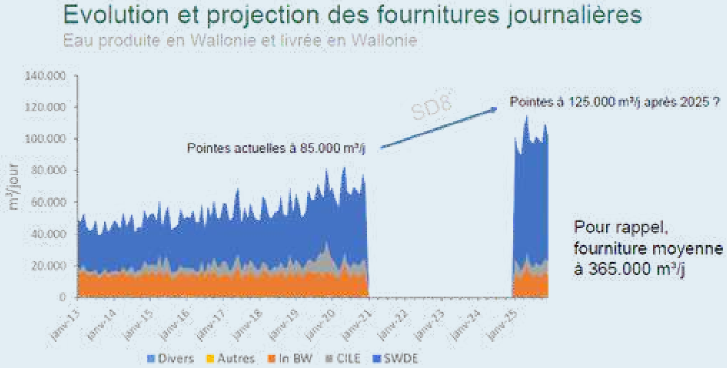
Finally, it is important to note that these plans are variable and contingent upon geographical, environmental, and institutional conditions within a given territory.

EXAMPLES:

VIVAQUA (Belgium) has developed a Water Quantity Plan: a risk analysis of the adequacy between its drinking water production, supply infrastructure and the water demand, also considering the impact of climate change. VIVAQUA manages 26 catchment sites in Brussels and Wallonia: 25 groundwater catchments and one surface water catchment (Tailfer on the Meuse River). It produces around 120 Mm³/year, with an average daily production between 320 000 and 360 000 m³ (potentially peaking at up to 450 000 m³ during heatwaves in May-June and September). 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 (in May-June and September). The recurrence of these three events has accelerated in recent years, increasing the likelihood of them occurring one after the other.

The winter droughts experienced by Belgium every 5 to 10 years are problematic for the production of drinking water from groundwater drainage galleries, which account for 40% of VIVAQUA's total production. The shortfall in aquifer recharge, affecting production from drainage galleries, has to be compensated by Tailfer (the Meuse River water treatment plant, contributing 40% of VIVAQUA's total production) and the Mons catchments (comprising 19 wells drilled in chalk with a mobilizable reserve of 4 000 m³ per hour).

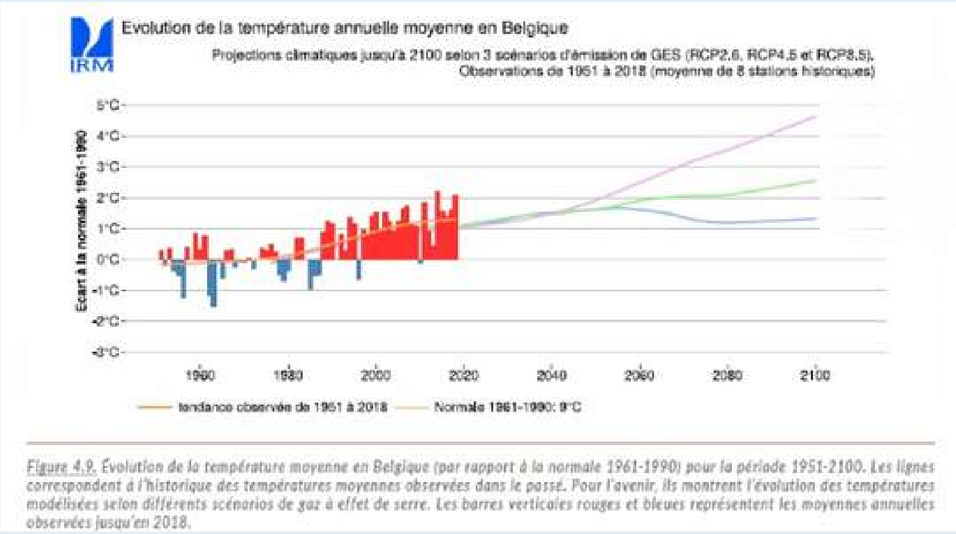


Graphic illustration of the expected evolution of water demand by 2025 in Wallonia.
Source: VIVAQUA Water Quantity Plan

However, droughts during spring and summer can lead to pronounced low-water level periods in the Meuse River, limiting the water that VIVAQUA can extract. Statistics on Meuse River water levels are compelling, showing a rise in severe low-water periods, both in frequency and duration. The interval between such low-water level instances has gone from 50 years to every 2 years. As a result, VIVAQUA has had to halve production at Tailfer during a week in 2020 and 2022 (from 185 000 to just 90 000 m³ per day) due to the lack of water in the Meuse.

Given the evolution of the Belgian climate, the risk of having to reduce production at Tailfer to a third of its maximum capacity (i.e., just 60,000 m³ per day) is now plausible. To prevent the depletion of a peat layer and soil compaction issues in the region of Mons, VIVAQUA maintains the groundwater level above a specified threshold. This ensures the availability of the resource during critical periods. This Water Quantity Plan has enabled VIVAQUA to anticipate the risks posed by climate change and to undertake initiatives to adapt its production facilities accordingly. **These iniciatives include**:

- Ensuring that catchments and the supply network are 100% operational
- Modifying the way drinking water is produced
- Rehabilitating old/abandoned catchments
- Optimising catchments
- Prospecting new catchments (e.g., deep aquifers in VIVAQUA’s sites or new ones in Brussels)
- VIVAQUA is also considering Managed Aquifer Recharge (MAR)



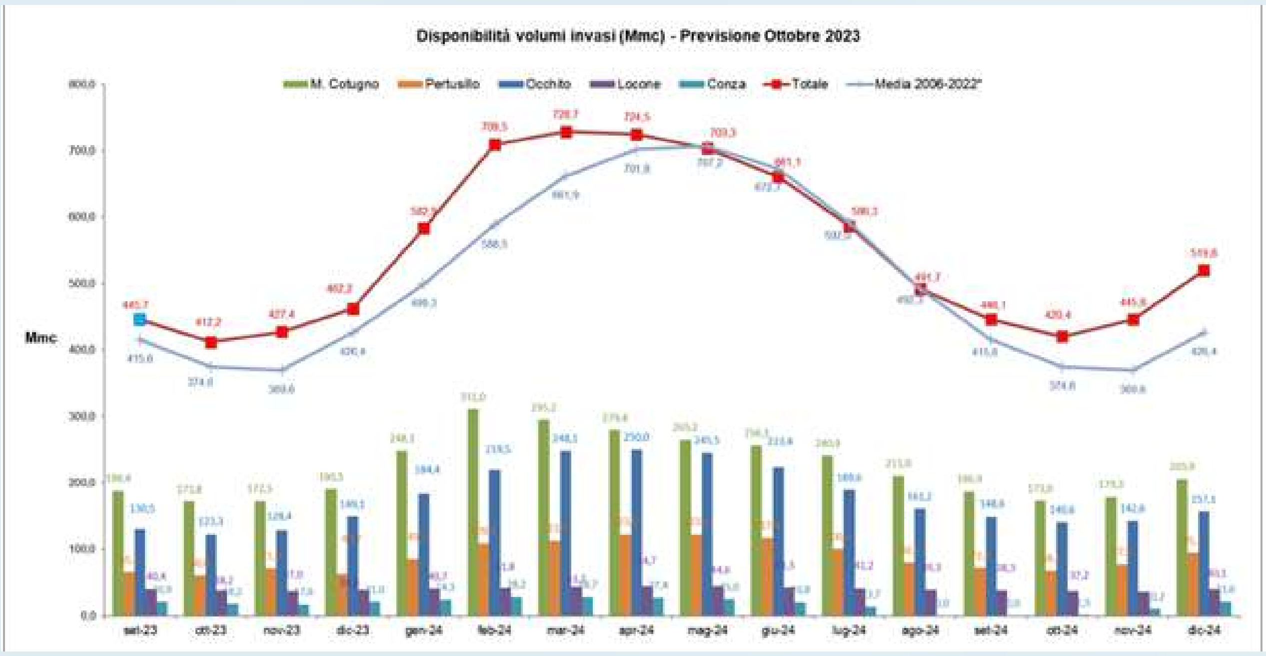
Expected average temperature evolution in Belgium.
Source: VIVAQUA based on data from the National Meteorological Institute

The supply system of **Acquedotto Pugliese (Italy)**, the operator of the Apulia region, is mainly fed by five artificial reservoirs, of which only one falls entirely within the regional territory it has the mandate to manage – the others are extra-regional reservoirs.

Acquedotto Pugliese (AQP) has therefore adopted tools to enhance its understanding of the hydrology of these supply sources in order to make its own assessments of short-to medium-term water availability. Thanks to this work, AQP has successfully reconstructed the monthly time-series of surface flows on sections of interest **using the following procedure:**

- The reservoir operating data (volumes invaded and volumes diverted for the various uses) were used to reconstruct outflows over the most recent periods
- Monthly regression models were calibrated between the outflows and rainfall for the reservoirs of interest
- Surface runoff was reconstructed for a homogeneous period starting in 1941, a year conventionally considered to be the first for which sufficient rainfall data was available for all the basins studied.

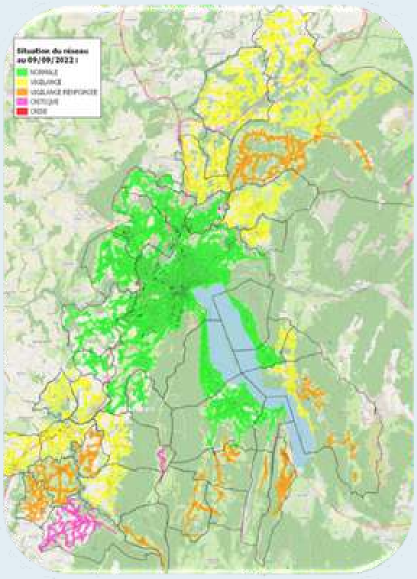
A forecasting procedure was then implemented, based on the correlation between runoff totals from the beginning of the hydrological year (September) up to the current month, and the total for the remaining months of the hydrological year. This procedure was calibrated using the reconstructed time series and adopted as a reservoir level forecasting tool by AQP. The procedure is coupled with the reservoir mass balance, taking into account planned disbursements for the following months. As a result, for each hydrological year and reservoir, a water availability forecast is prepared from the end of September to the end of the following August (projected over 11 months), with monthly updates until the end of July. This exercise provides them with a clear understanding of their water availability and allows for predictions to be made.



Projections of reservoirs volumes for October 2023 compared to the average 2006-2022 based on AQP forecasting model.
Source: Acquedotto Pugliese

Grand Annecy (France) is conducting several projects in the field of water resource management in the context of drought and climate change. For instance, the Chez Grillet aquifer, an important resource for the region, has been analysed and studied for several years with the support of a hydrogeologist. Its physical and hydrodynamic characteristics, operating history, and productivity are well documented and monitored.

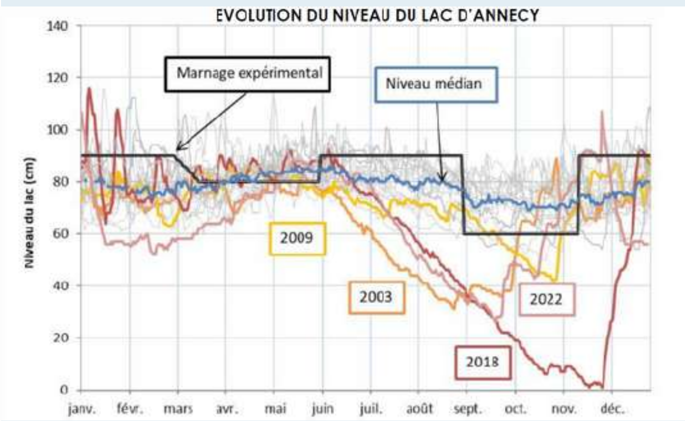
Through an integrated hydrological model that includes piezometric data, flow rates, and observed rainfall history, Grand Annecy endeavours to manage this resource sustainably, taking into consideration rainfall from previous months and groundwater recharge. Grand Annecy is also conducting a study, in collaboration with a consultancy, to assess the impact of climate change on the availability of water in Lake Annecy, the primary source used for the drinking water supply.



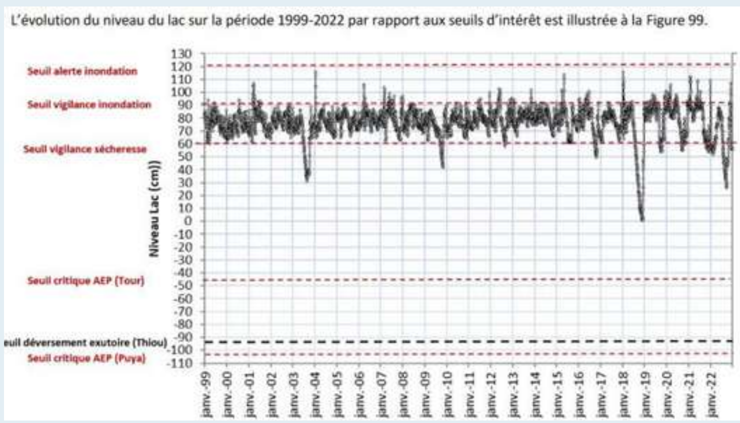
Network status on 09/09/2022
Source: Grand Annecy's presentation

THIS STUDY CONSISTS OF TWO PHASES:

- ▶ Phase 1 focuses on historical climate trends and their impact on water resources.
- ▶ Phase 2 addresses future climate trends and their impact on water resources. This includes data extraction, preparation and comparative analysis, an analysis of future climate for 3-time horizons (2021/2050 2041/2070 2071/2100), an analysis of the hydrological balance of Lake Annecy and impacts, and the development of adaptation strategies.



Evolution of the Lake Annecy water level.
Source: Grand Annecy's presentation on Phase 1 of the study



Evolution of Lake Annecy water level over the period 1999-2022 in relation to thresholds of interest
Source: Grand Annecy's presentation on Phase 1 of the study.

2 Participatory production/elaboration

The effective implementation of any policy, plan or programme that addresses water-related challenges requires the participation of those to whom it is addressed[6]. This is particularly important in the management of hydro-climatic risks such as droughts, as they might impact the functioning of our societies and involve difficult trade-off and prioritisation decisions. Moreover, information and data necessary for developing water scarcity and DRMPs may be scattered across various stakeholders and institutions. Consequently, this risk planning and management has to be approached as a **collaborative effort** in which all relevant actors are

Ideally, such participatory processes should be better coordinated by river basin authorities (RBAs), in line with Article 14 of the Water Framework Directive. This holds true whether or not the water scarcity and DRMP is integrated into the River Basin Management Plan because water quantity management encompasses all its different uses and not just the domestic one. While in many contexts such governance arrangements may not yet be fully developed, water operators undoubtedly have a role to play in driving participatory processes for the elaboration of water scarcity and DRMPs.

EXAMPLE:

Empresa Metropolitana de Abastecimiento y Saneamiento de Aguas de Sevilla, S.A.

Logo of EMASESA Water Observatory

EMASESA (Spain) has established a Water Observatory[7], which acts as a dynamic hub for public engagement and communication. This initiative fosters the organisation of conferences and interactive discussion forums. The main objective of each meeting is to provide information on the state of the system, the impact of proposed measures, the objectives to be achieved during the scarcity period, and the range of measures under consideration. The active participation of citizens and stakeholders is also encouraged through an open communication channel that allows them to ask questions, give their opinions and share experiences related to the situation. This process continuously enriches the management and decision-making that EMASESA undertakes. While the Water Observatory's focus extends beyond drought and water scarcity, aiming to establish comprehensive water governance, its importance is particularly evident in times of drought and water scarcity. It serves as a crucial platform for engaging citizens, stakeholders, and public authorities.

3 Developing the risk management plan

The third step involves developing a plan to address drought and water scarcity. The plan will outline a series of actions to be taken depending on various levels of risk (or scenarios).

The level of risk will then be assessed through a series of pre-defined indicators and based on regular monitoring.

Monitoring, defining indicators and establishing scenarios

Monitoring provides crucial information and data – based on past periods of drought and water scarcity, real-time data analysis and weather forecasts – that help water operators take appropriate and timely action.

EXAMPLES:

In collaboration with Athens Technical University, **EYDAP (Greece)** is closely monitoring the levels of all lake headwaters to draw conclusions and provide alert indicators for impending drought conditions. Additionally, EYDAP is starting a new collaboration with the National Observatory of Athens to initiate a project that explores the correlation between rising temperatures and increased drinking water needs, which will provide meaningful data to forecast future water needs.

CILE (Belgium) carries out an analysis each year, towards the end of March – at the end of the winter recharge and the start of the vegetation period – to forecast the possible supply risks in the event of a summer drought. CILE then communicates this analysis to the Walloon Regional Crisis Centre.

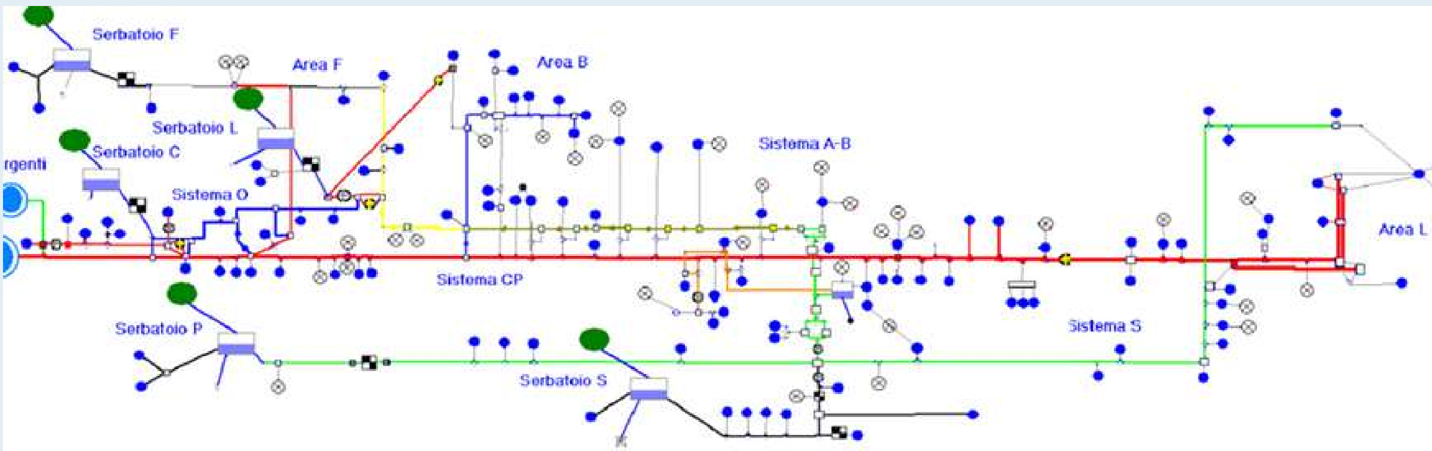
Scottish Water (United Kingdom) has operational drought management plans which are implemented during extended dry periods to ensure customers are kept in supply. These include all-year round monitoring of reservoir levels and drought action planning to ensure appropriate actions can be taken early enough to maintain supplies to customers. These actions may include the temporary use of alternative water sources, balancing supplies between adjacent systems and the short-term use of tankers where required, particularly for smaller communities, at times of peak demands.

VIACQUA (Italy) monitors water availability by utilising measuring devices installed in catchment plants and conducting complex analyses of data and relevant environmental variables. With the data collected, VIACQUA is able to map areas of greatest criticality to droughts within the vast aqueduct network it manages and to intervene with targeted management and regulatory actions at the plants. For example, by maximising the use of existing aqueduct interconnections to alleviate the impacts of abrupt and substantial reduction in the flow rate of specific springs.

After implementing an advanced remote management system and a GIS (Geographic Information System), **Acquedotto Pugliese (Italy)** has now acquired a DSS (Decision Support System), using the "Aquator" software for environmental management and optimisation purposes and "Infoworks" for purely hydraulic reasons. The aim of this project is to offer Acquedotto Pugliese (AQP) a tool that provides answers to incidental problems and, at the same time, to push the structure to adopt a rule to organise and systematise answers to structural problems in order to improve efficiency. **In a nutshell, the information collected is mainly used to:**

- ▶ Plan and manage the resource optimally
- ▶ Define the investments required to implement and/or renew the overall system
- ▶ Rank possible risks, with a consequent assessment of their effects and solutions

The two tools combined, Aquator and Infoworks, help monitor the availability of the resource in the medium term and to check the impact that a potential water shortage could have on the system in terms of meeting demand.



Graphic illustration of the topology, characteristics and operating modes of the AQP water system.
Source: AQP

Defining Indicators: Drought indicators are parameters that help assess and monitor the occurrence and severity of droughts. They provide crucial information to support decision-making processes and the implementation of appropriate mitigation and response measures.

The specific indicators vary from operator to operator, but here are a few examples:

- Precipitation deficit
- Groundwater level
- Reservoir storage levels
- Streamflow and river discharge
- Soil moisture

EXAMPLE:

Operators in **Wallonia (Belgium)** have established a decision tree based on four parameters:

- Level of availability (based on the source of water: wells, groundwater drains, surface water reservoirs or river flow)
- The possibility of additional resources for the supply zone (securitization rate of 30%)
- The maximum level in the storage building
- The possibility for the network to deliver the amount of water

The decision tree is then applied across all conceivable combinations of these parameters. The result is a colour code that defines whether the supply zone is in alert or crisis state. This colour code assessment serves as a tool for authorities and operators to enact appropriate measures.

Establishing scenarios: Scenarios are developed in close collaboration with political and scientific authorities to inform response planning and provide a framework for escalation.

EXAMPLE:

Here is an example of a nomenclature from **Aguas de Cádiz (Spain):**

- Normality: when all uses are guaranteed.
- Pre-alert: moderate scarcity scenario with no socio-economic or environmental impact.
- Alert: this scenario is an intensification of the pre-alert, both in terms of the progression of the drought/water scarcity and the planning of measures.
- Emergency: high probability of shortages due to drought and/or water scarcity. This scenario is only expected to occur following severe drought events.

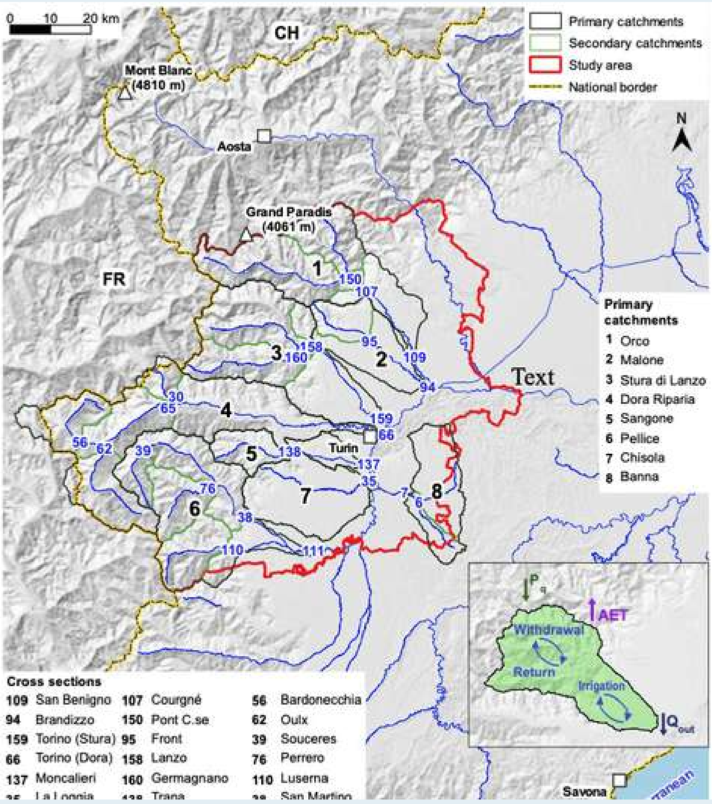
The classification can slightly vary from one country to another, and from one operator to another. However, in general, the main classes are identical.

As mentioned at the beginning of this chapter, and as some of these examples suggest, the actual monitoring of indicators and scenarios is often rcarried out by public authorities, with varying degrees of involvement of water operators. However, regardless of who concretely monitors the resource, it is essential that water operators have access to this data, as it will help them determine the thresholds above which they must take action.

EXAMPLE:

SMAT’s Research Centre **(Italy)** has launched a project aimed at defining the meteo-hydrological precursors of water crises in the Turin area. The Piedmont region lies between the Alps and the Mediterranean, which are areas in which the effects of climate change are severe. Additionally, recent drought episodes (2017, 2021, and 2022) have affected regions not typically prone to such phenomena, such as the Piedmont region, leading to water shortages. In this framework, SMAT and public authorities have stepped up their efforts to improve drought monitoring, forecasting, and assessment methods, to enable better anticipation and preparation. With this project, conducted in collaboration with the Regional Environmental Protection Agency of the Piedmont Region (ARPA Piemonte), SMAT has adopted a bottom-up approach to identify events that have led to crises in drinking water supply sources. This approach has allowed for critical thresholds and parameters to be identified and a first combined index to be proposed. Developed during the 2022 water crisis in Piedmont, this combined index served as the foundation for developing an operational system that can provide advance alerts to water operators, stakeholders, and authorities.

It is a monthly blended drought index that represents a weighted combination of the Standardized Precipitation-Evapotranspiration Index (SPEI), the Standard Runoff Index (SRI), and the Standardized SnowPack Index (SSPI). The blended index has been tested and validated in the past: it has successfully identified all water crises that occurred in Piedmont over the past 25 years and also has the potential to be used in a predictive way.



Study area of river catchments and sub-catchments with illustration of the water balance terms.
Source: ‘Progetto Risknat – Base topografica transfrontaliera, ARPA Piemonte’

Identify measures to be implemented

Monitoring, defining indicators, and developing scenarios will enable the implementation of specific measures. For each scenario, specific preventive and mitigation measures will be identified. The next chapter of this publication (chapter II) will describe a non-exhaustive list of these measures.

Many of the responses need the coordination of water operators and other actors to be implemented.

Consequently, it is essential that the water scarcity and DRMP – regardless of the administrative level at which it has been implemented – clearly **outlines the responsibility of the different actors in performing relevant actions for each level of risk**.

EXAMPLE:

Promedio (Spain) undertakes the following measures, in coordination with the relevant competent authorities:

On the administrative organisation (normality)	Competent authority	Remarks
Monitoring of the indicator system: monthly values	Operators involved in bulk water abstraction and selling	
Development of an annual report on the evolution of indicators	Operators involved in bulk water abstraction and selling	
Development of administrative coordination procedures for pre-alert, alert, and emergency	Operators involved in bulk water abstraction and selling	In coordination with operators responsible for distributing water and local councils
Establishment of a Water Board/Commission for the water supply system	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water • Local councils • Representatives of the water supply system • Representatives of companies/collectives particularly affected by water • Hydrographic Confederation	In coordination with other relevant Hydrographic Confederations

On the supply side (pre-alert)	Competent authority	Remarks
Intensification of leakage detection plan and anti-fraud plan	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water	These measures should be coordinated through the Council/Commission by exchanging appropriate information
Activation of the pre-alert situation monitoring and control plan	Operators involved in bulk water abstraction and selling	
Preparation for the activation of operational measures in the event of a worsening of the situation, inventory review, updating and maintenance of specific infrastructures to deal with worst case scenarios	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water	
Analysis of relevance for the implementation of measures specific to more severe scenarios: activation of complementary resources	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water • Local councils	
Development of technical study to identify alternative sources such as wells that need to be legalised and/or introduce the study of additional infrastructures/elements for population supply	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water	
On the demand side (alert)	**Competent authority**	**Remarks**
Public information on the situation through the media, social networks and/or municipal notices	• Operators involved in bulk water abstraction and selling • Operators responsible for distributing water • Local councils	In coordination with other relevant operators responsible for distributing water
Activation of an education and awareness campaign designed to achieve a 5% saving in household consumption. 5% savings in household consumption	Operators responsible for distributing water	In coordination with the local council
Activation of specific campaigns (16 - 19)	Operators responsible for distributing water	In coordination with the local council
Reduction of municipal consumption: reduction of watering, reduction of irrigation in gardens and public parks and closure of ornamental fountains	Local councils	In coordination with operators responsible for distributing water
Implementation of the dissuasive tariff plan: Alert scenario	Local councils	In coordination with operators involved in bulk water abstraction and selling and operators responsible for distributing water
On the water environment (emergency)	**Competent authority**	**Remarks**
Implementation of options for the improvement of water quality in reservoirs	Operators involved in bulk water abstraction and selling	In coordination with the Hydrographic Confederation
Activation of the surveillance and self-monitoring plan for the conservation and protection of aquatic resources in municipalities for emergency situations	Entities managing wastewater treatment services	In coordination with the Hydrographic Confederation
Activation of self-monitoring plan for discharges for emergency scenario: to avoid deterioration of water bodies due to reduction of circulating flows and intensification of treatments if necessary	Entities managing wastewater treatment services	In coordination with the Hydrographic Confederation

4 Evaluating

Once a drought episode has ended and de-escalation measures can be safely implemented, the final component of the water scarcity and DRMP is to establish an approach to assess its effectiveness and the economic impact of implemented measures.

With regard to this de-escalation process, it is important to distinguish between when a drought event ‘breaks’ – when the period of low rainfall has ended – and when sources have truly recovered, and levels/flows have returned back to a recognised normal range of conditions.

Uisce Éireann (Ireland), for example, defines the end of a drought as: ‘*the moment when the risk of impacts from drought is no greater than during a normal year and where normal conditions have continued for a certain period of time.’* The drought indicators established in the water scarcity and DRMP will be used to define when situations have returned to a ‘normal’ condition.

Evaluate the effectiveness of implemented measures:

After a period of drought and water scarcity, operators carry out analyses to assess the effectiveness of the implemented measures. In doing so, operators can identify which measures worked and which were less successful. This information is invaluable in refining and optimising the water scarcity and DRMPs to make them more efficient and, ultimately, more effective.

Evaluate the economic impact of the measures

The various measures implemented during and in anticipation of drought and water scarcity periods will not only have an impact on the environment and society but also on the overall cost of the service. It is therefore important to assess the cost of implemented measures in order to better prepare for the future.

Taking this into consideration, operators can modify, adapt, or change their water scarcity and DRMP as needed, considering both the effectiveness of the implemented measures and their economic impact.

EXAMPLE:

EMASESA metropolitana

Empresa Metropolitana de Abastecimiento y Saneamiento de Aguas de Sevilla, S.A.

EMASESA (Spain) assesses the economic impact of measures for two reasons: to adapt their financial planning to cope with these phenomena, including by considering the cyclical nature of droughts, and to create public awareness regarding associated costs and the importance of water conservation.

The measures are evaluated at two levels: resources and demand. Regarding resources, EMASESA’s assessment encompasses the costs derived from resource management which generate higher costs and the modification/starting up of infrastructure.

The following key cost categories have been identified:

- ▶ Monthly cost of modifying the operating strategy
- ▶ Monthly cost of external resources contribution
- ▶ Monthly cost due to resource quality deterioration
- ▶ Monthly operation-related costs
- ▶ Communication and awareness campaigns costs

Initial cost estimates for these concepts have been established, but they have to be adapted to the specific circumstances of each drought situation.

The costs associated with demand-side measures are divided into expenses related to awareness and dissemination campaigns and those resulting from reduced water consumption. These measures can immediately impact the operator’s finances, either through increased costs or through a reduction of the income generated from water billing.

AÑO		REFERENCIAS			IMPACTOS REGISTRADOS			
Inicio	FINAL	AÑOS	LOCALIZACIÓN GEOGRÁFICA	COMENTARIOS	ECO.	AMB.	HIDRO.	SOCIAL
1414	1416	2	Meseta. Andalucía.	Hambre en Sevilla en 1414	Sí	No	No	Sí
1462	1464	2	Meseta. Andalucía.	Hambre en Sevilla en 1461-64.	Sí	No	No	Sí
1472	1476	4	Generalizada.	Carmona (2000): Hambre en Sevilla en 1472-74.	Sí	No	No	Sí
1489	1492	3	Generalizada.	Hambre en Sevilla en 1489.	Sí	No	No	Sí
1501	1507	6	Andalucía y otras regiones	Hambre en Sevilla en 1503 y 1505-1510.	Sí	No	Sí	Sí
1521	1528	7	Generalizada.	Hambre en Sevilla en 1520-22.	Sí	No	No	Sí
1525	1531	6	Andalucía y Levante	Hambre en Sevilla en 1526-29. Sequía en 1525 que abarcó Andalucía y Levante	Sí	No	No	Sí
1528	1535	7	Generalizada.	Hambre en Sevilla en 1526-29. Sequía en 1528 que hizo que fuera para la Meseta un "año terrible" y que también afectó a Andalucía, donde se prolongó hasta marzo.	Sí	No	Sí	Sí
1537	1544	7	Generalizada.	Hambre en Sevilla en 1541-42. En 1537 fue un año de gran sequía, tanto en Murcia como en toda España. En este año se trató por primera vez de trasvasar los ríos Castril y Guardal (Guadiana Menor), por medio de un canal, que, recogiéndolos por sus cabeceras, los cambiase de vertiente, para hacerlos correr por la región de Lorca. Año 1539: "*a causa de la sequía vino un hambre muy grande, que fue seguida de la peste, la cual diezmó la población de España*" Sequía generalizada, sobre todo en Andalucía; 1542: cosecha malograda por la sequía.	Sí	No	Sí	Sí
1545	1549	4	Andalucía y Alta Extremadura	Hambre en Sevilla en 1545-46. 1546 fue un año seco y con plaga de langosta sobre todo en Andalucía	No	Sí	No	Sí
1566	1576	10	Generalizada.	Hambre en Sevilla. Sequía en Granada en 1567: "*Conviene subrayar la importancia de la sequía de 1567, como un motivo más para formarse la conspiración que condujo al levantamiento general de los moriscos en 1568*".	Sí	No	Sí	Sí

Extract from the historic records of droughts in Andalusia and their impact.
Source: EMASESA drought management plan

II. Actions and Measures to Combat Drought and Water Scarcity - The Role of Water Operators

II. ACTIONS AND MEASURES TO COMBAT DROUGHT AND WATER SCARCITY - THE ROLE OF WATER OPERATORS

In the previous chapter, we explored the approach and methodology by which water operators assess the risk of water scarcity or drought and then define a course of action to manage different levels of risk: this is the water scarcity and drought risk management plan. In this and the next chapter, we will review the set of measures that operators can employ during the implementation of the plan to either prevent or mitigate the risk.

Traditionally, measures to combat water scarcity and drought are classified as either **'demand-side'** – if they aim to reduce consumption – or **'supply-side'** – if they aim to expand the availability of water resources. While this distinction is certainly relevant (as we will discuss in the conclusion), in this and the next section, we have chosen to organise the measures based on who has primary responsibility for their implementation.

In this section, we explore a range of measures and actions directly implemented by water operators. In the next section, we will review measures that water operators cannot carry out alone, as they require the active involvement of stakeholders and public authorities in order to be implemented. We consider this classification to be more relevant for the purposes of this publication, namely presenting good practices from public water utilities and discussing the need and the conditions for collective action to address the challenges related to water scarcity.

Seminar: *Water Scarcity and Drought: From Crisis Management to Long Term Adaptation* - co-organised by Aqua Publica Europea and EMASESA in Sevilla on 05 July 2022

LEAKAGE REDUCTION

In a world where water is becoming an increasingly scarce resource, leakage is an issue that needs to be addressed as it can exacerbate the effects of droughts and water scarcity. It is important to note that all water operators have strategies to reduce leakages, regardless of the issue of water scarcity.

Addressing leakages is indeed crucial in tackling waste production and saving energy. By persevering in their efforts to curtail leakages, operators are strengthening the foundations of a resilient system capable of withstanding periods of high-water stress.

EXAMPLE:

Smart metering is an effective tool for tackling leakages. Compared to traditional meters, smart meters can more easily detect anomalous water consumption in a building – often caused by a leak – and send a real-time signal to the operator. The operator can then alert the owner and, if necessary, intervene directly to address the leak. One of the most promising developments in the field comes from the SMART.MET project [8], funded under Horizon Europe.

Led by seven water operators, members of APE, including SDEA (France), CILE (Belgium), Budapest Waterworks (Hungary), Eau de Paris (France), VIVAQUA (Belgium), Promedio (Spain), Viveracqua (Italy), along with other partners, the project aimed to drive the development of new technologies to deal with the collection and management of smart metering data, through a joint Pre-Commercial Procurement (PCP).

Prototypes of the innovative smart metering developed within the framework of the project

A moment during the *Open Market Consultation,* part of the joint procurement process

The project has produced very satisfactory and tangible results, both in terms of detecting leaks in the network and after the meter, on the users' network. The outcomes of the field testing of the innovative solutions developed by two companies – **Telereading (Italy)** and **Hydroko, Ng (Belgium)** – succeeded overall in meeting most of the technical requirements specified by the seven water operators in their PCP, **particularly in the following areas:**

- Bi-directional communication capacity and the possibility to control the risk of reverse flow with an automatic valve.
- More accurate detection of leakage after the meter, on the users' networks.
- A stable NB-IOT/SIGFOX communication in real-life conditions, including in rural areas or challenging environments such as cellars, basements, and garages.
- Interoperability between different device systems.
- Very high level of performance on the data collection platform, along with centralised back-up and synchronisation.

Furthermore, the project assisted partner utilities in improving their understanding of their internal operational procedures, digital readiness, and contextual specificities through cooperation and exchanges among each other. These innovative solutions are now helping the seven water operators involved in the project (and additional ones wishing to adopt the technology) to enhance the speed, efficiency, and accuracy of their leakage control. This, in turn, generates significant benefits for both the environment and users.

NETWORK INTERCONNECTIONS

Enhancing the integration and interconnection of water networks is a crucial element in building a resilient water network. The greater the network's interconnectivity within a territory, the more resilient the entire area becomes against drought, as water can be redistributed from wetter areas to compensate for dry ones, and from low consumption areas to high consumptions areas.

EXAMPLES:

De Watergroep (Belgium) recognises the importance of maintaining existing interconnections and further leveraging interconnectivity to increase supply security across different areas. This principle stands as a key focus within their long-term supply strategy. Taking this into account also allows for a more strategic use of available water resources; for instance, by maximising the use of surface water during winter months, thereby preserving groundwater for the warmer summer months. Through this strategy, De Watergroep can effectively balance the disparity in the supply of sources between the West and the East of Flanders.

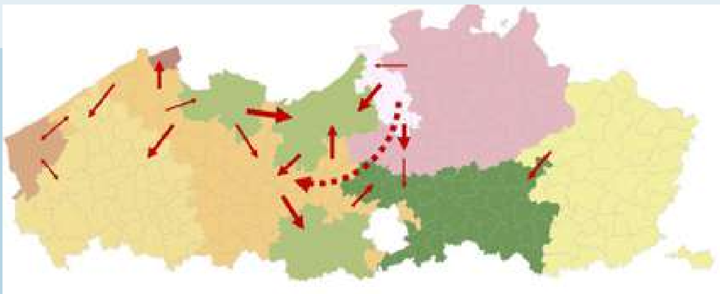


Illustration of the interconnection scheme in Flanders.
Source: Strategic Water Supply Plan for Flanders

Since 2012, **SWDE (Belgium)** has been designing and implementing an interconnection scheme for undersupplied areas in Wallonia. This scheme aims to ensure an adequate level of supply security for all supply zones within the region. The main motivation behind this scheme was the increased demand during droughts and heatwaves, which have been increasingly affecting Belgium over the last years.

SMAT (Italy) is building interconnections between water systems to ensure that, in times of scarcity, one network can support another and prevent service disruptions. This approach creates synergies between the different aqueduct networks, increasing the potential for 'water rescue' during periods of drought and enhancing the resilience of the water service.

SMAT has set this objective as a strategic focal point and has activated several interconnections between aqueducts. For instance, an interconnection has been created between the water systems of three member municipalities in the Eporedo area, which allows the activation of mutual aid between the three aqueducts, increasing the resilience of the overall water system benefiting around 13 000 inhabitants. Additionally, with drinking water provision prioritised over other uses in Italy, SMAT can utilise water from hydroelectric reservoirs if drought conditions require it. In this context, SMAT has recently completed the construction of an aqueduct connecting a hydroelectric dam in the Susa Valley to serve 27 municipalities (or 180 000 inhabitants) downstream in case of a severe drought.

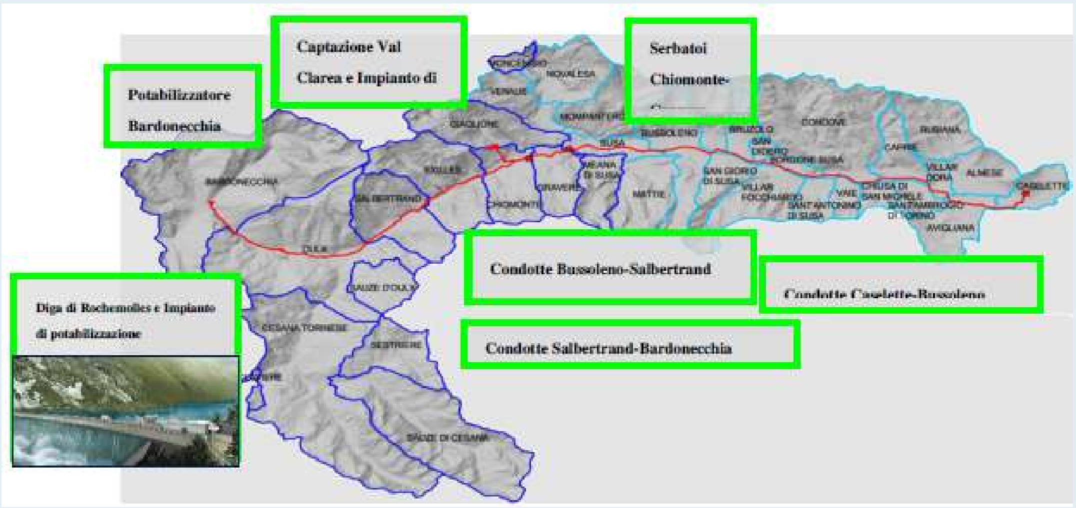


Illustration of the interconnection scheme in the Eporedo area, Piedmont region.
Source: SMAT Drought Management Plan

Uisce Éireann (Ireland) can act to meet demand in times of scarcity by rezoning supplies from more resilient sources to reduce demand and pressure on vulnerable sources. Rezoning involves temporarily altering the water supply network for the area that a particular water source supplies and requires detailed discussions to identify restrictions in the existing system that could be removed by quickly implemented engineering works.

PROTECTION OF WATER RESOURCES

In the face of mounting challenges linked to water scarcity, the protection of water resources and catchment areas from sources of pollution has emerged as of paramount importance. Beyond ensuring high quality water with a reduced need for treatment, the protection of water resources is also beneficial for reducing vulnerability to droughts, as it guarantees a reliable supply of water for various uses, even in times of high water stress. Additionally, it helps protect the ecological balance of water sources, preserves water quality, and contributes to reducing social and structural vulnerabilities.

EXAMPLES:

Water operators may promote responsible farming practices locally, with significant benefits for both aquifers and water resources. For example, **SDEA (France)** has established 'water missions' aimed at encouraging farming practices that involve using reduced quantities (or not any) phytopharmaceutical substances in catchment areas, no extensive crop cultivation, and improved livestock management. These missions also include communication with the population and local gardeners to discourage the use and discarding of chemical products and to promote the consumption of crops produced responsibly. SDEA has further deepened this initiative by implementing a fully circular farming approach in one of its catchment areas: farmers are encouraged to grow silphium (cup-plant) crops, which require almost no treatment and less irrigation, while also supporting native biodiversity through abundant flower production (wild bees, butterflies, etc.) and beekeepers. These crops are used by the local wastewater treatment plant to boost biogas production with sludge and can also serve to feed livestock. SDEA also supports in structuring the agricultural sector through, for example, partnerships for meadow-grown cow's milk and the production of organic or low-treatment crops in catchment areas, all aimed at preserving water quality. Moreover, SDEA has introduced a new approach by using economic incentives to promote farming practices that protect the quality of drinking water in its catchment areas. Beyond safeguarding water quality, these practices also preserve water quantity by preventing pollution and contamination, maintaining healthy water resources, and promoting more sustainable and water-efficient farming methods, ultimately reducing the demand for freshwater.

A close protection perimeter around grass-covered water catchment areas.
Source: SDEA

Uisce Éireann (Ireland) has deployed a new technology in two lake sources in the south of Ireland in the hope of controlling excessive algal growth. Algal blooms in both lakes have led to challenges with raw water quality and treatment. The technology employs low-powered ultrasound to prevent lysis. Instead of destroying the algal cells, ultrasound is used to construct and maintain an ultrasound barrier to migration. This type of ultrasound functions as a long-term barrier rather than a quick response to acute blooms.

The expected advantage of this system is that, by not rupturing the algal cells, harmful toxins are not released by the organisms as they die off. The constant pressure cycle generated around algal cells by the ultrasound waves interferes with the algae's buoyancy regulation, preventing them from accessing sunlight and nutrients. As a result, the algae sink to the bottom and decompose naturally. The instruments have been installed for over a year now, and data is being analysed to determine the full benefits.

COMMUNICATION

Communication campaigns aimed at raising public awareness of water scarcity situations and how to respond are essential, not only as a preventive measure, but also during periods of high water stress. Many water operators have put in place a number of initiatives to this end.

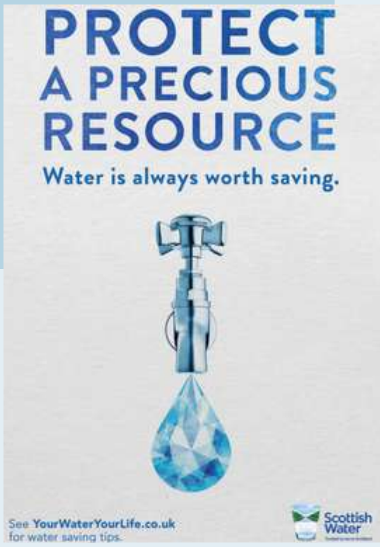
EXAMPLES:

Scottish Water
Trusted to serve Scotland

Scottish Water (UK, Scotland) has launched a campaign called 'Water is Always Worth Saving'[9], also linked to energy issues.
It involves 13 good practices:

- ☑ Take shorter showers
- ☑ One flush makes a difference
- ☑ Only use a full load
- ☑ Install a water butt
- ☑ Use a watering can instead of a hose
- ☑ Use a sponge and bucket to wash your car

- ☑ Only boil what you need
- ☑ Turn the tap off when brushing your teeth
- ☑ Fix dripping taps
- ☑ Fix leaky toilets
- ☑ Use eco settings
- ☑ Get water fit



Illustrations from the campaign 'Water is Always Worth Saving'.
Source: https://www.yourwateryourlife.co.uk

France Eau Publique (FEP, France) released a report on the communication actions deployed by members of the FEP network – made up exclusively of public operators and local authorities responsible for publicly managed water and wastewater services – during a period of drought. In a nutshell, the actions can have both an informative purpose (dissemination of prefectural decrees and restrictions imposed at different alert levels) and an educative goal (promotion of good practices to be adopted by the population).

Illustration from a water saving communication campaign from Eau de Paris (France). Source: France Eau Publique's report on 'drought and communication'.

The tones used in the communication campaigns differed according to the very objective of the message itself:

- Shock communication to spark emotion and make people react
- Reassuring communication to explain and get people to adhere

EMASESA (Spain) launched a water saving awareness campaign called 'Objetivo 90'[10] ('Objective 90') that aimed to reduce daily consumption from 116 litres to 90 litres per inhabitant. With the help of this campaign, EMASESA has currently succeeded in reducing domestic consumption from 116 to 109 litres.

Poster of EMASESA campaign 'Objective 90'.

A similar initiative has also been launched by **Aguas de Cadiz (Spain)**. Through a series of awareness campaigns and online tools, citizens have the opportunity to calculate whether their water consumption is above or below the average by factoring in a series of parameters. They are then provided with advice on how they can further reduce their consumption to reach the objective of 100 litres per day.

Logo of Aguas de Cadiz's campaign 'Reto 100' ('Challange 100').

RELATIONS WITH LARGE WATER USERS

In times of water scarcity, but even more generally when demand for water increases, cooperation with industries that rely heavily on water is extremely important. It is essential to ensure that these industries participate in water saving efforts, as does the population as a whole, while preventing their activities from being negatively affected economically.

EXAMPLES:

Uisce Éireann (Ireland) Water Stewardship Programme[11] has successfully promoted demand reduction in drought-prone areas across Ireland, particularly through recent collaborations with large water users in Wexford. This programme was established with the primary objective of fostering responsible water usage in Ireland. By encouraging sustainability, reducing waste and business customers operation costs, and promoting conservation through collaboration with various stakeholders. **It entails different measures**:

- **Education and Training: Empowering Large Water Users**

  The programme has trained over 700 large water users nationwide, enabling them to understand the importance of water conservation and equipping them with practical tools and strategies to minimise their water footprint.

- **Collaboration with Large Water Users: Recent Focus in Wexford**

  One of the programme's significant achievements is its collaboration with large water users in areas with water scarcity such as Wexford. By engaging with key accounts across industry, Uisce Éireann has offered training and support around water reduction strategies tailored to these specific sectors.

- **Water Conservation Projects: A Pathway to Sustainability**

  The programme has facilitated the development of over 1500 water conservation projects, providing a platform for innovation and collaboration. These projects range from rainwater harvesting systems and leak detection programmes to the implementation of advanced water management technologies.

- **Significant Water Reduction Results**

  The programme’s efforts have yielded substantial water reduction results. On average, participating sites have achieved a 20% reduction in water consumption. Moreover, an encouraging 70% of large water users have committed to annual water targets, emphasising their dedication to sustainable water management.

SWDE (Belgium) has established a dialogue with large water consumers in areas affected by severe water stress to limit consumption during periods of high demand or risk of supply interruption. For instance, in 2022, SWDE held discussions with some of its industrial customers, mainly in the Luxembourg region. This area was experiencing quite significant water stress, and some industries, which were mainly supplied by private wells and/or reuse, were confronted with a shortage of water. This situation led them to consume much more from the public distribution networks, which were not necessarily calibrated for this, thus affecting the overall supply for domestic users, SWDE opted to engage in a dialogue with these companies to collaboratively explore ways to improve and reduce their water intakes. SWDE's policy focuses on working upstream with companies to prevent the need for supply interruptions. This approach yielded positive results, as SWDE successfully averted halting water supply to any of its customers.

III. Actions and Measures to Combat Drought and Water Scarcity - The Role of Multi-Stakeholder Coordination

III. ACTIONS AND MEASURES TO COMBAT DROUGHT AND WATER SCARCITY - THE ROLE OF MULTI-STAKEHOLDER COORDINATION

In the previous chapter, we presented a review of initiatives and measures routinely carried out by members of APE, more or less in an autonomous way, when implementing their long-term water quantity plan or drought risk management plan. By ‘autonomous implementation’, we mean that the decision to implement certain measures falls to a large extent within the capacities – technical, legal, and financial – of water operators. However, there is a wide array of measures that cannot be solely carried out by operators, as they require coordination and collaborative efforts between multiple stakeholders. These measures will be the object of this chapter.

WATER REUSE

Water reuse is increasingly the focus of attention as its benefits – including reducing pressure on freshwater resources and providing an alternative source of water – are being recognised. According to the European Climate Adaptation Platform Climate-ADAPT (a partnership between the European Commission and the European Environment Agency), water reuse refers to ‘the process whereby wastewater is reclaimed from a variety of sources and treated to a standard appropriate for a second purpose. Any type of wastewater (domestic, municipal, or industrial) can be considered for reuse and, depending on its quality, can be deployed for several different secondary purposes’[12].

Water reuse in agriculture

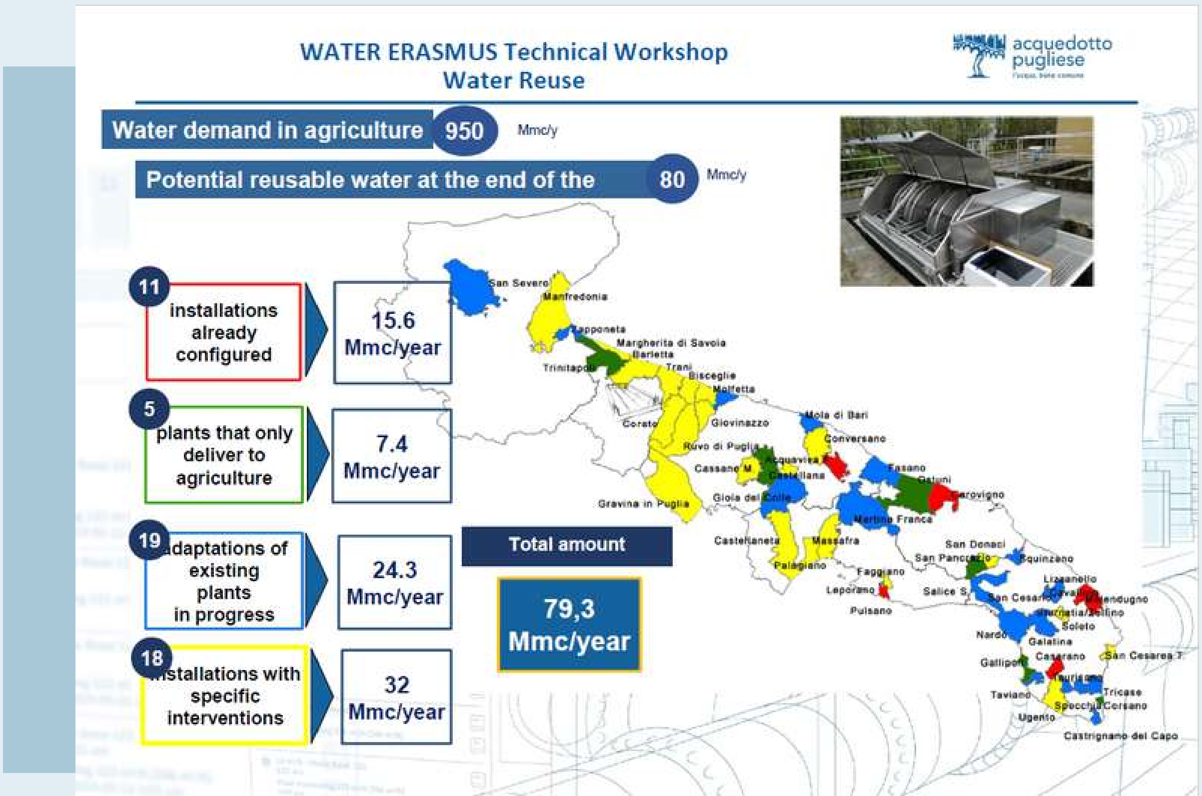
The EU regulation 2020/741 on ‘minimum requirements for water reuse’ is expected to encourage the reuse of wastewater for agricultural irrigation by providing a harmonised legal framework for quality and monitoring requirements, along with provisions on the governance of the risk management and permitting systems. The regulation addresses a growing demand, voiced by both water operators and farmers, to establish common European standards on water reuse. The objective is to facilitate a practice that is already well tested and secure from a technical standpoint, and which is already implemented by some operators, including by several APE members.

EXAMPLES:

EYDAP (Greece) has made significant investments in a large-scale water reuse project that combines the design, construction, and operation of an extensive integrated wastewater management system throughout Greece's Eastern Attica region. The reclaimed water will primarily be used for irrigation – as it is an agricultural region – but also for urban and suburban reuse and aquifer recharge.

The foreseen positive impacts include water and energy conservation, environmental protection, and long-term water security for the region. These projects also incorporate a Centre for Environmental Awareness and Information (CEAI), aiming to foster a transformative approach to addressing water circularity. This approach necessitates the acceptance and involvement of the local population.

To preserve the limited water resources available, **Acquedotto Pugliese (Italy)** produces nearly 50 million m³ of reclaimed water through 36 plants and plans to increase production to 79.3 million m³ in the coming years. The operator is able to purse this strategy thanks to a regional regulation – the regional Water Protection Plan – which already complies with the European regulation and goes even beyond it in some respects, in particu - lar for other non-agricultural uses and for establishing minimum ecological flows to be respected. The economic resources required for the investments in the treatment plants to produce water of reusable quality are coming partially from the EU, and partially from the own resources of the operator (from domestic bills).



Installed capacity and planned development for water reuse by Acquedotto Pugliese in the Apulia Region.
Source: Aqua Publica Europea's workshop on water reuse

Special focus

Water reuse: potentialities and limitations - Outcomes from APE seminar 'The Value(s) of Water'

Implementing water reuse schemes can be quite complex and comes with its own set of challenges. During a public seminar dedicated to strategies for reducing impact on freshwater resources that APE organised in Porto on 30/13/2023[13], APE explored the benefits and challenges of wastewater reuse in the light of the new regulation.

For operators, the reuse of wastewater in agriculture presents several advantages. It helps alleviate pressure on freshwater resources, encourages responsible water management practices, and enhances circularity. Nevertheless, it is important to consider that the effectiveness of water reuse varies depending on where it is implemented. It can be highly effective in dry coastal areas, where treated wastewater is otherwise discharged into the sea; in areas with significant river bodies, the advantage of direct water reuse may become less relevant.

Additionally, water reuse may involve additional energy consumption, a factor that needs to be considered in the overall environmental cost-benefit analysis of the practice. The extra economic costs – and their distribution – that can be associated with water reuse, such as additional treatment, transportation, etc., also need careful consideration for several reasons: equity, internal market functioning, and the necessity to strike a balance between maintaining a competitive water price compared to traditional sources of water for farmers, without inducing a rebound effect.

Lastly, water reuse requires the coordination of different actors, particularly three key entities: a public authority responsible for granting a permit and ensuring that standards and procedures are respected; a water operator managing a wastewater treatment plant that provides water meeting legislative quality standards; and irrigators (along with their associations) responsible for distributing the water to farmers. While the new regulation allows Member States a certain degree of freedom in organising this governance, it is crucial that the perimeter of responsibilities among these entities is clearly defined to prevent potential conflicts and ensure the effective deployment of the process.

In general, a stronger framework needs to be established wherein agriculture makes greater use of water reuse and contributes to some of the associated costs. This framework should also establish collaborative mechanisms for consultation with local communities and stakeholders, based on science and research.

Panel discussion 'The Value of Water(s): Strategies to reduce impact on freshwater resources'.
Source: Aqua Publica Europea's workshop on water reuse

Water reuse for industrial and urban purposes

Treated wastewater also finds valuable applications in various industrial processes and urban contexts, contributing to reducing the pressure on freshwater resources and the conservation of drinking water. Although there is currently no EU legislation establishing standards for these uses, we anticipate a growing adoption of these practices as the utilisation of different qualities of water for different purposes.

However, similar to water reuse in agriculture, the implementation of water reuse for industrial and urban purposes requires coordination between diverse public and private actors.

Supportive policies at both EU and local levels that incentivise such practices – through economic regulation, environmental protection requirements, or a combination of both – are therefore key to increasing the number of projects in this domain.

EXAMPLES:

COMO ACQUA

Como Acqua (Italy) has recently obtained the necessary permit from competent authorities to provide reused water to municipal services for street cleaning and other urban uses. Como Acqua has taken a proactive stance by proposing reclaimed water to both public and private entities (industries) as a response to the increasing frequency of drought phenomena and the need to preserve drinking water.

HYDRIA

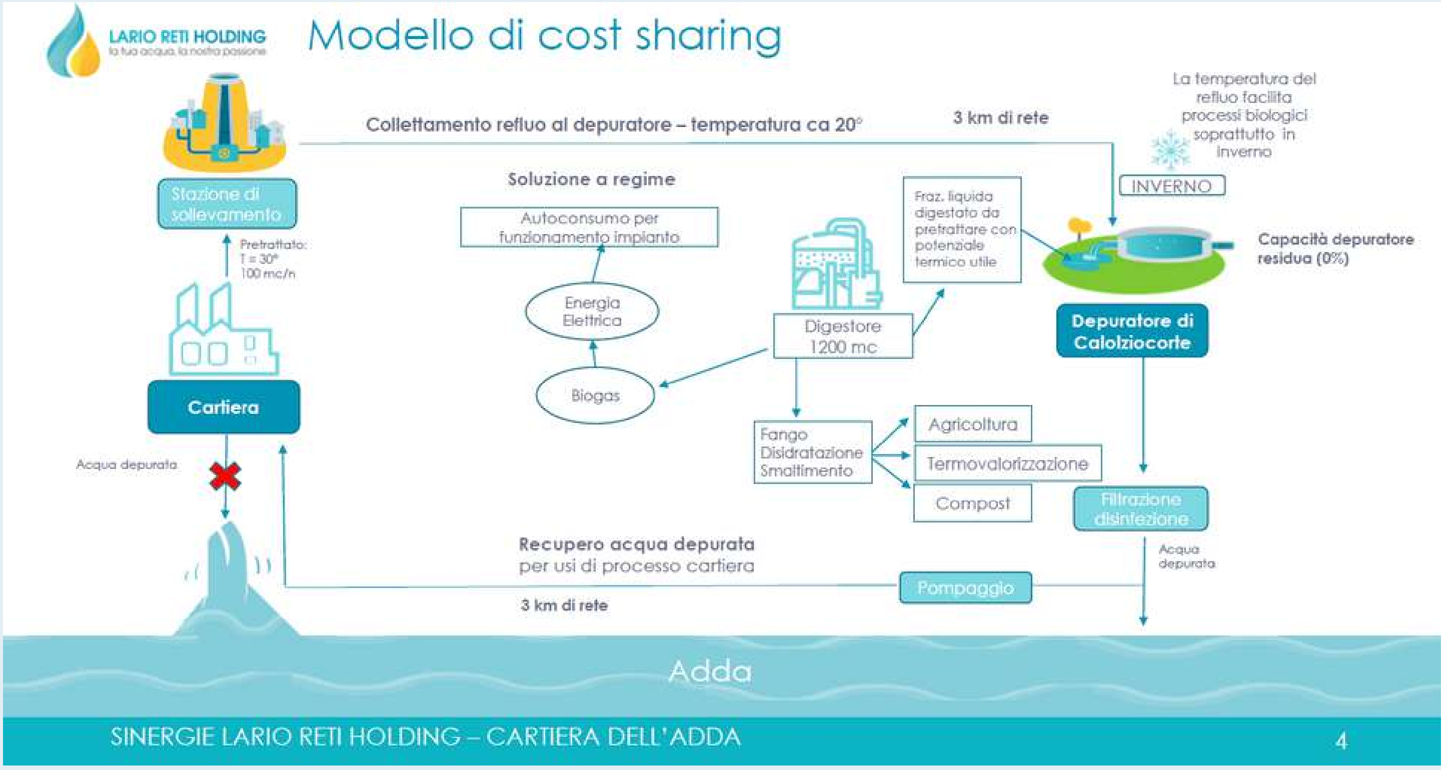
The recently renovated wastewater treatment plant ‘Brussels South’ managed by Hydria.

Following the completion of a 100 million euros investment to implement advanced tertiary treatment (membranes) at one of the two treatment plants in Brussels, **Hydria (Belgium)** has recently finalised an agreement with a local car manufacturing plant – Audi – to supply a portion of their water needs with reused water. The project is expected to start on 1st January 2024, with a supply of 100 000 m³ of reused water to Audi. As for the investment necessary to establish the network that will deliver the reused water to the company, Audi will cover the entire investment (OPEX and CAPEX) throughout the 10-year contract duration. The service price consists of a fixed annual charge (to cover CAPEX) and a price per m³ (to cover OPEX).

Lario Reti Holding (Italy) has successfully concluded a feasibility study aimed at providing reused wastewater to a local paper mill plant, and to then use the paper mill's wastewater to improve the biological process in the wastewater treatment plant. Adopting a fully circular approach that will involve the construction of a two-ways dedicated 3 KM-long sewage pipe connecting the wastewater and the paper plants, the project offers a dual advantage:

1. It will reduce the consumption of freshwater by the paper plant
2. The wastewater from the paper mill, with its constant and relatively high temperature (around 20°C), will enhance the efficiency of the biological process in the wastewater treatment plant

Additionally, as the paper mill wastewater is low in nitrogen and phosphorus, it will contribute to rebalancing the biological process at lower costs and reduced consumption of energy and chemicals.



Scheme of the project to provide reused water to the local paper mill plant.
Source: Lario Reti's feasibility study

NATURE-BASED SOLUTIONS

The concept of Nature-Based Solutions (NBS) is rooted in the evidence that nature can provide solutions to many of the current challenges we face. Rather than relying solely on conventional 'grey' solutions, i.e., traditional engineering solutions, we can restore nature and its capacity to mitigate some of the negative effects of climate change and pollution. In addition to producing less CO2 emissions and other positive environmental side effects compared to traditional solutions, NBS also tend to be more cost-effective and better suited to adapt to transformations caused by climate change.
In particular, NBS can serve as valuable tools for mitigating the impact of droughts and water scarcity. In that light, APE members have initiated projects aimed at harnessing the benefits of NBS.

EXAMPLES:

Restoration and renaturation work on the Souffel river [14]

SDEA (France) undertook significant restoration and renaturation work on the Souffel river in the Strasbourg area. This project has restored the hydro-morphological functioning of the watercourse by creating meanders, planting riparian vegetation, and restoring meadows to encourage biodiversity. The project had two main objectives: firstly, to restore the river's main bed and course, creating a more dynamic and vibrant river with enhanced biodiversity; secondly, to mitigate flooding risks by creating a meso-hygrophilous meadow with flood-resilient plants alongside the river, to allow it to overflow if necessary.

Beyond its role in flood risk prevention and biodiversity restoration, this project also holds the potential to address drought issues. This is notably due to the creation of the meso-hygrophilous meadow, which will facilitate the healthy recharge of the aquifer, thereby contributing to overall water conservation.

Restoration of the Stadenrhein river [15]

The Stadenrhein is a particularly sensitive and important watercourse for the region. Its quality has been impacted by historical cleaning works and, during heavy storms, by overflows from the combined sewer system, which carries both wastewater and rainwater. The water flow, often quite weak, limited the dilution of discharges, resulting in the deterioration of habitat conditions for aquatic fauna and the quality of the watercourse.

To remedy this situation, **SDEA (France)**, in collaboration with other actors, carried out major work in two main areas:

1. Restoring the minor bed and banks of the watercourse
2. Filtering the water discharged from the sewerage system into the natural environment during wet weather using four Vegetated Discharge Areas (VDAs) located between the storm overflows and the watercourse

What is particularly interesting in the context of addressing water scarcity is that, by addressing and reducing pollution, this approach contributes to ensuring that there is enough good quality water available for different uses, without the need for further treatment. Additionally, it supports the development of healthy ecosystems that can naturally assist in water purification processes.

Managed Aquifer Recharge

Managed Aquifer Recharge (MAR) is the purposeful recharge of water to aquifers for subsequent recovery and environmental benefit[16].

EXAMPLES:

In collaboration with the local river basin authority, and in the framework of a wider nature protection project for the Brenta river (Natura 2000 site) in the north-eastern part of Italy, water operators **ETRA** and **Viacqua (Italy)** have implemented a series of *Forest Infiltration Areas*.

These infiltration areas not only facilitate the recharge of groundwater aquifers by surface waters during non-irrigation months but also bring benefits in terms of increased biodiversity and recreational value for the areas. Stemming from a feasibility study funded under the Life Programme, the project has been financed through water tariffs following approval by the Italian water regulator (ARERA)[17].

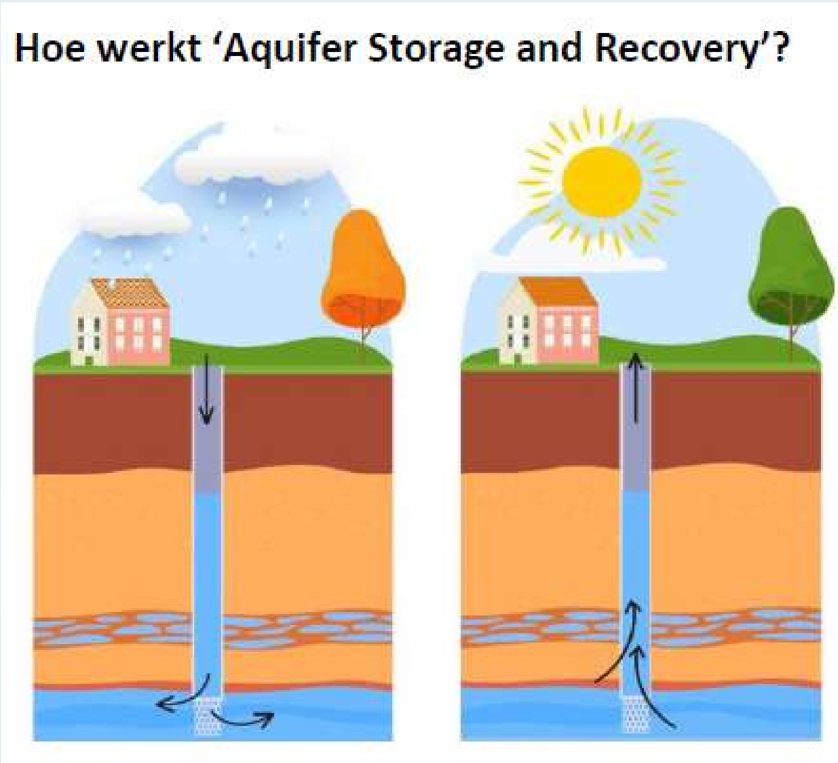
Forest Infiltration Area for aquifer recharge along Brenta River. Source: ETRA

Historically, **VIVAQUA (Belgium)** has used Managed Aquifer Recharge (MAR) techniques in its groundwater catchment sites located in the Forêt de Soignes, Braine-l'Alleud, and at the Vedrin mine. These catchments, some dating back over 170 years, comprise drainage galleries containing underground floodgates that regulate production flow using mechanical valves. Maximum water production from these drainage galleries occurs during the transition from winter to spring, when the aquifer recharge period stops. Conversely, water production reaches its minimum in autumn, when the first useful rains arrive and recharge aquifers. The floodgates made it possible to buffer this drop in production over the year and conserve reserves for the summer and drought periods. The use of floodgates ceased when VIVAQUA acquired large reservoirs at the entrance to Brussels. However, due to recent droughts in Belgium, VIVAQUA is revisiting the option of rehabilitating these structures. Both in Lillois and the Forêt de Soignes, the galleries consistently produce around 5 000 m³ of water per day. Historically, the use of floodgates enabled the storage of reserves within the galleries and the local aquifer, resulting in a production surge of 15 000 m³ per day for several weeks. Consequently, VIVAQUA possesses a theoretical surplus of 20 000 m³ per day, which could be advantageous when peaks in water demand align with periods of exceptionally low water levels in the Meuse River.

Drainage gallery in Forêt de Soignes, Brussels. Source: VIVAQUA

De Watergroep (Belgium), through a joint cooperation subsidiary called 'Waterunie', is currently carrying out research in this field alongside another Flemish water operator (Farys), but for a different purpose than VIVAQUA: Aquifer Storage and Recovery (ASR) of drinking water. This is part of their efforts to increase the climate resilience of the water supply and is in line with the Flemish government's Blue Deal programme. The aim of the research is to validate the feasibility of injecting drinking water into deep aquifers, storing it for prolonged periods, and bringing it back up for use in the drinking water transport/distribution network (preferably without any further improvement in quality). Such a facility would act as a seasonal 'battery'. Drinking water would be injected during periods of low consumption/over-capacity in production (winter) and recovered during periods of high consumption/stressed supply capacity (summer/prolonged drought).

The injected drinking water is stored as an independent 'bubble' in the aquifer body and, as such, does not recharge the aquifer. Ongoing testing projects at two sites in Flanders have established the feasibility of drilling into deep rock formations and their storage potential. Further testing will focus on the water quality aspects of storage and recovery. If the current test projects prove successful, the operational implementation of ASR sites is envisaged within a two to five years' timeframe. How does it work in practice? For one of its current projects in Aalst, Waterunie has drilled a well 220 meters deep, directly into the permeable rock. Through this well, purified surplus water is injected into underground cavities. This water pushes away the water that is already there naturally, creating a bubble of injected water. During the dry seasons, this water is pumped up. The bubble of injected water gets smaller and the water from that bubble can be used in drinking water supplies.



Functioning of Aquifer Storage and Recovery.
Source: Waterunie's report on successful first tests in Aalst

Special focus

Exploring the conditions to mainstream large-scale NBS – MERLIN project

APE is currently part of MERLIN[18], a EU-funded project that explores existing policy levers that could be utilised at European level to mainstream the use of NBS to restore freshwater resources for the benefit of societies.

Despite the benefits of NBS, there are indeed still some challenges that stand in the way of their large-scale implementation in the water sector.

NBS often involve changes to land uses and to urban spaces, necessitating intricate and complex coordination between various sectors of local administration and different stakeholders. In that sense, and in particular for large-scale NBS (at river basin level), water operators alone cannot unilaterally decide whether NBS will be adopted; a robust governance framework is key. Moreover, the institutional complexity that underpins the implementation of NBS, coupled with their public good nature, makes their financing inherently challenging. For that reason, establishing an enabling policy framework is crucial.

RESERVOIRS

The construction of reservoirs – artificial bodies of water – is a measure that can and has been used to combat climate change and mitigate the impact of water scarcity. The water stored upstream in reservoirs can be strategically released during times of high pressure on water resources to enhance the resilience of the system by, for example, replenishing watercourses and facilitating irrigation and the normal functioning of ecosystems.

EXAMPLE:

SMAT (Italy) takes part of its drinking water supply from the Po River. The Po River drinking water plant can either draw water directly from an inlet on the watercourse or be supplied from a lagoon basin, used as a reservoir, located approximately 8 kilometres away. The lagoon basin allows the water to settle and deliver raw water free of turbidity, even during periods of heavy rainfall. Conversely, in times of reduced resource availability, the basin can sustain the plant's operations for around 15 days. SMAT has undertaken the design and implementation of an expansion of the current basin, increasing its capacity from 2 to 5 million cubic metres, to guarantee a reliable water supply to the plant even during prolonged drought conditions. Through this infrastructural enhancement, SMAT will ensure water supply to the city of Turin and part of the metropolitan area for more than a month, even in the unlikely event of an extremely prolonged drought.

Lagoon basin near the Po river.
Source: SMAT

The decision to construct new reservoirs, especially based on dams, can have several implications, some adverse, that need to be considered.

Governance issues: the construction of reservoirs has an impact not only on water operators but also on a large number of stakeholders and local communities. Therefore, governments have a vital role to play in guaranteeing and facilitating an open dialogue among various parties, as well as in providing regulatory authorities with a framework that empowers them to effectively oversee installations. The role of the state as a neutral party is also of utmost importance. In this context, the establishment of a clear, robust, and appropriate governance framework is essential.

Biodiversity issues: The construction of reservoirs, especially dams, can have negative consequences for biodiversity.

For example, it can alter and fragment natural habitats and ecosystems, modify flow regimes, and disrupt biotopes. Storing water also presents risks; if not managed properly, it can result in water quality issues and, consequently, hinder compliance with the Water Framework Directive.

In summary, while the construction of reservoirs can prove useful and, in certain cases, might even be a necessity to preserve water resources and tackle the impacts of climate change, there are two conditions that must be met to ensure the viability of this measure, as highlighted by water operators:

- The ecological continuity of rivers needs to be maintained
- Biodiversity must be conserved

The construction of reservoirs should be implemented through a collaborative and participatory process involving all stakeholders.

RESTRICTIONS

In case of extreme drought and water scarcity, measures that temporarily limit allocation or abstraction rights to some categories of users may be necessary. Planning and predictability of the measures are essential to minimise disruptions and give economic actors the possibility to adopt contingency plans.

EXAMPLES:

Aguas del Huesna (Spain), undertakes the following actions – among others – on the demand side for each scenario:

Drought situation	Measures implemented	Collective housing	Individual houses	Industry and commerce	Internal institutions	External audiences
Pre-alert	Persuasion and responsible use	8%	14%	12%	5%	40%
Alert	General induction of consumption reduction	20%	35%	20%	20%	50%
Emergency	Special obligation or rationing	32%	54%	50%	50%	60%

Acquedotto Pugliese (Italy) regularly informs local authorities about the expected medium-term quantitative status of water resources based on the predictive model described in example at page 14. When a significant risk for future water scarcity is detected, an institutional coordination mechanism is established. This mechanism brings together several actors (including regional authorities, river basin authorities, Acquedotto Pugliese, national government representatives) that analyse together, in the framework of an institutionalised process, the possible socio-economic impact of the drought and possible remedial actions. These actions may provide for – like during the 2017 drought – a revision of allocation regimes for some economic activities, and in particular for agriculture. Thanks to the early timing of the communication, the reduction of allocation are better accepted as they allow more time for farmers to adapt.

Special focus

The importance of strengthening the governance of water quantity: APE Manifesto for EU elections

The decision to implement demand-side measures is clearly a sensitive one. In order to minimise the risk of tensions between different users, such decisions have to be based on inclusive participatory processes in which public authorities and local governments need to play a key role in both setting up the consultative process and taking then the final decisions on restrictions. As the examples above show, regions in dryer areas of Europe tend to have already developed institutionalised frameworks (in the case of Spain the governance of these processes is defined in national legislation, with the law 10/2001 and following integrations). With drought phenomena increasing in frequency and geographical extension across Europe, it is fundamental that all regions develop appropriate institutional framework to address both acute drought and long-term water scarcity.

While these frameworks will necessarily be context-specific depending on the local institutional set-up, and so the decisions about prioritisation of uses (with drinking water at the top), the EU could promote peer-to-peer learning and exchange of best practices, with a view to strengthening governance framework across Europe. As we argue in our ‘Manifesto for 2024 EU elections”, the EU should in particular foster the development of shared governance mechanisms for trans-regional and, above all, trans-boundary river basin, that define common rules for “water solidarity” between territories. This represents a key element of a forward-looking policy that, taking into account the impact of climate change, aims at minimising the risk of conflicts on water access between European regions and countries.

Conclusion

CONCLUSION

Throughout this publication, we have tried to illustrate how public water operators are preparing to tackle the risks of drought and long-term scarcity through a series of concrete examples that highlight their approaches and initiatives. As mentioned in the introduction, the publication collects and assembles elements deriving from the strategies of different members; each strategy, of course, has its own specificities and may not feature all the components outlined in the previous pages.

This is normal as public water operators are 'embedded' in their local context, each with its own environmental challenges, regulatory specificities, and governance arrangements.

The main purpose of this publication is therefore to serve as a (certainly non-exhaustive) reference for water utilities and practitioners regarding concrete aspects to be considered or actions to plan when developing a strategy for water scarcity and drought risk management. By doing so, the publication also aims to provide a reflection about the different conditions that need to be met to develop an effective strategy to manage water quantity, as well as the responsibilities that different actors may have in creating these conditions. In the previous sections, we have seen that some of the important actions to be taken fall under the responsibility of water utilities, while others require cooperation with other actors and institutions.

This final section of the publication will, therefore, attempt to pinpoint **the kind of coordination and collective endeavour needed to guarantee that available water is used and distributed effectively and equitably, while reducing potential conflicts** and ensuring that water operators can fulfil their mission to the best of their ability.

THE IMPORTANCE OF A COMMON FRAMEWORK AND DATA

While we finalise this publication, the Ad Hoc Task Group (ATG) on Water Scarcity and Droughts – established by the European Commission in the framework of the Common Implementation Strategy for the Water Framework Directive – is working on the elaboration of new EU guidelines for drought risk management. These guidelines will also provide indications for a common methodology to assess water scarcity and drought risks.

As Aqua Publica Europea, we look forward to the outcomes of the work of the Task Group. A common methodology for assessing water scarcity and drought will provide an important building block to develop a reference framework. This framework, in turn, will help compare the effectiveness of different strategies, identify relevant stakeholders, and determine the type of data necessary to accurately assess the level of severity of risks.

From the perspective of water operators, the importance of availability, accessibility and cost of data has to be stressed. As demonstrated in many of the examples reported in the previous pages, accurate data on water quantity and water usage is crucial for activating different tools in response to varying levels of drought or for the development of a long-term water quantity plan.

Some data are in the hands of operators, while others are often scattered among various entities, or, in some cases, not available at all due to the incorrect metering or control of uses, as well as the unknown total amount of available water.

A **thorough quantification of the available resource and overall water usage is therefore essential for water quantity management**. Equally important is that these data are collected and made available through a 'one-stop-shop', preferably at river basin scale or, at the very least, within the administrative entity legally responsible for water quantity management. When planning for the medium to long term, additional and more complex sources of data will also be crucial, such as historical series on water usage, meteorological data on the evolution of rainfall patterns, economic and demographic forecasts, and so forth. The aggregation and analysis of these data in relation to water availability require the contribution of different actors and the combination of different know-how.

In summary, **while data is key, their collection, access, and analysis require a complex coordination among various actors and institutions**, a task that only public authorities with a clear policy objective can effectively organise.

Within the EU, comprehensive databases on water availability and drought impacts are currently being developed or expanded[19]. On one hand, national and local authorities bear the responsibility for ensuring that these databases are correctly and timely updated.

On the other hand, we expect that the new guidance document currently being elaborated by the Commission's ATG will offer a clear reference for member states and local authorities to ensure a consistent management of data – especially at river basin level – thus avoiding the fragmentation and dispersion still observed in some contexts.

Furthermore, we firmly believe that the European Commission could play a more proactive role in ensuring that relevant data are duly collected and shared, as well as in clarifying the conditions (in terms of responsibility, obligations, resources, etc.) for this to occur.

STAKEHOLDERS' PARTICIPATION AND THE GOVERNANCE OF WATER SCARCITY

The availability of reliable data and indicators is crucial to provide an objective foundation for discussions on the actions to be taken.

Whether these discussions revolve around decisions regarding infrastructural interventions to enhance the long-term resilience of the water system or, more critically, around the prioritisation of uses during acute droughts, comprehensive information on water availability and demand is an essential condition to inform a factual decision-making process. This, in turn, should improve the effectiveness of intervention and reduce the risk of conflicts.

However, although an essential condition, information alone is insufficient to ensure appropriate decision-making processes. As recent news reports have highlighted, the number of conflicts between water users due to water scarcity is increasing in Europe. The severe drought that affected a large part of Europe in 2022 also showed that some contexts were not prepared to address the problem not only for a lack of an available risk-management approach but, more importantly, for the absence of an institutionalised context where responses should be discussed and decisions taken.

Precisely because there is no one-size-fits-all response to water scarcity, and solutions depend on local factors (climate, topography, socio-economic conditions, etc.), the existence of a clear and dedicated governance framework for the elaboration of risk management plans and for the management of temporary or structural water scarcity represents another important condition for effective decision-making.

By 'clear and dedicated governance framework', we mean a set of regulatory provisions and institutional arrangements that define the tasks and responsibilities of different actors in relation to water scarcity management (in particular with regard to prioritisation decisions), and which provide a template for action in response to different situations or levels of risk, as illustrated in the example from **Promedio (Spain)** in chapter I. Such a framework should also determine which stakeholders ought to be involved or consulted during the decision-making process in a transparent and predictable manner: if droughts (and the measures to mitigate them) have far-reaching impacts on various economic and social aspects of society, then stakeholder engagement is key.

Many members of APE have established participatory mechanisms (see example from **EMASESA (Spain)** in chapter I) with the objective of raising awareness among citizens about the importance of water conservation during drought periods, as well as of involving relevant stakeholders when difficult decisions on water restrictions need to be taken.

This approach represents a good practice that we hope will be replicated in other contexts. However, considering that domestic consumption typically accounts for just over 10% of the total consumption on average[20], the participatory mechanisms set up by water operators alone are not sufficient to address the societal dimension of the water scarcity problem.

As already implied by the Water Framework Directive[21], the establishment of participatory mechanisms at river basin level – involving relevant economic actors, civil society organisations, and non-professional water users – appears as a crucial pillar of good governance, also for quantity-related aspects of water resources management. The main responsibility for establishing such mechanisms lies with public authorities, in particular river basin authorities, which need a clear political mandate to do so, whether or not drought management plans are part of a wider river basin management plan.

Dedicated coordination and consultation mechanisms are also essential to manage water quantity for transboundary (trans-national and even infra-national) water bodies. The potential for disputes between European countries over the allocation of water resources in transboundary water bodies should not be underestimated. While examples of successful coordination between countries or regions exist, they are the result of a cooperative approach by the parties involved which cannot be taken for granted.

The provisions of the Water Framework Directive are certainly relevant in this domain, but they may not provide sufficient instructions to address the specific issues and sensitivities related to water quantity management.

Consequently, common EU guidelines (or a framework) that sets more targeted instructions for participatory governance mechanisms related to water quantity management, both infra- and transnational, would be particularly relevant. This framework should also outline conditions under which solidarity mechanisms between regions should operate.

LONG-TERM PLANNING AND POLICY COHERENCE

Collective efforts and coordination are also needed to implement the majority of climate adaptation strategies. For instance, interventions aimed at restoring wetlands or the natural hydro-morphology of rivers are among the most promising and cost-effective long-term approaches to increase resilience, including resilience to flood risks. However, as discussed in chapter **III**, their planning and implementation require a fine interaction and consensus between a plurality of stakeholders and public administrations. This holds true for most small and large-scale Nature-Based Solutions. Similar considerations can then be made for water reuse in both agriculture and industry.

The same can be said for technology. Technology development is undoubtedly a key factor in increasing our resilience. Yet, there is already a wealth of effective and tested technological solutions to reduce water demand (from water reuse to smart irrigation). The widespread adoption of these solutions, however, remains unsatisfactory due to a complex set of reasons (inadequate standards, investment and market barriers, lack of proper incentives and regulation) that only well-designed and targeted policies can address.

However, even if we succeeded in accelerating our climate adaptation efforts and the widespread adoption of effective technologies, it may still not be sufficient to address our water scarcity challenge, especially if the predictions of the IPCC regarding the expected increase in evapotranspiration phenomena and changes in rainfall patterns are confirmed[22]. We must acknowledge the possibility that, at least in some areas of Europe, in the medium term, there might not be enough water to meet all economic and societal needs.

The concept of water scarcity is intrinsically dependent on the level of anthropic pressure. If analyses and predictions on long-term availability and demand for water resources reveal a structural imbalance, even after mitigation measures are factored in, then decisions on the prioritisation of water uses become necessary. Clear prioritisation rules are indeed key to increasing predictability and consequently allowing economic actors to get prepared with contingency planning.

These decisions are inherently political. The most effective approach – although not necessarily the easiest – to minimise the risks of conflicts between water users in cases of an imbalance between water availability and demand is long-term economic and land land planning.

Decisions related to **urban development** in areas likely to undergo structural water stress should be carefully considered; in any case, the extra costs associated with ensuring a stable water supply should be transparently discussed in the decision-making process. While **allocation regimes for agriculture** (and industry) should become more flexible to account for temporary droughts, local institutions will have to engage in foresight exercises (e.g., through the 'adaption pathways' methodology) to make strategic decisions on the development path of a territory, taking into account the long-term availability of water.

Farmers cultivating **water-intensive crops** should be incentivised to transition to more water-sustainable cultivations or face the risk of restrictions during droughts. The issuance of permits to particularly **water-intensive industries** (such as micro-electronics or hydrogen production), and the development of touristic facilities, should be carefully assessed based on water availability.

In short, long-term territorial planning that considers water availability, the costs of remedial actions, the distribution of such costs across users, and their potential environmental side-effects (for instance on biodiversity), is a fundamental condition for achieving true sustainable development in European territories.

The role and responsibility of democratically elected institutions in defining this sustainable path for local development in relation to water availability are, and will continue to be in the future, of paramount importance.

However, the EU also has an important role to play. Firstly, the EU can promote peer-to-peer learning and the dissemination of best practices for establishing an enabling and forward-looking governance framework for long-term water management.

Above all, the EU, and in particular the European Commission, bears the responsibility to ensure that water is streamlined across all relevant fields.

Similar to what has been accomplished for greenhouse gases, the impact on water resources should become an essential component of any impact assessment for new policy initiatives. In this framework, the potential impact on water of some policies related to renewable energies (including hydrogen), raw materials (mining), and reshoring of manufacturing (including micro-electronics) should be carefully considered.

A NEW FINANCING MODEL FOR ADAPTATION

Most of the measures to increase our resilience to water scarcity and droughts described in chapter III will require new investments. Drought management plans and long-term planning for water scarcity must be supported by sound economic analyses that assess the financial impact and trade-offs between different options, in particular for supply-side measures, which tend to be the most expensive and potentially carry more environmental side-effects.

These investments will add up to the already significant financial needs required to comply with quality standards established in existing legislation (for drinking water quality and wastewater treatment) [23] and to realise the current Programme of Measures under the Water Framework Directive, which in most cases do not yet factor in the impact of climate change.

Art. 9 of the Water Framework Directive requires the full recovery of the costs associated with water services, including financial, environmental, and resource costs. It also requires member states to establish water-pricing policies to promote the efficient use of water, and to ensure an 'adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water uses'.

However, in many contexts, the contributions from industry and agriculture still seem inadequate, especially with regard to environmental (pollution) costs, as recently pointed out by the European Court of Auditors[24]. As a result, the burden of cost recovery falls disproportionately on households: in addition to generating inefficiencies and potential market distortions, this also exacerbates affordability problems. Moreover, while pricing mechanisms certainly help increase efficiency, the reliance on volumetric tariffing as the most common approach to recover costs on households appears increasingly inadequate to guarantee both financial sustainability and social equity – the latter due to the partially regressive dimension of volumetric tariffing, especially in urban areas[25].

Against this background and considering that many of the adaptation measures (in particular NBS) have a clear public good dimension, there is **an urgent need to launch a reflection on new financing mechanisms** that can complement volumetric tariffing. Recent scholarship on innovative financing mechanisms, such as the 'beneficiary pays' approach, offers promising perspectives.

The European Commission's recent proposals to reinforce the application of the polluter-pays principle (e.g. the introduction of the 'Extended Producer Responsibility' in the proposal for a revision of the Urban Wastewater Treatment Directive) are highly commendable. The introduction of ring-fenced taxes in some countries, such as Portugal and France[26], to finance initiatives aimed at upstream protection or restoration of water bodies, serves as an inspiring example of how fiscal tools can be used in a targeted way to support adaptation efforts.

In conclusion, while it is essential to better integrate the economic impact of adaptation measures for water scarcity into our long-term planning, we must also develop a new financing model capable of reconciling environmental efficiency, financial sustainability, and social equity in the era of climate change.

The European Commission could take the lead in launching a transparent and participatory EU-wide process to discuss the components and objectives of this new model.

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18. https://project-merlin.eu/
19. Like the extension of the ‘WISE’ system to freshwater uses or the development of the European Drought Observatory (EDORA)
20. https://www.eea.europa.eu/data-and-maps/daviz/annual-and-seasonal-water-abstraction-7#tab-dashboard-02

21. Art. 14 of the Water Framework Directive provides that Member States “shall encourage” participation of citizens and stakeholders in the implementation of the Directive and in particular in the production of river basin management plans. Clearly, the concrete obligations that may derive from the use of the verb “encourage” are quite vague.

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25. Across most of Europe, the tariff is not related to users’ revenues and the assumption that more well-off households tend to consume more water compared to more vulnerable ones is questionable, especially in a urban context.

26. Like the provisions of the law 2017-1838 in France on the implementation of obligations related to the ‘management of aquatic environment and prevention of floods’ (GEMAPI)

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