STARS4Water

Assessment of the needs on data services and modeling tools of stakeholders in selected European river basins

Deliverable D1.2

Assessment of the needs on data services and modelling tools of stakeholders in selected European river basins

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Summary

This report presents the findings from the first stakeholder workshops undertaken to establish the stakeholder communities and assess their needs in each specific river basin hub. The findings from each river basin hub are presented under the different themes of the needs assessment.

The outputs of the workshops are input for the next steps in STARS4Water, to improve the capability of stakeholders, by developing the next generation tools and data services including dashboards for informed decision making and executing risk assessments for water resources availability related issues.

In all the river basins, stakeholder communities are set up and first workshops have taken place. As the river basins are of different nature and different state of maturity in their policy making and operation, the results of the stakeholder meeting are heterogeneous. In some instances, such stakeholder meeting was a first in the river basin; in other basins such collaboration has existed for centuries. We can conclude that, after this first round of workshops, the organization phase of the stakeholder communities for the STARS4Water project is finalized.

Based upon the challenges in relation to the effects of climate change, water availability and changes in land- and water demand on water use and supply, there are similarities across all the river basins, however detailed needs vary based upon physical and sociographic circumstances. In this first round of needs assessment, we collected all the wishes. Based on the identified needs and the goals of the STARS4Water project and the capabilities within the consortium, the STARS4Water team has selected priority topics for further development within the project. In a next step we will further co-design the data services and modeling tools with the stakeholder partners within the STARS4Water team. The compiled overview of the stakeholder's needs and the priority list are the main results of this report.

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1. Introduction

1.1. STARS4Water project

STARS4Water (Supporting Stakeholders for Adaptive, Resilient and Sustainable Water management) is a 4-year research project under the Horizon Europe Program. The project is addressing a call on improved understanding, observation and monitoring of water resources availability to support European Green Deal and EU water policies.

Worldwide, freshwater resources are under increasing pressures of rapidly intensifying climate change effects putting the availability and quality of water resources and socio-economic developments at risk. Recent IPCC report (IPCC, 2021) concluded that climate change is widespread, rapid and intensifying, bringing more intense rainfall and associated flooding, as well as more intense droughts. Further global warming will amplify permafrost thawing, the loss of seasonal snow cover, melting of glaciers and accelerating sea level rise. River basins are under increasing pressures due to greater frequency and intensity of floods and droughts, unpredictable rainfall patterns, altered river flows, degradation of aquatic ecosystems, sea level rise-induced salinization of coastal groundwater and river mouth. Due to the changing climate, Europe will face exceptionally hot and dry summers, mild winters and heavy rainfall leading to river flooding and flash floods. The flood and drought events of recent decades have illustrated Europe's vulnerability to hydrological extremes. In the years 2017-2023, Europe has again been hit hard by flood and drought events, affecting food supplies, agricultural incomes, employment, ecosystems, drinking water supplies and energy production.

A cornerstone of the EU strategy on adaptation to climate change is the implementation of pathways with targeted actions to protect and ensure the availability and sustainability of freshwater resources. Also, there is a clear need for developing climate resilient sustainable water management plans both at national level and river basin level. Good understanding of the water resources system and the consequences of trends in availability, behaviour, and change, is essential for developing plans to strengthen water security and enhancing climate resilience. Recently, river basin authorities across Europe have started initiatives to better monitor and assess water resources availability and water use. Many have expressed a clear need to improve information, data services and modelling tools to enhance their understanding of the water resources availability and use within the river basin and to help improve their decision-making with respect to climate change.

Recent advances in earth observation and environmental data acquisition, in cooperation with relevant EU earth observation initiatives, such as ESA and GEOSS, have opened a new world of climate data services and provide significant potential for improving the accuracy and spatial resolution of models. However, application of such advancements remains mainly in the scientific domain. Uptake of these novel approaches by water resources planners and the stakeholders on the river basin level is rare, even amongst frontrunner river basins like the Rhine or Danube. The main objective of the STARS4Water project is to bridge this gap by unlocking the potential of new data sources into new services and data-driven tools that will meet the future needs of water resources planners across Europe. By doing so, STARS4Water will help improve the understanding of climate change impacts on water resources availability and the vulnerabilities for ecosystems, society, and economic sectors at river basin scale. Consequently, the STARS4Water project will develop and deliver new data services and data driven models for better supporting the decision making on planning on actions for adaptive, resilient and sustainable management of freshwater resources at river basin scale, particularly in the context of climate change (Figure 1.1).

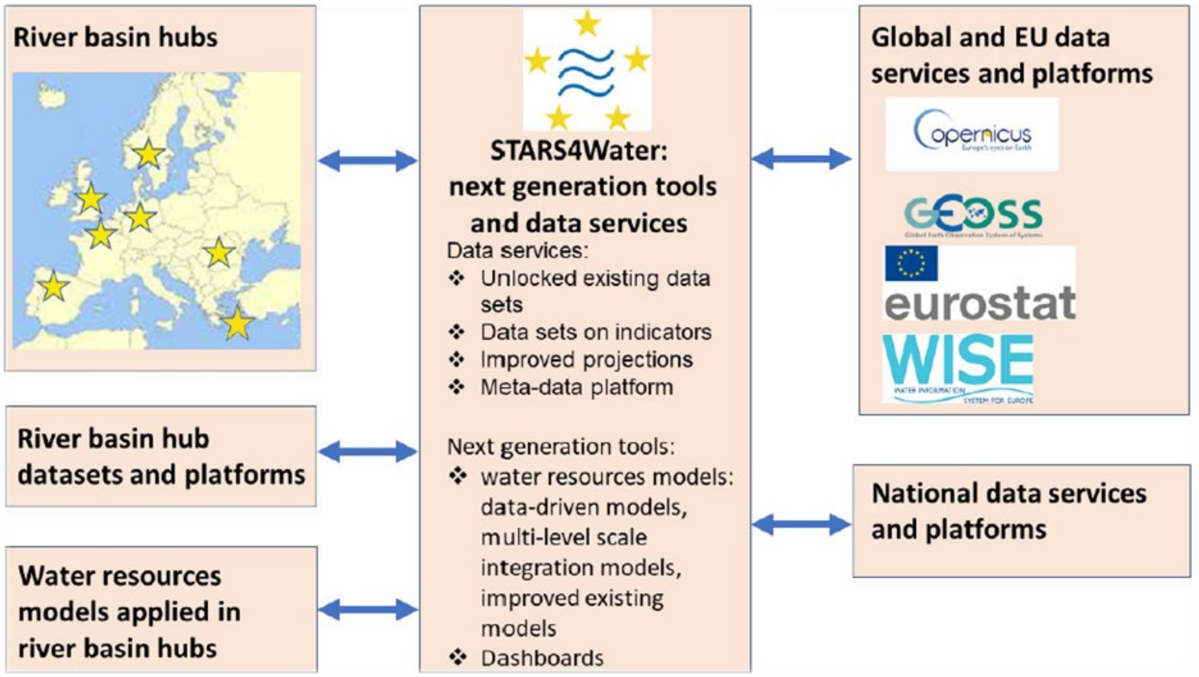


Figure 1.1: The STARS4Water framework for developing next generation tools and data services to improved understanding and management of water resources in European river basins.

1.2. Co-creation with stakeholders in river basin hubs

The STARS4Water project applies a stakeholder-driven approach to develop the new generation tools and data-services to assess the impact of climate changes on water resources availability and the impact on the sectors. This requires a co-creation approach with the key stakeholders in river basins to meet their needs on data and information, ensuring relevance and uptake for use beyond the lifetime of the project. Seven European River basins serve as a 'hub' for co-creation with stakeholders (Figure 1.2). For each river basin hub, STARS4Water has established a River Basin Hub Team comprising a Focal Point from the research partners and the corresponding stakeholder partner (Table 1.1). Each team is responsible for the stakeholder engagement processes and interactions between the consortium partners and external stakeholders in the river basin hub. The stakeholder engagement processes, activities and planning are described in detail in D1.1. (Hegdahl et al., 2023).

To ensure a good outcome from the stakeholder workshops, it has been found useful to involve, at an early stage, a few key stakeholders who are important for making decisions in the respective river basin hubs. For example, if it is important to develop environmental flow tools or a reservoir management optimization tool, it makes sense to involve representatives interested in these themes already in the co-development of the workshop. These key stakeholders are the STARS4Water stakeholder champions, and they play a more active role during the stakeholder workshops. The stakeholder champions are a small group of stakeholders with a position to identify challenges, gaps and needs, and contribute in a constructive way to presented solutions throughout the lifetime of the project. Depending on how the river basins are organized, the stakeholder champions could be between one and four stakeholders. The stakeholder champions should have a high interest and preferably a high influence in the river basin hub.

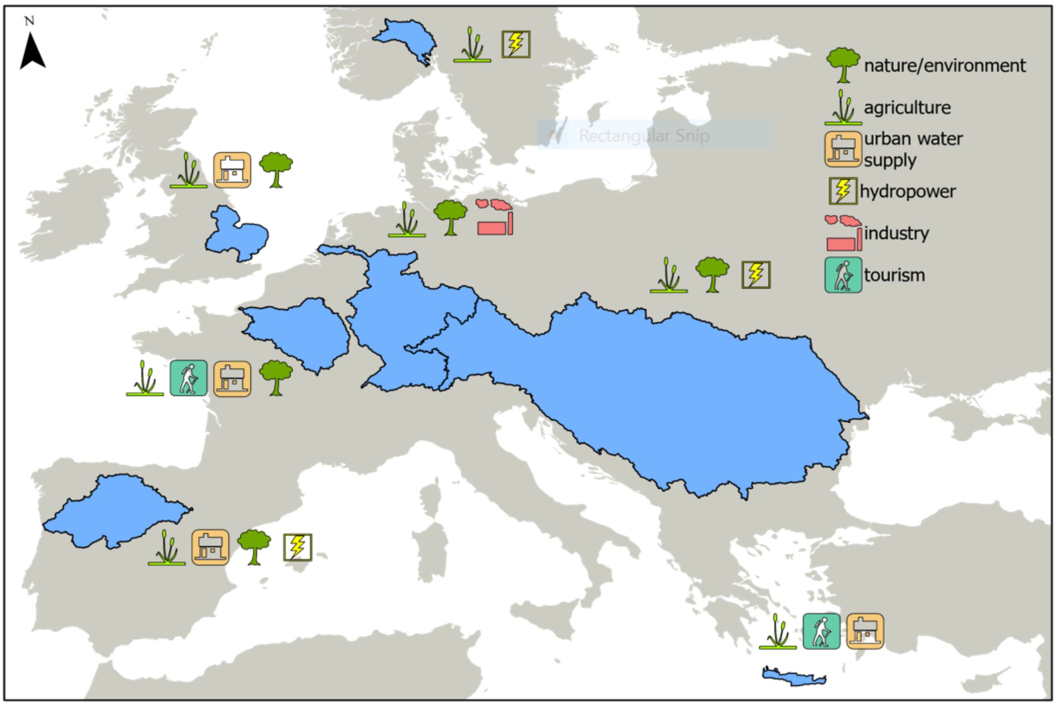


Figure 1.2: the River Basin Hubs in STARS4Water

Table 1.1: The river basin hub teams: Focal Points and stakeholder partners

River Basin Hub Teams		
River Basin Hub	**Research partner (Focal Point)**	**Stakeholder partner**
Messara (Crete)	Seven Engineering Consultants	PERIFEREIA
		Helenic Ministry of Environment and Energy
Duero (Spain)	Instituto Geológico y Minero de España-CSIC	Confederación Hidrográfica del Duero
Seine (France)	Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement	EPTB Seine Grands Lacs
East Anglia (United Kingdom)	UK Center for Hydrology & Ecology	Anglian Water Services Ltd.
Drammen (Norway)	Norwegian Water Resources and Energy Directorate	Norwegian Water Resources and Energy Directorate
Danube	Universität für Bodenkultur Wien	Administratia Fluviala a Dunarii de Jos R.A. Galati
	Institutul National de Cercetare-Dezvoltare Pentru Geologie si Geoecologie Marina	International Commission for the Protection of the Danube River
Rhine	Deltares	Rijkswaterstaat
	Bundesanstalt für Gewässerkunde	International Commission for the Hydrology of the Rhine River

1.3. This report

This report presents the stakeholder communities in each river basin hub and gives an overview of the findings of the first round of stakeholder workshops in each river basin, including an initial assessment of the needs and requirements with respect to tools and data-services. All seven workshops were structured according to the same format (see Annex 1). Key questions were:

- How is the water resources system in the river basin functioning now and what are the main water resources availability related issues and challenges in the river basin according to the stakeholders?
- Which data, modelling tools and/or information do the stakeholders need for a better understanding of the system and for planning and decision making?
- How should the information be presented?

Chapter 2 presents the stakeholder community of each river basin hub. Chapters 3 to 6 present the outcome of discussions regarding issues in the basins (Chapter 3), needs for data and modelling tools (Chapter 4) and how information for decision-making should be presented (Chapter 5). The research Focal Point analysed all the information received and made a first summary of key messages and proposal how the STARS4Water project could support the River Basin Hub Community (Chapter 6). This information was input for the STARS4Water consortium meeting on April 25 -26. The final Chapter 7 presents the conclusions and reflections and scoping of activities (thematic areas, modelling improvements etc.) for all river basins together for next steps in the project.

2. The stakeholder communities in STARS4Water

In this chapter, we present the results of the stakeholder mapping and describe the organization of the stakeholder community within the river basin hubs to establish a strong stakeholder engagement from start to finish of the project.

2.1. Drammen

The Drammen River basin is represented by the STARS4Water project consortium through the Research Focal Point: Norwegian Water Resources and Energy Directorate (NVE). The STARS4Water stakeholder community concerning the Drammen River basin consists of four stakeholder champions and two research organisations in the stakeholder community for this river basin (Table 2.1).

Table 2.1: The STARS4Water stakeholder community of the Drammen River basin

Organization	Theme	Comments
Regulation cooperation hydropower (Regulerings- samarbeider for Drammensvassdraget (RSD) and Å energi) – Stakeholder champion	Hydropower	Regulatory cooperation for all hydropower companies and associations in the Drammen River basin (107 HP plants)
Norwegian Water Resources and Energy Directorate (NVE) – Stakeholder champion	Water Resources Management and R&D	Examples: contribution to the implementation of the EU water framework directive, regulations and licenses for hydropower and water extraction
River Basin District Board (Vannregion-område ansvarlig) – Stakeholder champion	Water Framework Directive	River basin management with a special focus on monitoring and reporting about water quality and ecosystems
Glitre vann /Godt vann – Stakeholder champion	Domestic water supply	Water supply for six municipalities and 150 000 persons within the basin
Norwegian Institute of Water Research (NIVA)	Research	Water quality monitoring and modelling, Oslo/Drammens fiord
University of Oslo (UiO)	Research	Lisflood hydrological modelling for Drammen

Regulation cooperation's hydropower
The regulation cooperation for the Drammen River basin (RSD) is responsible for the preparedness and cooperation between the different hydropower regulation organizations during floods. The Drammen River basin consists of several hydropower companies, and four regulatory cooperation's covering the main river courses of the Drammen basin. All hydropower companies are licensed by NVE and are obliged to follow regulatory provisions related to the reservoirs HRV (highest regulated water level) and LRV (lowest regulated water level), in addition to eco-flow/environmental flow to ensure favourable conditions for fish and other freshwater species.

Water quality and ecology
The River Basin District Board consist of several administrative levels and ensure that the water quality and ecological state of the water systems are monitored and reported according to the water framework directive. This includes all freshwater bodies of the river basin. The Drammen basin is divided into seven Catchment Water Boards, that are responsible for separate parts of the basin, and often working within a municipality.
The transportation within the river and the ultimate state of the Drammen fjord is modelled and monitored by the Norwegian Institute for Water Research (NIVA, including use of NVE data to estimate the river flow).

Water supply
There are several public water suppliers in the Drammen River basin. The largest, Glitre and Godt vann is represented in the stakeholder community in STARS4Water. In addition to the public services there are private wells and water extractions that are often less monitored. NVE is responsible for giving licenses for water use and extraction. There are, however, several user groups that do not need to apply for a license, depending on the size and estimated volume of water withdrawal. The water quality for drinking water is managed by the Norwegian Food Safety Authority.

Regulations, licensing, and warning
The Norwegian Water Resources and Energy Directorate (NVE) is responsible for regulations and licenses for hydropower and water extraction. Any deviations from regulation provisions during floods or droughts must be approved by NVE. In addition, NVE is responsible for the national monitoring and forecasting of natural disasters in Norway, including floods, and will issue warnings and assist emergency and preparedness units during events. NVE is also monitoring drought situations and collaborates with other governmental institutions with respect to the implementation of the EU water directive.

2.2. Danube

The Danube River basin is represented by the STARS4Water project consortium through the Research Focal Points: Universität für Bodenkultur Wien (BOKU) and Institutul National de Cercetare-Dezvoltare Pentru Geologie si Geoecologie Marina (GeoEcoMar) and by the stakeholder partners Administratia Fluviala a Dunarii de Jos R.A. Galati and International Commission for the Protection of the Danube River (ICPDR).

Bringing together a broad field of technical and practical expertise in water resources management in the Danube area, the STARS4Water stakeholder community of the Danube River basin consists of five stakeholder champions (Figure 2.1). In the Danube Basin, two major River Basin Organizations

(RBOs) are responsible for transboundary river management and water resource issues: the International Commission for the Protection of the Danube River (ICPDR) and the International Sava River Basin Commission (ISRBC). Both RBOs were, nominated as part of the stakeholder champions group.

With respect to the Danube River, the ICPDR is an essential institution to facilitate cooperation between Danube countries. The ICPDR emerged from the Danube River Protection Convention, the major legal instrument for cooperation and transboundary water management in the Danube River Basin. In a legal sense, 15 contracting parties have committed themselves to implement the Protection Convention and jointly act on water polices to maintain and improve the quality of the Danube River and its environment.

The ISRBC tackles transboundary water issues on the major tributary the Sava River. Both the ISRBC and the ICPDR are selected to support and advice the Danube hub, respectively the Focal Points as coordinators for STARS4Water, in achieving the project goals of STARS4Water in the Danube basin. The ISRBC builds on a joint agreement for cross-border cooperation of governments, institutions, and individuals towards sustainable development of the Sava River Basin. The contracting parties relate to the four countries that share the river basin.
Besides of the RBOs, we identified three other stakeholders of relevance for addressing the key topics of the STARS4Water project. The UNESCO Intergovernmental Hydrological Program (IHP) was founded in 1975 and is committed to water research and management as well as promoting education and institutional capacity building in that field. Experts from the IHP are expected to support the handling and interpretation of hydrological data and can offer insights in water resources modelling. The World Wildlife Fond - Central and Eastern Europe (WWF-CEE) are regarded as a reliable and strong partner representing environmental and ecological needs and requirements in the entire Danube Basin. WWF-CEE provides overall leadership and coordination of environmental conversation commitment ranging from protection of biodiversity over to sustainable agricultural practices to floodplain restoration in the Danube and Carpathian eco-regions. The Danube Commission is an international organization, founded in 1948 in Belgrade, that jointly addresses the regime of navigation on the Danube River. It is dedicated to enable and guarantee free navigation of the Danube River for commercial waterway transportation.

Figure 2.1: The STARS4Water stakeholder community of the Danube River basin

2.3. Duero

The Duero River basin is represented by the STARS4Water project consortium through the Research Focal Point: Instituto Geológico y Minero de España (IGME-CSIC) and by the River Basin Organization (authority): Confederación Hidrográfica del Duero (CHD). Table 2.2 provides an overview of the stakeholder community of the Duero River basin.

Table 2.2: The STARS4Water stakeholder community of the Duero River basin.

Organization	Role in water management	Priorities
Confederación Hidrográfica del Duero/ Duero River Basin Authority (Stakeholder champion)	Inter-community basin organization for the management of the waters within its hydrographic district, the Spanish part of the Duero basin	Achieve water bodies "good status"; To meet the water demand for all users
Waters of Castilla y León	Urban supply water quality control	Provide good-quality water to urban population
-	-	Water availability for crops
NATURGY	Company of energy production	Water availability for energy production
Canal de Villagonzalo Irrigation Community	Association of farmers who belong to the same municipality	Water availability for crops
Cubeta de Santiuste Groundwater Users Association	Association of groundwater users for irrigation who belong to the same municipality.	Water availability for crops
IBERDROLA	Company of energy production	Water availability for energy production

The Duero River basin is characterized by 90% of water users devoted to agriculture, 7% water supplies and the remaining 3 % for other users (industrial, recreational, etc). The stakeholder mapping incorporates representatives from surface water irrigation associations, and Groundwater Users Associations as the bigger groups of water users in the Duero basin, jointly with water supplies and hydroelectric enterprises.

According to the definition given for stakeholder champions, we consider that there is just one stakeholder which fulfils such a role, namely the Confederación Hidrográfica del Duero (CHD). The CHD will participate in 1 stakeholder meeting each year, to discuss general progress on models, storylines and story-maps for the Duero River basin. The CHD will be the end-user of the STARS4Water products. Each annual workshop will be followed by technical meetings organized by STARS4Water with the stakeholder champion to support application and validation of models and tools, and to discuss feedback.

The CHD provides a publicly available viewer (MIRAME-Duero[1]) which incorporates all georeferenced information related to water management including the measurements considered in the river basin management plan in force (2022-2027) (Figure 2.2). At the stakeholder workshop, the current data available related to the water availability and the main problems and challenges for the Duero River basin in the MIRAME-Duero viewer was discussed.

Figure 2.2: The MIMARE-Duero viewer. The information related to available water resources is associated to each specific groundwater body. Here is an example of Los Arenales-Tierras de Medina y La Moraña groundwater body.

2.4. East Anglia

The East Anglia basin is represented by the STARS4Water project consortium through the Research Focal Point: UK Center for Ecology & Hydrology (UKCEH) and by the river basin organization (authority), Anglian Water Services Ltd (AWS). Stakeholder champions within the stakeholder community of East Anglia basin, besides AWS, are Water Resources East and Environmental Agency (Table 2.3).

[1] https://mirame.chduero.es/chduero/public/home accessed 05-04-2023.

Table 2.3: The STARS4Water stakeholder community of the East Anglia basin.

Stakeholder champions		
Organization	**Brief Description**	**Priorities**
Anglian Water Services	Largest water and water recycling company in England and Wales, supplying 7 x 10^6 people	- Provision of wholesome drinking water (1.5 × 10^9 L/day for AW) - Bring social and environmental prosperity - Water Use Efficiency
Water Resources East	Not-for-profit organisation pioneering a collaborative approach to water resources planning to safeguard a sustainable supply of water for the East of England	- Understand water resources challenges across all sectors and show solutions - Develop ability to add value and challenge sectors to be ambitious - Develop capability of sectors to adapt to their needs
Environment Agency	Public body responsible to protect and improve the environment. Their mission includes (amongst others) flood management, water quality and resources, navigation and conservation and ecology.	- Water industry national environment program (WINEP): License reduction and river augmentation - Planning system, water demand and protection - Environmental plan: 75% of waterbodies reaching 'Good Status' - Net Zero
Wider stakeholder community		
Organization	**Brief Description**	**Priorities**
National Farmers Union	Largest industry association for farmers, agriculture and horticulture, in England and Wales.	- Delivery of ecosystem services and nature-based services. - Food supply and irrigation - Water resources for agriculture - Food audit - Innovative use of technology
Middle Level Commissioners	Statutory corporation responsible for the provision of flood defence, land drainage, water level management and navigation in the Fens region of East Anglia.	- Flood risk management - Water level management for farming, navigation and environment - Climate change adaptation - Working in partnership with other organisations - Conservation - Balancing discharge with abstraction

2.5. Messara

The Messara basin is represented by the STARS4Water project consortium through the Research Focal Point: Seven, and by the stakeholder partners: PERIFEREIA and the Hellenic Ministry of Environment and Energy. A complete mapping of the stakeholders in the Messara basin hub, along with their main roles and competences, is presented in Table 2.4.

Table 2.4: The STARS4Water stakeholder community in the Messara basin

Organization	Theme	Specific roles / competences
Region of Crete – Directorate of Environment and Spatial Planning – Department of Hydroeconomy	Protection and management of water resources	• Responsible for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems). Once these works are completed, the Region of Crete constitutes a local land reclamation organization (TOEB) to operate and maintain the system and to provide water to farmers • Design and implementation of measures • Decisions on water use restrictions • Pollution monitoring and environmental protection (e.g., ecological flows, good water quality status, etc.)
Region of Crete - Directorate of Technical Works	Construction of infrastructure, water works	• Responsible for the construction and maintenance of the dams • Responsible for the water allocation system
Region of Crete - Directorate of Agricultural economy & Veterinary	Regional agricultural development	Responsible for the development of the Regional Agricultural Development Plan
Water Directorate of Crete Decentralized Administration (WDC)	Protection and management of water resources	• Main role in the development and implementation of the WFD River Basin Management Plans (RBMPs) and Programme of Measures • Responsible for issuing water use licenses: the water in Greece is considering as a public domain good and every user has to have a license. The license describes the terms and conditions to use the water, the specific amount/volume of water to be abstracted and used within specific time (usually 10 years) • Monitoring and data collection • Regulation enforcement • Coordination of stakeholders and public participation
Water Council of the Decentralized Administration	Social dialogue and consultation on water protection and management issues	Promotes and supports consultation with the general public and the various stakeholders, and dialogue with the civil society
Special Secretariat for Water (SSW) of the Ministry of	Protection and management on the water resources	• National Focal Point for the WFD • Responsible for the development and implementation of the National Programs

Environment and Energy		for the Protection and Management of Water Resources of the country, and the coordination of agencies and national bodies regarding the protection and management of water resources
Local Land Reclamation Organizations: - TOEB of Zone B of Messara - TOEB of Zone C of Messara - TOEB of Vassilikon-Anogion	Irrigation management and operation of irrigation water works	• Responsible to operate the water supply and distribution system for local farmers (i.e., provision of irrigation water to the farmers), including the maintenance of the pipeline network. • Responsible to cover the full operational costs • Collection of the water fees from the connected agricultural users / monitoring of the installed water meters
Municipalities of Phaistos and Gortynas – Technical Services Department	Water supply for domestic use, municipal wastewater treatment	• Responsible for the design of the domestic water supply system to cover domestic and touristic water use • Responsible for the design of the sewage system
Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos)	Water supply, wastewater treatment	• Responsible to construct, operate and maintain the domestic water supply and sewage systems (i.e., supply water for domestic use and also for the tourist activities - resorts, hotels, etc.) • Responsible for wastewater collection and treatment • Cost recovery and collection of water fees from the users • Analysis and monitoring of drinking water quality
Hellenic Survey of Geology & Mineral Exploration (EAGME)	Monitoring system, R&D in groundwater management and exploitation	• Responsible for the monitoring system of the groundwater • Research for water development
Messara Associations' Network	Educational, social, humanitarian, environmental and cultural activities	Responsible for coordinating a network of 24 Associations in the Messara wider region
Agricultural School of Messara (under the auspices of ELGO-DIMITRA and the supervision of the Ministry of Rural	Education, training	• Education • Capacity building and training of farmers • Dissemination of best agricultural practices

Development and Food)		
Individual Farmers	Irrigation water	Construction and operation of private wells for agricultural use, after having issued a valid water license from the WDC

The Messara basin, located in the central-south area of the Crete Island, with a population of almost 45,000 inhabitants and an area of 611 km^2, constitutes the most important agricultural region of Crete. The annual water use amounts to 70 million m^3/year, of which 96.6% for agriculture, 3.2% for domestic use (including tourism), and 0.2% for industrial supply. The irrigated area is about 16,263 ha, which represents 56% of the total cultivated (29,109 ha) area. A total of 1,400 groundwater wells operates in the basin, with a total of 63 million m^3/year been abstracted annually from groundwater, causing a drop in the water table of as much as 45 m due to overexploitation in some areas. In terms of quantitative and chemical status, out of the 3 main groundwater bodies (GWB) in the basin, the GWB 'Porodes Moiron' (about 56 km^2 area) has already been characterized in poor quantitative and poor chemical status (nitrates presence). As such, water supply and allocation, sustainable management of the irrigation water, limiting overexploitation (and its adverse impacts) and controlling nitrates pollution are of main concern in the basin. In this respect, we have identified 4 key stakeholders with high influence and interest, as presented below:

- The Region of Crete, with a direct interest in the protection and management of water resources. As the Region of Crete bears the responsibility for the design and construction of infrastructure/ water works (dams, wells, water supply and distribution systems) it has a high influence on the overall water supply and allocation. It is also responsible for the design and implementation of measures, such as water use restrictions among others. Finally, the Region of Crete is responsible for pollution monitoring and environmental protection (e.g., ecological flows, good water quality status, etc.), as well as for the development of the Regional Agricultural Development Plan. It is thus a stakeholder in a position to strongly influence decision-making and planning.
- The Water Directorate of Crete Decentralized Administration (WDC), with a direct interest in the proper implementation of the WFD River Basin Management Plans (RBMPs) and related Program of Measures. As the WDC bears the responsibility for issuing the water use licenses it has a high influence on controlling groundwater abstraction and overexploitation.
- The Local Land Reclamation Organizations (TOEB of Zone B of Messara, TOEB of Zone C of Messara, TOEB of Vassilikon-Anogion) have a direct interest on efficiently meeting irrigation water demand. These three organizations (TOEBs) bear the responsibility of providing sufficient irrigation water to the farmers, as well as adequately operating and maintaining the irrigation water supply and distribution systems, including cost recovery. Among others they define the water tariffs for the farmers, they are responsible for the collection of the water fees from the farmers and the monitoring of their water meters, they monitor the levels of their pump stations, they set irrigation rules. As such, the TOEBs have a high influence on irrigation water supply and management, and on the Messara water productivity noting that agriculture is the dominant water use.
- The Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos) has a direct interest on the provision of adequate domestic water and wastewater treatment. As DEYA Faistos bears the responsibility to collect and treat domestic wastewater it also has an influence on irrigation water supply through the provision of treated wastewater for agricultural reuse.

Among these 4 key stakeholders listed above, the “Region of Crete” and the “Local Land Reclamation Organizations” have been further flagged as “stakeholder champions” and are chosen to closely work with the STARS4Water consortium to identify challenges, gaps and needs, and contribute in a constructive way to co-develop solutions throughout the lifetime of the project.

2.6. Seine

The Seine River basin is represented by the STARS4Water project consortium through the Research Focal Point INRAE, France's National Research Institute for Agriculture, Food and Environment, and by the local public river basin authority EPTB Seine Grands Lacs (“Établissement Public Territorial de Bassin Seine Grands Lacs”, hereafter EPTB SGL).

The EPTB SGL is a joint union of regional authorities in charge of designing and managing infrastructures to improve integrated water resources management. It brings together 18 departments in the Seine River basin. The EPTB SGL has three main missions: the protection and prevention against flooding, the maintenance of a minimum flow of the Seine and its main tributaries during the driest seasons, and the adaptation to climate change in the upstream basin of the Seine River. It operates four large dams and their respective water reservoirs located upstream of the Seine River (Figure 2.3). These lake-reservoirs are operated to guarantee flood protection and low flow support for downstream water users. They also have a fundamental role for ecological protection and enhancement.

In addition to EPTB SGL, another main river basin authority identified as “stakeholder champion” to the STARS4Water project in the Seine hub is the Seine-Normandy water agency (“Agence de l’Eau Seine Normandie”, AESN). The AESN is one of the six agencies responsible for preventing pollution and protecting aquatic environments in France. It operates in the Seine River basin and in the coastal waterways of Normandy. The agency is a financial water agency in charge of coordinating the general framework of water resources management over the river basin. It provides the financial means to improve water quality, the rational use of water resources, and the protection of aquatic environments. It is therefore a strategic stakeholder in understanding the water needs over the catchment and the challenges of future management.

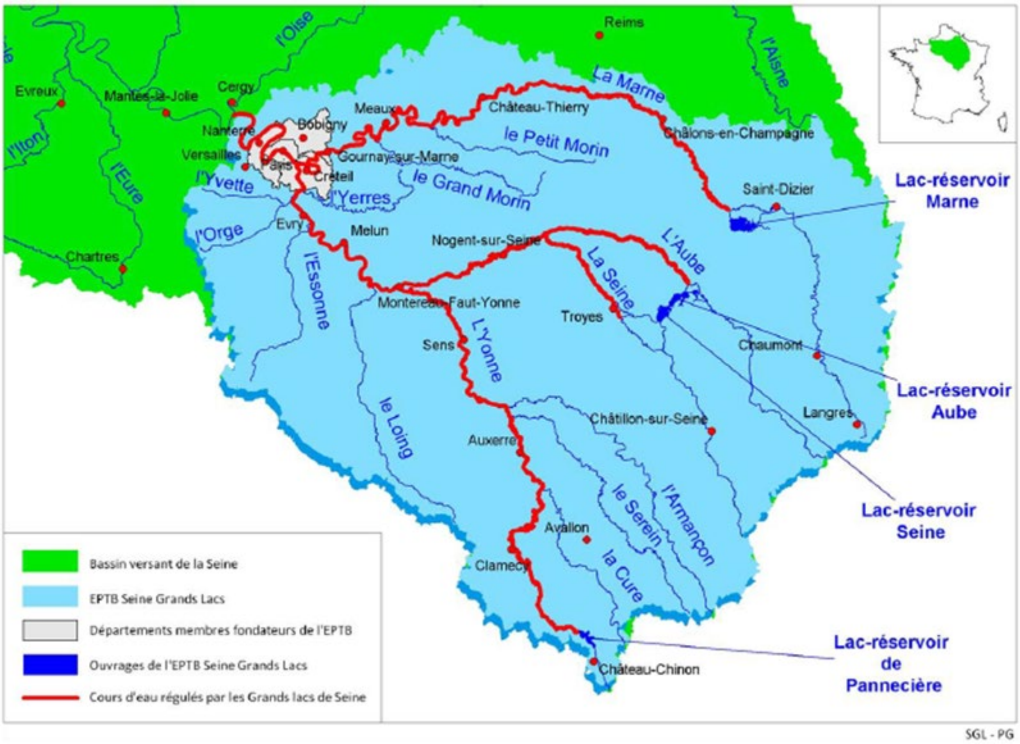


Figure 2.3: Location of the four lake-reservoirs managed by the EPTB Seine Grands Lacs. Source: EPTB SGL

Associated to the AESN, the PIREN-Seine scientific community ("Programme Interdisciplinaire de Recherche sur l'eau et l'environnement du bassin de la Seine") is another key pillar within the Seine River basin (in 2019, over 100 researchers and PhD candidates and 13 stakeholders/water managers). The aim of the PIREN-Seine research group is to develop an overall vision of the operation of the system comprising the Seine hydrographic network, its river basin and the human-society interactions within the basin. INRAE is a research institution involved in this group and has contributed to generate knowledge on the past and future trajectories of the river basin status and evolution, mainly concerning aspects related to water quality, aquatic communities and habitats. EPTB SGL and AESN are partners in the PIREN-Seine. This research program is currently in its 8th phase, initiated in 2020. It has organized its focus areas of research to respond to major issues related to the agri-food system, climate change, risk management, biodiversity, the Parisian metropolis and the contamination of aquatic environments. Some reflections for the 9th phase (2025-2028) have pointed out to the following key aspects:

- Vulnerabilities and adaptation of the basin and its territories.
- Knowledge of the activities and sectors influencing water and aquatic environments.
- The Seine socio-ecosystem through the "One health" prism.
- Acquisition and use of environmental data.

A possible contribution to/from the STARS4Water project is through sharing hydrological modelling outputs and enhancing the use of Earth Observation data for modelling and adaptation.

2.7. Rhine

The Rhine River basin is represented by the STARS4Water project consortium through the Research Focal Point: Deltares and Bundesanstalt für Gewässerkunde and by the stakeholder partners: Rijkswaterstaat and the International Commission for the Hydrology of the Rhine.

The collaboration between the member states in the Rhine catchment has a long history. It started with the Central Commission for Navigation on the Rhine (CCNR, founded in 1815), and was followed by the International Commission for Protection of the Rhine (ICPR, founded in 1950) and the Commission on Hydrology of the Rhine (CHR, founded in 1970). The CCNR focusses on navigation in broad sense, the CHR focusses on research and providing the knowledge base on hydro-morphology and the ICPR is the political platform also in charge of implementing of the international parts of the EU Water Framework and Floods Directive.

For STARS4Water both ICPR and CCNR are chosen to form the stakeholder community of Rhine River basin hub. ICBR and CCNR make the connection to the political decision-making process on climate adaptation and water security, while the CHR supports the ICBR, CCR and others with scientific research and knowledge (Figure 2.4). Through the CHR (in the role of stakeholder champion) the STARS4Water consortium is connected to the ICPR and the CCNR and the wide range of stakeholders connected with these commissions (the stakeholder community). The three commissions are represented by the secretary or scientific officer (Table 2.5). Based upon the long history and strong collaboration within and between the commissions and the goals and working programs, we may conclude that there is a very solid base present.

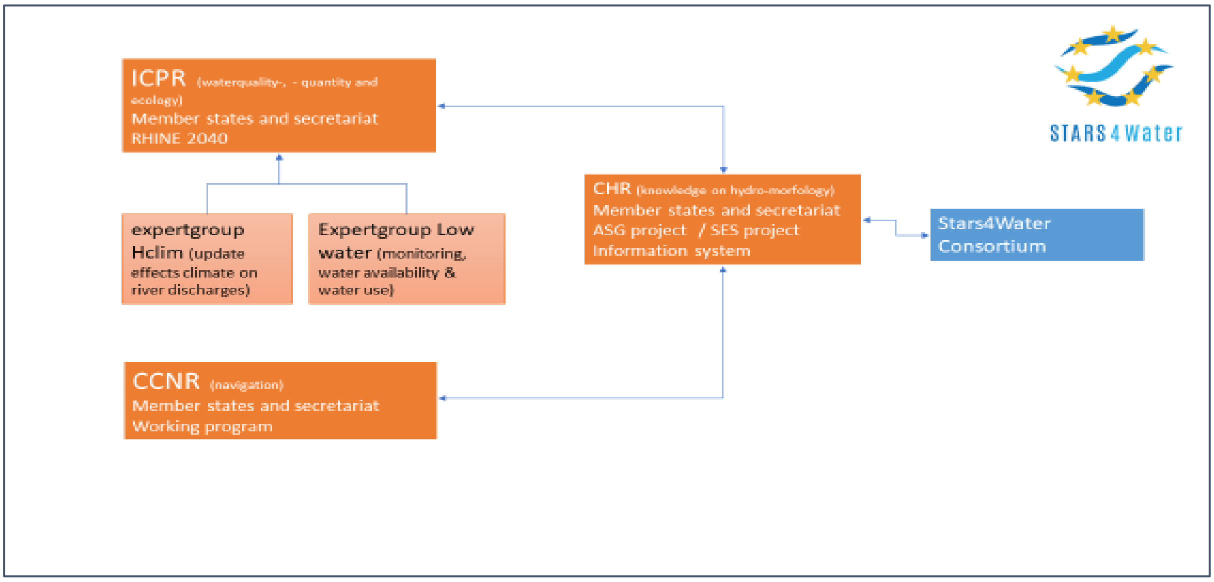


Figure 2.4: The STARS4Water stakeholder community for the Rhine River basin.

The first STARS4Water stakeholder meeting, was organized "back-to-back" to the the CHR at the spring 2023 meeting in Biel, Switzerland. During the meeting the needs of the ICPR, CCNR and CHR have been discussed. The three commissions expressed that they have a high interest on better understanding and assessment of water availability and water use under various scenarios. In the past months they were already discussing how to cooperate more on this research topic and prevent redundancy. All participants believe that STARS4WATER can be a catalyst for these activities and cooperation. The commissions expressed that they want to be involved in the Stars4water project and want to play an active role.

Table 2.5: The STARS4Water stakeholder community of the Rhine River basin.

Organization	Role in water management	Comments
CHR – stakeholder champion	CHR coordinates and conducts transboundary cooperation in research and knowledge development on hydrology and morphology in the Rhine basin.	The CHR has several research lines in which experts from riparian countries work together on topics related to climate change, sediments, socioeconomic scenarios, information system and other topics.
CCNR – stakeholder community	In application of the Mannheim Convention, the CCNR's role is to implement any initiative intended to guarantee freedom of navigation on the Rhine and promote navigation on the Rhine.	Activity of regulating navigation on the Rhine, maintenance of good conditions for navigation on the Rhine, promotion of ecological inland navigation, development of the law of inland navigation, coordination of national regulations regarding the social protection of boatsmen, economic issues and other points of attention related to inland navigation.
ICBR – stakeholder community	ICBR is a political platform. The ICBR oversees implementing of the international parts of the EU Water Framework and Floods Directive. The Rhine Ministers Conference 2020 approved its Rhine 2040 program.	Various expert working groups with representatives from riparian countries are active within the context of ICBR. Each working group addresses a topic like climate change, high and low water, groundwater, water quality or other

3. Issues and challenges related to water resources availability in the river basins.

In this chapter we describe how the water system is functioning now, and the main challenges or conflicts that will have the focus of in STARS4Water.

3.1. Drammen

The Drammen River basin consists of several river courses and tributaries, Hallingdalvassdraget, Begnavassdraget, Etna-/Dokkavassdraget including Randsfjorden, and Simoa, and enters the sea at the city of Drammen. It is the third largest river basin in Norway (17,114 km2 area). The climate varies substantially along the Drammen River, from glaciated regions in the upper catchments in the west (annual average temperatures close to 0 °C) to the lowlands Southwest (annual average temperature in Drammen: 5,9 °C). Annual rainfall ranges from 500 mm at Nesbyen up to 2500 mm at Hardangerjøkulen.

The water resources in the catchment are used for hydropower production, water supply, agriculture, industry, and tourism (fishing, boating). Approximately 20 % of the catchment is situated above 1000 m asl. (i.e., above the tree line), hence, the large altitude gradients are making it suitable for hydropower production. The catchment has 107 hydropower stations, 2 TW installed capacity and an annual production of 8.3 TWh.

Flood and drought events
The Drammen River have experienced several types of floods. During July 2007 and May 2013, snowmelt floods combined with rainfall led to damages to properties and roads. Severe rainfall floods occurred during autumn and winter (December 2021 and August 2015). An extreme rainfall event in August 2012 led to rapid increases of the water levels in small catchments. Flood discharges in Mjøndalen River and Krokstad River were estimated to approximately 100-year floods. Damages were especially severe in urbanized areas north of Drammen city, Nedre Eiker.

Issues and challenges

Coordination during floods and droughts
Since many different hydropower producers operate in the catchment, water management during floods is coordinated by a regulation cooperations for hydropower (RSD) involving the four different regulatory cooperations that represent all hydropower companies within the basin. One important task for RSD is to ensure cooperation and emergency preparedness during floods. How to prioritize water management during floods is, however, not clear and information is lacking, especially information to help municipalities to prioritize emergency preparedness. Any deviations from regulation provisions before or during floods or droughts are applied for and approved by NVE.

During the dry summer of 2022, the water level in Drammen River was the lowest in 140 years. Energy producers needed to prioritize between the lesser of two evils: maintaining environmental flows or storing water for energy production during the coming winter.

The multi-year reservoirs in Drammen River can withstand one dry year, possibly two consecutive dry years. However, two or three consecutive dry years are critical for hydropower, water supply and biodiversity. High water temperature leads to oxygen-poor water. High water temperature can also cause algae blooms, poor bathing water quality, and an increased need for water treatment.

Water quality and biodiversity
Urban drainage systems are ageing and need maintenance. Leakage losses from the drinking water network to the sewage network are usually 20% to 40%. Low water quality and/or low discharge in Drammen River may negatively influence the water quality in Drammensfjorden. During the summer of 2022, low discharge increased the salinity in Drammensfjorden from 1-5 psu up to 11 psu at its highest, which persisted for a long time.

Drammen River is a popular fishing river, containing salmon and trout among other species. The parasite Gyrodactylus salaris is present in Drammen River, and there is a risk of spreading the parasite to clean rivers. Rare species such as European crayfish (*Astacus astacus)*, brown trout (*Salmo trutta lacustris)*, eel and freshwater pearl mussel (*Margaritifera margaritifera*) live in Drammen River. Freshwater pearl mussel is an endangered species that purify water; it cannot tolerate drought. A mass death of river mussels was observed in Drammen River during the dry summer 2022 due to a rapid lowering of the water level.

The ecosystem in the Drammensfjord is unique, due to the very low salinity in the surface layer (1-5 psu, practical salinity unit, in the upper 5-10 metres). The low river discharge during 2022 drought caused an increased salinity which most likely caused great damage to the aquatic plants in the Drammensfjord, where several species may have disappeared.

3.2. Danube

The Danube River basin, spanning an area of 801,463 km2, is the second-largest river basin in Europe. It is a highly international basin, home to over 80 million people from 18 different nations, making it the most international river basin in the world. The International Commission for the Protection of the Danube River (ICPDR) plays a crucial role in coordinating the preservation, enhancement, and sustainable use of the Danube waters. The ICPDR is a contracting party to all countries encompassing more than 2,000 km^2 of the basin, as well as the European Union.

The Danube River basin can be divided into three sub-regions: the Upper, Middle, and Lower Basins, with the Lower Basin including the Danube Delta. The Upper Basin stretches from the Danube headwaters in Germany to Bratislava in Slovakia. The Middle Basin, the largest of the three sub-regions, extends from Bratislava to the Iron Gate Gorge dams on the Serbian-Romanian border. The lower basin comprises the lowlands, plateaus, and mountains of Romania and Bulgaria.
Beyond the Iron Gate, the lower Danube flows through a wide plain, becoming shallower and broader with a slower current. On the right side, Bulgaria's Danubian Plain extends above steep banks, while the low Romanian Plain is located on the left side, separated from the mainstream by a narrow band of lakes and wetlands. Numerous tributaries, including Jiu and Olt from Romania, Timok from Serbia, and Ogosta and Iskar from Bulgaria, flow into the Danube in this stretch.

Climate and hydrology

The climate and hydrology of the Danube River basin vary across its three portions. The upper Danube experiences runoff similar to Alpine streams, with peak flow occurring in June during intense snow and ice melting in the Alps. The central basin exhibits two runoff peaks between June and April, with the June peak originating from the upper course and the April peak resulting from melting snow and early spring rainfall in the lowlands and low mountains. The lower basin, where the Romanian study area is located, shows a different river regime, with the average discharge in this stretch of the Danube River recorded at 5,420 m^3/sec, ranging from 7,930 to 3,730 m^3/sec in wet and dry years, respectively (Haidvogl et al., 2021).

Romania's climate is characterized as transitional temperate-continental, influenced by oceanic effects from the west, Mediterranean influences from the southwest, and excessive continental influences from the east. The average temperature ranges from 8°C in the North to over 11°C in the South, with mountainous regions experiencing lower temperatures and plains having higher temperatures. Annual precipitation averages 637 mm and decreases from west to east, with the East Romanian Plain receiving less than 500 mm and the coast around 350 mm, while hilly areas receive between 1000 - 1500 mm. Severe droughts occur every 15 to 25 years. Romania is considered a water-scarce country, ranking 13th in Europe with an average water availability of only 1,700 m^3/person/year. Approximately 6.1% of Romania's territory, covering an area of 14,437.3 km^2, has been designated for habitat and species preservation, particularly in locations with critical water resource status.

Agriculture is the predominant land use in the study area. According to the land use recorded, approximately 63% of the area is covered by crops, mainly concentrated in Romania and Bulgaria, with a smaller portion in Serbia. Vegetation covers 19% of the surface area, primarily in the north-western part of the study area. Bare land accounts for 11%, built areas for 5%, and water bodies for 2%.

The Danube River basin, comprising rivers, lakes, transitional and coastal waters, and groundwater, is a vital natural resource with diverse applications such as drinking water supply, wildlife habitat support, and resources for industry, agriculture, transport, energy production, and recreation. However, a significant portion of this resource is currently damaged or at risk, necessitating protective and restorative measures. Sustainable development and the long-term well-being of the Danube region's population depend on the successful conservation of these water bodies. Recognizing the need for transboundary cooperation in water resource management, the countries sharing the Danube River basin have collectively committed to this objective. The Danube River Protection Convention (DRPC), established in 1994, serves as the legal framework for cooperation within this globally renowned international river basin.

All countries within the Danube River basin, including Austria, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Germany, Hungary, Moldova, Montenegro, Romania, the Republic of Serbia, the Slovak Republic, Slovenia, Ukraine, and the European Union, are Contracting Parties to the DRPC. The International Commission for the Protection of the Danube River (ICPDR) is entrusted with facilitating multilateral cooperation and implementing the DRPC, in accordance with its mandate. In 2000, the European Union Water Framework Directive (WFD) was adopted to establish a comprehensive framework for the conservation and enhancement of inland surface waters, transitional waters, coastal waters, and groundwater, while promoting sustainable water resource utilization. The primary aim of the WFD is to achieve and maintain "good status" for all water bodies, thus preventing their deterioration. EU Member States are obligated to work towards achieving "good status" in all surface water bodies and groundwater by 2015, with a final deadline of 2027. While not all countries in the Danube region are EU Member States, Bosnia and Herzegovina, Moldova, Montenegro, the Republic of Serbia, and Ukraine are Non-EU Member States, with Montenegro and the Republic of Serbia holding candidate country status.

Although not legally binding, all countries cooperating under the DRPC committed to making substantial efforts to implement the WFD throughout the entire basin when it was adopted in 2000. The WFD incorporates several integrative principles for water management, including public participation in planning, the integration of economic considerations, and the harmonization of water management with other policy areas. The directive follows a cyclical process of river basin management, involving tasks such as characterization and assessment of impacts, water status monitoring, establishment of environmental objectives, and the implementation of measures to achieve these objectives. In 2009, the Danube River Basin completed these tasks for the first time, and they are currently being updated in line with the cyclic approach of the WFD, enabling adaptive basin management.

Infrastructure

From all significant water-related infrastructures in the Danube River basin, the Iron Gate Dam I and II are the most important in the region. The Iron Gate Dam I, located upstream of Drobeta Turnu Severin town in Romania, has a total storage capacity of 2,400 million m^3 and is one of Europe's largest hydroelectric power dams. It serves various purposes, including base hydropower generation, navigation, flow regulation, and industrial water supply. The average flow rate in this section of the Danube is 5,420 m^3/sec, ranging from 7,930 to 3,730 m^3/sec in wet and dry years, respectively. The Iron Gate Dam II, located approximately 78 km downstream of Iron Gate Dam I, has a total storage capacity of 830 million m^3. It consists of two sections, with the upper dam situated on the Gogosu secondary branch entirely within Romanian territory, and the lower dam shared between Romania and Serbia on the Danube River's left bank. The total capacity of the hydroelectric facilities at Iron Gate Dam II is 432 MW, divided equally between Romania and Serbia.

Hydro-morphological alterations resulting from hydro-engineering measures can have significant impacts on the structure of surface waters and the ecological status of river systems. These alterations, caused by activities such as hydropower generation, navigation, and flood protection, can disrupt natural conditions and habitats for aquatic species. The interruption of longitudinal and lateral river continuity, disconnection of wetlands/floodplains, and hydrological changes are key pressures that affect hydro-morphological structures. Anthropogenic sources like urban settlements and agriculture also contribute to these alterations. Such changes pose a risk to achieving environmental objectives set by the EU Water Framework Directive (WFD).

Regarding sediment quantity, the disturbance or severe alteration of sediment balance in most large rivers within the Danube River Basin has been observed. Ensuring the continuity of sediment flow and improving barriers are important for sediment management. However, reliable data on sediment transport is necessary to make informed decisions. The International Commission for the Protection of the Danube River (ICPDR) is leading a project on sediment management to gather this data and develop a sediment balance. The project involves collaboration between Hungary, Austria, Romania, and the ICPDR Secretariat, with the aim of identifying key measures to address sediment transport on a basin-wide scale. The results will inform future river basin management cycles.

Navigation
The Danube River is a crucial waterway for transportation, offering significant potential for cargo shipping. Out of its total length of 2,845 km, 2,415 km is navigable and connects ten riparian states. Romania, with a total length of 1,075 km, has the largest portion of the Danube, accounting for about one-third of its total length. The research area lies along a key route that connects many European countries to the Black Sea. In 2011, over 20% of Romania's cargo transportation relied on navigation, a significant increase compared to previous decades (Scholten & Rothstein, 2016). However, several bottlenecks, characterized by shallow river stretches or massive rock formations in the river beds (see Table 3.1), pose challenges to navigation along the Danube (Haidvogl et al., 2021). In this context, we can see first hand some of the major impacts and the effects that all the antropological factors add up to.

Table 3.1. Bottlenecks along the Danube river (Romania). After: Scholten & Rothstein (2017).

Country	*Danube (km)*	*Problem*	*Fairway depth (cm)*	*Number of days/year with low water*
Romania	**863 to 175**	low fairway depth during the dry season	below 250 at several critical sections	
1	**863 to 845.5**	low fairway depth during the dry season	220–230	7 to 15
2	**845.5 to 610**	low fairway depth during the dry season	210-220	210 to 220
3	**610 to 375**	low fairway depth during the dry season	180-200	20 to 40
4	**375 to 300**	low fairway depth during the dry season	160-220	30 to 70
5	**300 to 175**	low fairway depth during the dry season	190 - 210	15 to 30
6	**170 to the Black Sea**	low fairway depth during the dry season	Below 730	10 to 20

Water Quality – Pollutants

Organic pollutants
Organic pollution refers to the release of non-toxic organic substances that can be decomposed by bacteria. Point sources, such as untreated municipal wastewater and direct industrial discharges, are the primary emitters. Diffuse pollution, although less significant, comes from agricultural and urban runoff. Organic pollution impacts the dissolved oxygen balance in water bodies, causing downstream oxygen depletion due to microbial decomposition of organic matter. The affected river length depends on factors like wastewater treatment, dilution, and hydraulic conditions. Oxygen levels recover through atmospheric diffusion and photosynthesis. Organic pollution can harm sensitive

aquatic species and lead to anaerobic conditions, potentially producing methane and hydrogen sulfide gases and releasing toxic elements. Indicators of organic pollution include biochemical oxygen demand, chemical oxygen demand, total organic carbon, nitrogen, and coliform bacteria. Secondary wastewater treatment and runoff management practices effectively address organic pollution.

Nutrient pollutants

Nutrient pollution in aquatic environments stems from significant releases of nitrogen (N) and phosphorus (P). It arises from both point and diffuse sources. Point sources include municipal wastewater treatment plants, untreated wastewater, industries, and animal husbandry. Diffuse pathways, such as atmospheric deposition and runoff, contribute nutrients from agriculture, urban areas, and natural landscapes. Nutrient pollution, particularly from agriculture, has adverse effects on water ecosystems, causing eutrophication and impairing water quality. Managing point source emissions requires nutrient removal at wastewater treatment plants, while diffuse source management is challenging due to variability and hydrological factors. Key parameters for assessing nutrient pollution include nitrogen and phosphorus levels.

Hazardous pollutants

Hazardous substances pollution refers to the contamination of water with specific pollutants listed in Annex X and Annex VIII of the Water Framework Directive (WFD). These substances, including inorganic and organic micro-pollutants such as heavy metals, cyanides, pesticides, and pharmaceuticals, possess toxicity, degradability, or accumulative properties and are locally or regionally relevant. They can originate from both point and diffuse sources. Point sources include households, public buildings, and industrial facilities that release hazardous substances through wastewater discharges. Indirect dischargers transport industrial wastewater to treatment plants via public sewer systems. Diffuse emissions pathways vary depending on the substance, with surface run-off, sediment transport, and groundwater flow being the main contributors. Urban systems, agriculture, contaminated sites, and mining areas are the primary sectors responsible for diffuse emissions. Accidental pollution events can also lead to hazardous substances contamination, particularly in industrial facilities and mining areas. Hazardous substances pose a significant threat to the aquatic environment, potentially causing acute or chronic toxicity by targeting vital systems within organisms. Some substances are persistent, slow to degrade, and capable of accumulating in ecosystems, impacting habitats, biodiversity, and human health. These pollutants can attach to organic compounds, bioaccumulate in organisms, and undergo resuspension and dissolution from soil and sediment particles. Thus, hazardous substances pollution is recognized as a local, regional, or basin-wide water quality issue that requires the implementation of advanced technologies, improved wastewater treatment, sound agricultural practices, substitution of priority substances, and effective safety measures and crisis management systems. Monitoring of total and dissolved concentrations of hazardous substances in water, sediment, and biota is necessary to assess water status and prevent further deterioration.

Sediment Topic

Sediment Quantity

The first DRBM Plan found that most large rivers in the DRB have disturbed or severely altered sediment balances. To address this, it is important to improve existing barriers and prevent further disruptions to maintain a continuous sediment flow. However, the lack of sufficient data on sediment transport hinders decision-making regarding sediment management. Additional investigations are needed to understand the significance of sediment transport on a basin-wide scale. The ICPDR, is conducting an international project to investigate sediment management. The project aims to provide data on basin-wide sediment transport, develop a sediment balance, and propose measures for improvement.

Sediment Quality

The characterization of sediment quality in the Danube is primarily based on the Joint Danube Surveys (JDS). The surveys revealed occasional elevated levels of heavy metals and polycyclic aromatic hydrocarbons, raising concerns. The recent JDS3 results showed similar concentrations of metals compared to previous surveys. While some substances exceeded quality standards at certain sites, overall pollutant concentrations were lower than those in the River Elbe, as a comparison.

Ecological services

Approximately 21% (6,066 km^2) of the study area falls within the protection zone designated by Natura 2000 regulations, indicating the importance of preserving these areas for long-term provision of ecosystem services. Wetlands play a crucial role in enhancing food security through increased aquaculture production and contribute to biodiversity conservation and eco-tourism. They also serve as natural buffers, reducing flood risks. However, sectoral policies such as energy production, flood protection, agriculture, and navigation have had adverse impacts on the potential of these ecosystems to provide sustainable ecosystem services. The disconnection of wetlands from the main Danube River during the communist regime, in particular, has led to their degradation and reduced ecological functionality.

Risk and hot topics

Typically, throughout the year, the following flow pattern can be observed: maximum flow in April-May-June and minimum flow in September-October, with an increase in flow during autumn (November) and a decrease in winter (January-February). The Danube water freezes across its entire width only in very cold winters. The formation of an ice bridge usually occurs around mid-January, with the longest recorded duration being 54 days in 1954.In terms of its chemical composition, the Danube water is carbonated-sulphurated-chlorinated, but its mineralization level is relatively low, around 300 mg/L. Therefore, with proper treatment, the water can be utilized for human consumption, irrigation, or industrial purposes.

One of the major issues are the severe droughts, particularly during the summer season. Droughts arise from a combination of meteorological, physical, and human factors. The primary cause is a deficiency in rainfall, along with its timing, distribution, and intensity concerning existing storage, demand, and water usage. Temperature and evapotranspiration, coupled with insufficient rainfall, can exacerbate the severity and duration of droughts. Furthermore, changes in land use, water demand, and climate patterns may lead to more frequent and severe droughts in the future.

One of the most significant threats are the recurrence of floods. The construction of grey infrastructure along the riverbanks has accelerated the speed of flash floods along the Danube, causing regular flooding in most of the former floodplains now utilized for agriculture. For instance, in 2006, a major flood occurred near the town of Rast, resulting in severe impacts on the entire region. The floods in the Rast region in 2006 were particularly destructive, resulting in loss of life and substantial damage to infrastructure, agriculture, and the town itself. Following the rebuilding efforts, Rast town was divided into two parts: Old Rast, located near the riverbank and highly vulnerable tofloods, and New Rast, which has been developed approximately 3km away from Old Rast to reduce the flood risk. By implementing necessary precautions in the area's development, such events could be prevented or mitigated.

The key challenges include:

- Enhancing water governance to ensure effective management and regulation.
- Adapting to rapidly changing scenarios such as new agricultural practices, evolving demands, solar irrigation, and the impacts of climate change.
- Improving resource use efficiency to optimize water utilization.
- Enhancing the management of groundwater resources to ensure their sustainable condition.
- Strengthening communication channels between administration and water users to foster collaboration and understanding.

3.3. Duero

The Duero River Basin runs through the northwest of the Iberian Peninsula and flows into Oporto. It has an area of 97,290 km^2 of which 81 % corresponds to Spanish territory and 21% to Portuguese territory. It is the largest basin in the Iberian Peninsula. Most of the Spanish territory corresponds to the autonomous community of Castilla y León (77,626 km^2, 98.32%). In Los Arribes is located the hydroelectric complex made up of the Ricobayo, Villalcampo, Castro, Almendra reservoirs, and the border reservoirs of Saucelle, Aldeadávila, Bemposta, Miranda and Picote. Other dams regulate the headwaters of the tributaries, especially the northern ones. Apart from the Tormes (Santa Teresa reservoir) and the Adaja (Castro de las Cogotas reservoir), the main reservoirs are located in the Esla (Ricobayo and Riaño) and its tributaries (Barrios de Luna in Órbigo, Porma) and in the Pisuerga (Aguilar de Campoo). All these reservoirs are flood storage reservoirs.

The Duero River basin water system is formed by a huge aquifer which occupies the central part of the basin, and some surrounding areas which form the recharge areas. 67 GWBs have been identified in the whole basin (Figure 3.1). The most part of the water consumed in the basin comes from groundwater, either for urban water supplies or for agriculture. Nevertheless, the first most important water user in the Spanish part of the Duero River Basin is agriculture.

The CHD uses three different hydrological models for water management:

- AQUATOOL, a development environment for decision support systems (SSD) focused on the planning and management of basins or complex water resources systems. As SSD, it provides resources to help analyse various issues related to water management.
- SIMPA, a precipitation-Input simulation, is used mainly for surface water.
- PATRICAL, a software for the calculation of Precipitation-Contribution in Network Sections Integrated with water quality (nitrates, phosphorus, electrical conductivity and solids in suspension and Electrical Conductivity) in groundwater that also indirectly provides relevant information on the available resources.

They do not use these models directly but through a company contracted for this purpose. In the same case, the contract is signed with a university, something which makes access to the program more difficult.

Figure 3.1: The Duero River basin.

The main problems in the basin are:

- To achieve the good status of the water bodies.
- To improve or to preserve the state in those water bodies which achieve the good status.

The main challenges are:

- To improve the water governance.
- To face with increasingly changing scenarios (new crops, new demands, solar irrigation, climate change, etc).
- To improve efficiency in resource use.
- Improve the management of groundwater that does not meet a good status.
- Improve communication between administration and users.
- Digitalisation of the water sector.
- To hep to create communities of groundwater users (CUAS).
- Implementation of measures (restrictions) for all users in the groundwater body.
- Information in real time: evolution of piezometric level by sectors/municipalities/ CUAS.
- Knowledge on pressures on each GWB.
- Assessment and interpretation of trends and knowledge o of the GWB.

3.4. East Anglia

Eastern England is the driest region of the UK, receiving only two-thirds of the average national rainfall. With an average annual rainfall lower than 600 mm of rain per year, it is designated by the Environment Agency as an area of serious water stress. Increasing resilience to extreme drought is a major goal, with the aim to be resilient to a 1 in 500-year drought by 2040. Flood risk management is not a significant concern for water resources in the region, although it is relevant to Anglian Water's role in collecting storm water. The Environment Agency is the lead statutory agency that manages flood risk, with measures outlined in relevant Catchment Flood Management Plans; other organizations with notable roles in the region include Middle Level Commissioners, Internal Drainage Boards and the Broads Authority.

Most of the region lies less than 100m above sea level, and almost 30% of the land is below sea level. In terms of geology, the region has widespread superficial deposits including sands (e.g., Eastern part of Suffolk), peat (e.g., Fenlands and the Broads) and clays (e.g., Boulder clays of central East Anglia). The Chalk is the major aquifer in the region and is a microporous white limestone. In parts of East Anglia, pore water at depth in The Chalk may be saline. The river systems in the region tend to be slow responding catchments.

A significant proportion of the water supplies originates from aquifers and reservoirs, which are slow to recharge increasing their vulnerability to drought. Anglian water's eight raw water reservoirs, along with eight direct supply river intakes, provide approximately 50% of water supply. The remaining 50% is sourced via groundwater abstraction. Groundwater supply is complex: it involves over 200 water sources and over 450 boreholes ranging in depth from only 10m to 500m which are sited in many different types of rock. Anglian Water operates several reservoirs, including Rutland Water, Grafham Water, Alton Water, Pitsford Water, Covenham, Raventhorpe and Hollowell. Most reservoirs are pumped storage. There are a limited number of flood storage reservoirs.
With a population of almost 5 million people, East Anglia is the fastest growing region in the UK with a water demand of 1.1×10^9 liters of potable water per day, approximately 140 treatment works and 38,200 km of main waters. The area is also the key crop-growing region of England and is heavily reliant on water for irrigation to grow salad crops, vegetables, potatoes, and soft fruits. A significant increase in demand for spray and drip irrigation is anticipated over the coming years during the warmer, drier and extended growing seasons expected in the future. Eastern England hosts over 60% of abstraction licenses for England, with the water requirement following a seasonal pattern which peaks from May to September.

The second most important water user in the region is the energy sector. Power stations abstract freshwater for cooling purposes (mainly on the River Trent), and it is worth noting that many stations are situated near to coasts and estuaries. Future water needs for energy production in the region are highly uncertain. Rising wholesale energy unit prices and the move to new power sources mean that energy production is likely to increase. Thus, potential hydrogen production is of particular importance.

Navigation is also an important sector and is the second largest non-public water sector abstractor in the region. In East Anglia, navigation is the responsibility of the Broads Authority, Canal and River Trust and the Environment Agency.

Consideration of environmental flows is also key with regards to water allocation. The region is home to many internationally important wetland ecosystems that need protecting, including 40 Special Areas of Conservation (SAC), 28 Special Protection Areas (SPA) and 28 Ramsar wetlands. In addition, many unique habitats are located within the region, including reedbeds, inter-tidal mudflats, and grazing marshes. Abstraction from groundwater and surface water must be sustainable, and meet legislation such as the WFD, the Habitats Directive 1992, and the Wildlife and Countryside Act 1981. To ensure abstractions are sustainable, Anglian Water is implementing several mitigation schemes alongside sustainability reductions. Water Industry National Environment

Program (WINEP) mitigation options include river restoration, river support, recirculation, and adaptive management. The environmental need for water is identified as the biggest future driver.

Many of eastern England's chalk rivers, peatlands, wetlands, and sensitive water environments are in poor health due to decades of licensed over-abstraction alongside other pressures. Furthermore, East Anglia has one of the highest usages of arable pesticides which are very difficult to remove from water. Fertilizers containing nitrate and phosphorous are essential for growing crops, but leaching through the soil and runoff often causes these nutrients to move into surface and groundwater. In wet weather, storm overflows can discharge limited treated sewage which can have a significant impact on bathing waters. Population growth and changes in rainfall patterns are increasing the pressure on the sewer network.

In this context, a summary of the main challenges listed by the stakeholders consulted (see Section 2.4) are listed thematically in Table 3.2.

Table 3.2. Main issues and challenges related to water resources management in East Anglia basin.

Theme	Challenges
Natural water resources availability	• Management of Saline intrusion in aquifers. • Sinking ground due to drying of peat and increased pumping • Climate change: changing weather patterns. • Impacts of Climate change and drought including on water quality.
Water allocation and priority	• Planning applications: all principal aquifers are closed to new licenses. • Defining levels of service or resilience outside of the public water supply. • Balancing all the demands from the many sectors. • Catchment Based Approach: sustainability and compromise. • Planning applications: all principal aquifers are closed to new licenses. • Optimization of systems and assets (sustainability): drains, STWs, pumping stations.
Drought risk	• Pace of climate change: drought state is becoming normal!
Water demand and water use	• Growth-generated additional demand. • Water efficiency. • Development of new solution that are environmentally, economically and socially sustainable. • The value of water or perceived value of water. • Lack of Water Resources Management Plan for Agriculture. • Time to adapt in agricultural sector: e.g., EA under no obligation to give warning of decrease in license and creates planning issues.
Climate change scenarios	• Charting the course of climate change through short to long-term. and reflect on variety of risks and challenges.
Socio-economic scenarios	• Charting the course of socio-economic change through short to long-term and reflect on variety of risks and challenges. • Working in partnership to: i) explore how to retain carbon stores in peatland, ii) look at changes in farming practices.

Water Quality	• Groundwater quality (e.g., PFAS): need to account for groundwater quality when granting planning permission.
Environmental Flows	• Environmental Enhancement. • Ecosystem services: how should these be provided, efficiency of services and their influence on food production.

3.5. Messara

The water system in Messara basin
The Messara basin, located in the central-south area of Crete Island, encompasses an area of 611 km^2 and constitutes the most important agricultural region of Crete. It is also the site of Phaistos palace of the Minoan civilization and the Roman city of Gortys, and thus tourism is also an important economic activity. The Messara Valley has remained rural area with a “small” population of almost 45,000 inhabitants. The main land-use activity is olive growing with some grape vine cultivation. The remainder of the cultivated land is used for vegetables, fruits, and cereal-growing as well as for livestock grazing (higher grounds).

Crete has a typical Mediterranean island environment, and the Messara valley’s climate is classified as dry sub-humid according to UNCED definitions. Although the Valley receives on average about 650 mm of rainfall per year, it is estimated that about 65% is lost to evapotranspiration, 10% as runoff to sea and 25% recharging the aquifers. Rainfall increases with elevation from about 500 mm on the plain to about 800 mm on the basin slopes while on the Ida massif the annual precipitation is about 2,000 mm and on the Asterousian Mountains it reaches 1,100 mm. The average winter temperature is 12^0C while in the summer it is estimated at 28^0C (the annual mean is 16.6^0C). The relative humidity in winter is about 70% whereas in the summer it reaches about 60%. The potential evaporation in the area is estimated at 1,500 mm per year.

The valley of Messara is a typical graben formation and within two hydrological catchments are formed: the Geropotamos and the Anapodaris-Xarakas, with an area of 578 and 517 km^2 respectively (Figure 3.2).

The center of the valley comprises a plain with East-West orientation. The Geropotamos River with a westward direction and the Anapodaris River with an eastward direction drain the homonymous catchments. A low elevation of the ground in the village of Asimi divides Messara into two basins, the lower and the upper. The Geropotamos, crosses the plain of Lower Messara and discharges into the Gulf of Messara. The Faneromeni dam has been built on a tributary of the Geropotamos, with the purpose of irrigating the plain. Upper Messara flows from the Anapodaris river, on whose tributaries there are small dams (Partira, Amourgela, Damania, Armanogeia and Inio) and reservoirs (Karavado and Skinia). Also, the Plakiotissa dam is under construction (Figure 3.3). Along the two rivers there are three hydrometric monitoring stations (Festos, Lithaios and Plakiotissa) where daily streamflow data are measured since 1973.

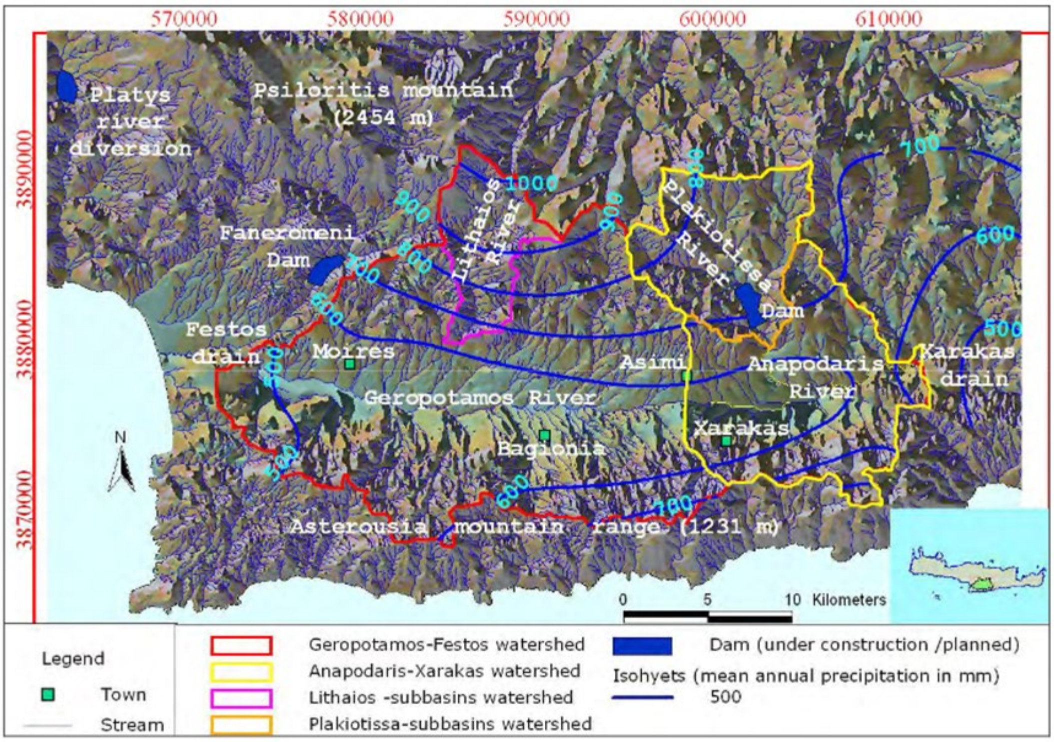


Figure 3.2: The surface water catchments of Geropotamos and Anapodaris in the Messara basin. Source: Kritsotakis & Tsanis (2009).

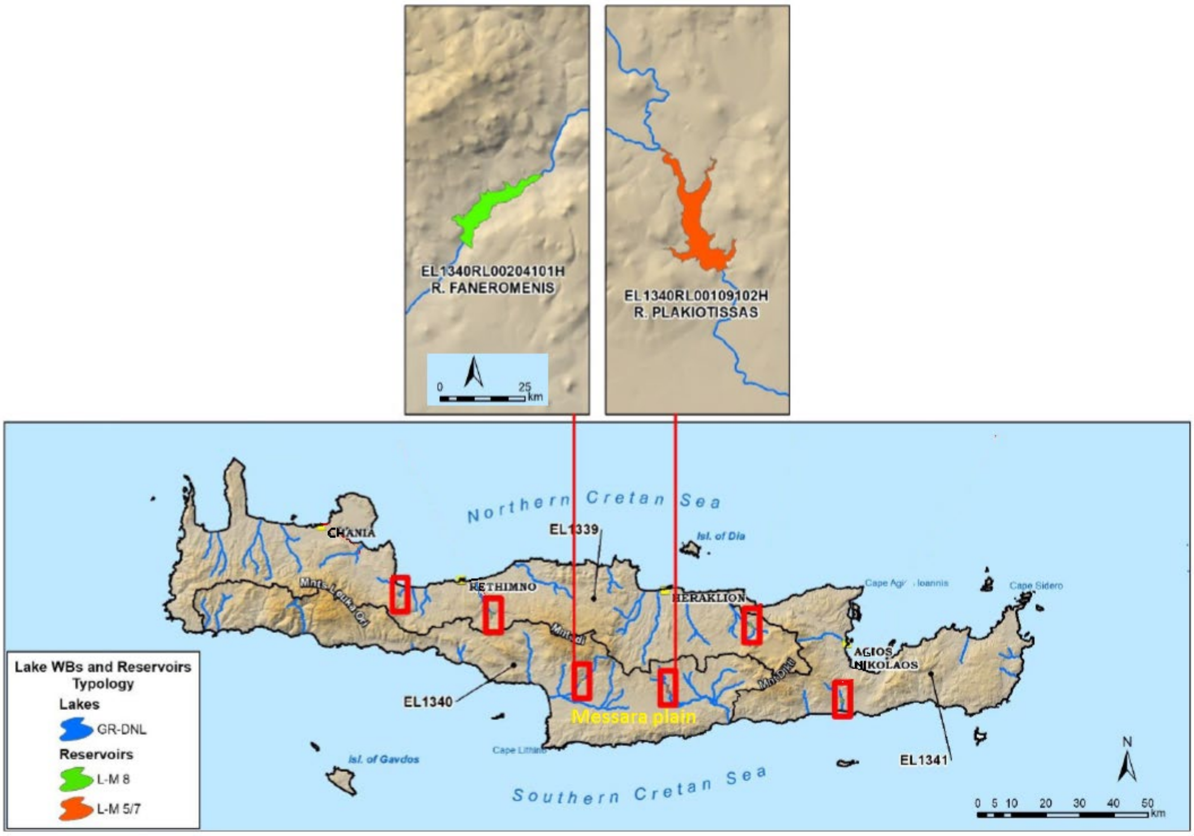


Figure 3.3: The Faneromeni and Plakiotissa (under construction) dams supplying irrigation water to the Messara basin. Source: Ministry of Environment and Energy, Special Secretariat for Water(2017a).

The plain area of Messara valley hosts the largest alluvium aquifer system of the island, extended in an area of 216 km2. Topographically, the Messara basin is characterized by a flat basin morphology modified by river terraces and alluvial fans. The plain is covered mainly by quaternary alluvial clays, silts, sands and gravels with thickness from a few meters to 100 m or more. The quaternary deposits of the plain host the main aquifer system.

Within the Geropotamos and Anapodaris catchments a number of water bodies (WB) have been defined according to the WFD typology and classisfication. Similary, groundwater bodies have been defined in the basin (Figure 3.4). Their status, as per the 1st Revision of the WFD River Basin Management Plan of Crete, is summarised in Table 3.3. Out of the 4 main groundwater bodies (GWB) in the basin, the GWB 'Porodes Moiron' (about 56 km2 area) has already been characterized in poor quantitative and poor chemical status (nitrates presence).

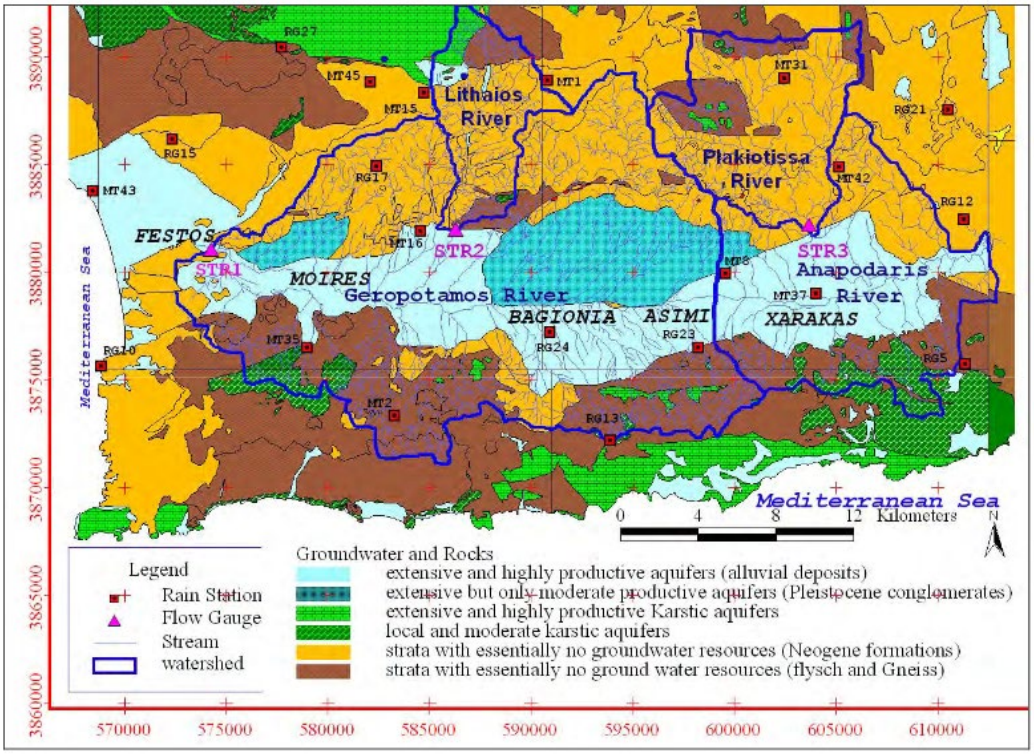


Figure 3.4: A simplified hydrogeological map of the Messara basin. Source: Kritsotakis & Tsanis (2009).

Table 3.3: Status (quantitative, chemical, ecological) of the surface and groundwater bodies in the Messara basin. Source: Ministry of Environment and Energy, Special Secretariat for Water, 2017a (1st Revision of the Management Plan of Crete River Basin District (EL 13)).

River water bodies in Messara basin					
WB No.	**WB name**	**WB code**	**Category**	**Chemical status**	**Ecological status**
62	Anapodaris	EL1340R000101001N	Natural	Good	Moderate
63	Anapodaris	EL1340R000102105N	Natural	Good	Moderate
64	Anapodaris	EL1340R000102107N	Natural	Good	Moderate
65	Anapodaris	EL1340R000103002N	Natural	Good	Moderate
66	Anapodaris	EL1340R000104108H	Heavily modified	Good	Unknown
67	Anapodaris	EL1340R000104109N	Natural	Good	Good
68	Anapodaris	EL1340R000105003N	Natural	Good	Good
69	Anapodaris	EL1340R000106109N	Natural	Good	Good

70	Anapodaris	EL1340R000106210H	Heavily modified	Good	Unknown
71	Anapodaris	EL1340R000106311H	Heavily modified	Good	Unknown
72	Anapodaris	EL1340R000107004N	Natural	Good	Good
73	Anapodaris	EL1340R000108116N	Natural	Good	Good
74	Anapodaris	EL1340R000109012H	Heavily modified	Good	Unknown
75	Anapodaris	EL1340R000109114N	Natural	Good	Good
76	Anapodaris	EL1340R000109215N	Natural	Good	Good
77	Geropotamos	EL1340R000201017N	Natural	Good	Moderate
78	Geropotamos	EL1340R000202122N	Natural	Good	Good
79	Geropotamos	EL1340R000202123N	Natural	Good	Good
80	Geropotamos	EL1340R000203018N	Natural	Good	Moderate
81	Geropotamos	EL1340R000204124H	Heavily modified	Good	Unknown
82	Geropotamos	EL1340R000204125N	Natural	Good	Good
83	Geropotamos	EL1340R000204126N	Natural	Good	High
84	Geropotamos	EL1340R000205019N	Natural	Good	Moderate
85	Geropotamos	EL1340R000206126N	Natural	Good	Moderate
86	Geropotamos	EL1340R000207020N	Natural	Good	Moderate
87	Geropotamos	EL1340R000208128N	Natural	Good	Moderate
88	Geropotamos	EL1340R000209021N	Natural	Good	Moderate
Lake water bodies and reservoirs in Messara basin					
WB No.	**WB name**	**WB code**	**Category**	**Chemical status**	**Ecological status**
	R. Plakiotissa	EL1340RL00109102H	Heavily modified	Good	Good and above
	R. Faneromeni	EL1340RL00204101H	Heavily modified	Good	Good and above

Groundwater bodies in Messara basin						
WB No.	**WB name**	**WB code**	**Area (km^2)**	**Quantitative status**	**Chemical status**	**Ecological status**
42	Porodes Moiron	EL1300083	55.89	Poor (over-abstraction)	Poor (nitrate pollution)	n/a
43	Porodes Galias-Vagionias-Asimiou	EL1300084	115.63	Good	Good	n/a
44	Porodes Mesochoriou	EL1300085	50.99	Good	Good	n/a
45	Porodes Mesaras-Notiou Irakleiou	EL1300086	508.00	Good	Good	n/a

Main water users and water supply

The annual water use amounts to 70 million m^3/year, of which 96.6% for agriculture, 3.2% for domestic use (including tourism), and 0.2% for industrial supply. As such, agriculture is by far the main water user, requiring approximately 68 million m^3/year. The irrigated area is about 16,263 ha, which represents 56% of the total cultivated (29,109 ha) area. The main crops are olives, some grapes, and some citrus and vegetables in greenhouses.

Groundwater is a major source for irrigation water: approximately 1,400 wells operate in the valley, with a total of 63 million m^3/year been abstracted annually from groundwater. The remaining 5 million m^3/year are supplied by surface water through the Faneromeni Dam. The domestic drinking water source is exclusively from groundwater and from springs.

In terms of water supply, the provision of domestic drinking water falls under the responsibility of the Municipalities of Faistos and Gortyna (namely their Technical Services Department) and the Municipal Water Supply and Sewerage Company of Faistos (DEYA Faistos). The former is responsible for the design of the domestic water supply and sewage systems to cover domestic and touristic water use and wastewater collection, while the latter is responsible for the construction, operation and maintenance of the domestic water supply and sewage systems, as well as the collection of the water fees collection from the users and the monitoring of the drinking water quality. DEYA is also supplying treated wastewater for reuse in agriculture.

Irrigation water currently comes from groundwater and from one reservoir, the Faneromeni dam, constructed in 2005, with a capacity of 17 hm^3 supplying water on the western area of the plain. One more reservoir, the Plakiotissa dam, with a capacity of 18 hm^3 is under construction and will supply water to the central area of the plain. Groundwater is a major source of water: approximately 1,400 wells operate in the valley, causing a drop in the water table of as much as 45m due to overexploitation in some areas (Figure 3.5). Additionally, a diversion of the Platis River is planned, with a twofold purpose: first to fill the Faneromeni dam, as it has been constructed with a capacity at 1.7 times the average yearly outflow, and secondly for the artificial recharge of the Messara basin. The provision of irrigation water falls under the responsibility of the Local Land Reclamation Organizations (TOEB). Three TOEBs cover the study areas, namely the TOEB of Zone B of Messara, the TOEB of Zone C of Messara and the TOEB of Vassilikon-Anogion. They are directly responsible for operating the water supply and distribution system for local farmers (i.e., provision of irrigation water to the farmers), including the maintenance of the pipeline network, and the collection of the water fees. On the other hand, the design and construction of the necessary infrastructure and water works (dams, wells, water supply and distribution systems) are within the responsibility of the Region of Crete, and once these works are completed, the Region of Crete delivers them to the TOEB in order to operate and maintain the systems and provide water to farmers. The TOEB of Zone C of Messara covers the largest irrigated area, about 3,600 ha and has been operating since 1988. It provides irrigation water to more than 9,500 subscribed farmers located in the Municipality of Faistos. It operates 29 groundwater pimping stations (with a total power of 2,945 KW), 9 reservoirs of a total capacity of 24,700 m^2, and provides to the farmers about 7 million m^3/year (of which 4 million m^3/year are abstracted from groundwater and the remaining 3 million m^3/year are provided by the Faneromeni Dam). In terms of irrigation efficiency, this is high in the Messara basin as the distribution network is a piped system with minimum leakage losses, and the application method is drip irrigation. Besides the farmers who are within the TOEBs, there are also numerous farmers who have their own private wells for irrigation water supply (see Figure 3.5). These farmers hold valid water licenses, issued by the Water Directorate of Crete Decentralized Administration (WDC), describing the terms and conditions to use the water and the specific amount/volume of water to be abstracted and used within specific time (usually 10 years).

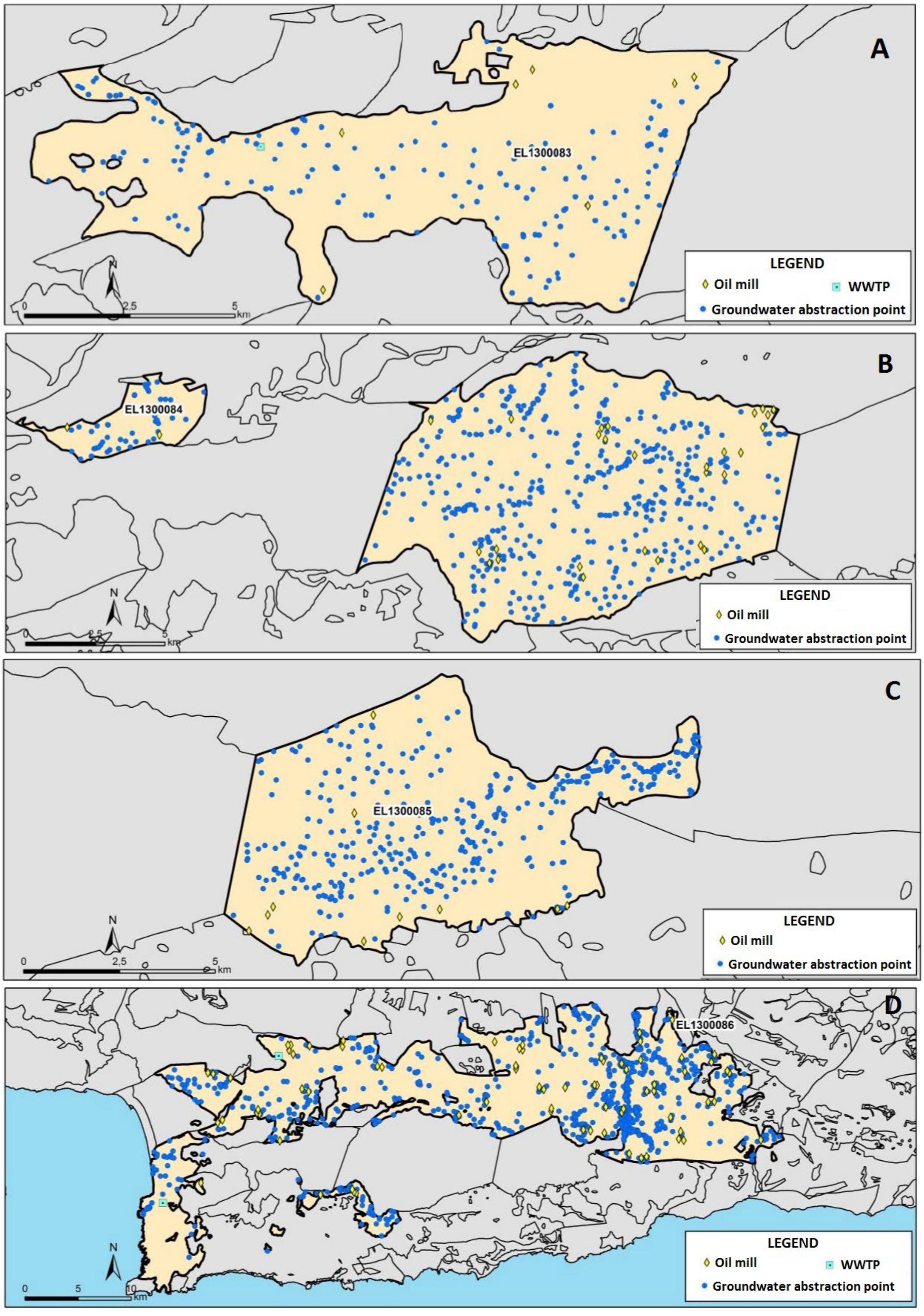


Figure 3.5: Location of groundwater abstraction wells within each of the groundwater bodies of Messara basin (A: Porodes Moiron; B: Porodes Galias-Vagionias-Asimiou; C: Porodes Mesochoriou; D: Porodes Mesaras-Notiou Irakleiou). Source: Ministry of Environment and Energy, Special Secretariat for Water, 2017b.


Views of the Faneromeni reservoir. *Source: website of the TOEB of Zone C of Messara (https://toebgzoni.gr/gallery-classic/)* .

Main water resources availability related issues and challenges

The overexploitation of groundwater has reduced water availability, while the uncontrolled pumping and use also creates tensions amongst the users. The impact of groundwater abstraction on the ecosystem of the watershed became obvious when the springs in the surrounding hills dried up and the natural flora and fauna of the environment around these springs perished, with the loss of birds, small animals, and flowers. Soil degradation and salinisation are also important issues of the wider area, while desertification in becoming an issue as well. Simulation of seawater intrusion has established that at the southern end of the coast, by the Geropotamos stream alluvial recharge zone, the toe of the saltwater intrusion front lies 550 to 600 m inland from the coastline. At the northern end of the coast, the toe of the saltwater intrusion front is located 1500 m inland from the coastline.

Natural water resources' availability, both groundwater and surface water, is also decreasing due to climate change trends. Changing precipitation and ET patterns drive changes in the springs' outflows, as well as in the crop water needs, and lead to increased water demands in the urban (including tourism) and agricultural sectors, which cannot be met by the current water supply and infrastructure. Robust climate change scenarios and forecasting are necessary for better planning and adaptation.

On 14th of March 2023 a local Workshop was held with the stakeholders of Messara basin. The key challenges identified by the stakeholders are listed below:

- Natural water resources' availability, both groundwater and surface water, is decreasing. At the same time there are conflicting water uses in the basin. There is expected increase in tourism activities, but the main water use will still be for agricultural use. Climate change is expected to increase water demand for the different users, and thus water conflicts may be exacerbated, posing the need for robust water allocation schemes which incorporate alternative scenarios and are transparently communicated to the stakeholders.
- Changing precipitation and ET patterns drive changes in the springs' outflows, the crop water needs, the natural water resources seasonal, etc. Combined with increased water needs, the current water supply and infrastructure will not be sufficient. There is already a plan for the diversion of the Platis River in order to supply additional water to the Faneromeni reservoir, as well as for artificial recharge in the Messara basin. Robust climate change scenarios and forecasting are necessary for better planning of measures and water works and better adapting to future climate change uncertainties.

- There is a need for incorporation of different socio-economic and land use scenarios, including changes in the current cultivated crop mix, in the decision support systems on water allocation and water abstraction caps.
- Groundwater resources are already threatened by over-abstraction, with some groundwater bodies being already in poor chemical and quantitative state, and with up to 45 m drop-down in the groundwater levels in some areas. Adequate measures are necessary to restore groundwater levels to sustainable levels, comply with the groundwater aquifers' sustainable yields, maintain environmental flows in the rivers, as well as improve the chemical status by containing and reducing nitrates pollution.

3.6. Seine

The water system in the Seine River basin

The entire Seine-Normandie River basin includes the Seine River, its tributaries (Yonne, Marne, Oise), and small rivers on the Normandy coast. It has 55,000 km of rivers and extends over 94,500 km², i.e., 18% of French territory. It has two of the most important river ports: Paris (Port de Gennevilliers) and Rouen. The basin includes nearly 8,138 municipalities, extends over 28 departments and concerns 6 regions. Its population is 18.3 million (30 % of the French population). The Ile-de-France region (Paris and surroundings) alone has 11.8 million inhabitants. The basin is very marked by human occupation. The Seine Valley is a major centre of industrial activities in France. The density of forests is low, while agricultural activity and urbanization are strongly present around the major rivers.

The Seine River has its source in the Côte d'Or on the Langres plateau, 450 meters above sea level, and flows 773 km further into the English Channel between Le Havre and Honfleur. The Seine catchment area covers 75,000 km². With a flat topography and slow flows, the mean annual streamflow is the lowest among the major French rivers. The observed flow regime shows an important interannual flow variation, with high flows in winter (February) and low-flow periods in summer (August). Measures at Paris (drainage area of ca 43,800 km²) indicate wet periods with monthly flows of approximately 500 m^3/s and dry periods with monthly flows down to 140 m^3/s. Evapotranspiration is relatively high and only 30% of the 800 mm of mean annual rainfall recharges the aquifers and/or reaches the streams.

Groundwater resources are important in the Seine River basin: the basin lies on the largest groundwater reservoir in Europe, which strongly regulates the temporal variability of surface flows. Groundwater makes it possible to satisfy nearly 60% of drinking water needs and plays a decisive role in the functioning of the rivers.

Water is also used by agriculture, with 60% of the land used for intensive agriculture (cereal production and industrial crops). Water demand is highly heterogeneous due to the high concentration of population and economic activities in Paris and its surrounding urban area. As mentioned earlier, EPTB SGL manages four upstream dam reservoirs in the river basin, which are operated to control floods downstream and maintain a minimum flow during the driest months. The management of these reservoirs has gained an important role in adaptation to climate change, as reduced precipitation and river discharges are projected for the river basin.

Main water resources related issues and challenges.
Overall in the Seine River basin, water quality has been a challenge and prompted the edition of a recent book that offers a comprehensive review of the agro-food system, ecological functioning and water pollution of the Seine River (Flipo et al., 2021). The last assessment for the Water Framework Directive, conducted in 2019, pointed out to the necessity of increased efforts towards pollution reduction.

Another challenge in the river basin is the implementation of state-of-the-art data and modelling tools for impact and adaptation studies, as well as to support decision making and planning. Over the past 30 years, the Seine River basin has been integrated in several large research projects such as the interdisciplinary environmental research program PIREN-Seine mentioned earlier, or the European Long-Term Socio-Economic and Ecosystem Research (LTSER) network. The PIREN-Seine programme, in particular, has brought together a multi-disciplinary group of hydrologists, environmental chemists, ecologists, biogeochemists, geographers, environmental historians and social scientists to generate knowledge, data and tools for the river basin status and future evolution in terms of water quantity and quality, and for an enhanced understanding of the social responses to water quality issues. Several datasets and modelling tools at various space and time resolutions were developed to address socio-economic features and the main environmental issues in the river basin, as well as the impacts of climate change on water resources availability. Some of these tools, however, remain largely in the hands of researchers or some practitioners with modelling expertise. Not all tools are well adapted to operational contexts and settings or explore all relevant data and climate change projections available. There is thus a need to evaluate the transfer of acquired research knowledge to operations.

One of the objectives of the work carried out within the STARS4Water project in the Seine hub is to connect existing knowledge, research models and novel datasets to real-life operations for river basin water management, fostering the operational use of decision-support tools by stakeholders, in particular at the EPTB SGL. Recently, the EPTB SGL and Eaucea consultancy have carried out a study to assess the socio-economic and environmental impacts of severe low water levels in the Seine River basin (available at: https://www.seinegrandslacs.fr/actualites/et-si-la-seine-etait-sec). This study, finalized in February 2023, had two main objectives. The first was to characterize the most severe low water levels observed on the territory managed by the EPTB SGL (events that occurred in 1921, 1949, 1976 and 1991). The second objective was to assess the potential impact of these low flows on the environment and on socio-economic activities, as well as the capacity of the low flow support provided by the four upstream lake-reservoirs to reduce these impacts. The study concluded on the vulnerabilities of the current system to face severe droughts and proposed further studies and future actions to enhance adaptation and resilience. Among these, we note the needs to:

- evaluate long time series of climate change projections and their uncertainties for a more robust risk analysis of the system,
- improve surface-groundwater modelling to better evaluate the interactions and pathways of water within the river basin, and
- enhance knowledge on the downstream responses of the water system to the water releases of the lake-reservoirs during low flow periods.

3.7. Rhine

The Rhine basin starts in the Alps and crosses 9 countries when entering the Dutch delta in the North Sea. The total length is 1233 km, the basin covers 185.000 km^2 and the difference in height from source to mouth is 2,341 meters. The Rhine River basin is the home of about 60 million inhabitants. The river flows through Switzerland, France, Germany, Luxemburg, and the Netherlands while the basin also stretches into Austria, Liechtenstein, Belgium as well as Italy. The main stream covers a length of 1223 km, of which 825 km is intensively used for inland navigation. Rhine water is used for industrial and agricultural purposes, for energy generation, for the disposal of municipal wastewater, for recreational activities, and for the production of drinking water for more than 30 million people. Furthermore, the Rhine is a natural habitat for a diversity of plant life and many birds, fish and other species.

The discharge of the Rhine River is dominated by a combination of snow- and glacier melt and rainfall, and it is expected that climate change will result in higher high flows and more severe periods with low discharges with lesser discharge over longer periods of time. Stahl et al. (2022) have indicated that under the RSP8.5 scenario, the proportion of snow and glacier melt in the river flow of the Rhine and its tributaries will turn around the year 2045, which may lead to a 23% lower minimum flow at Lobith in 2100. Based on used models/scenarios (RCP8.5), we may assume that the total stream flow will be stable - also in the long run - and that the low flows will remain in the familiar range during the next three decades, after which they will decrease quite rapidly during the last 50 years of this century.

In addition, changes in socio-economic activities may lead to changes in water use and water consumption, and also influence the river flow of the Rhine River. The results of a recent study have shown that under future scenarios, the total water consumption in the Rhine River basin could increase from 50-75 m^3/s to 200-250 m^3/s in summer, which is significantly during low flow periods (Ruijgh, 2019). The water consumption of the public sector and the industry sector is relatively small compared to the river flow of the Rhine. Irrigation, cooling water, lignite mining and irrigation are considered as the most important sectors with respect to the water consumption. The Rhine River is the most important shipping routes in Western Europe and therefore a very important economical factor for the member states.

In combination with climate change the effects of changing land- and water is a dominant, and relatively unknown factor. What is the impact of low and long-lasting discharges in navigation, hydro power, drinking water, ecology, agriculture / irrigation and water quality? A combined study on the effects of climate change and socio-economic changes is one of the main topics in the Rhine River basin.

During the stakeholder workshop in Biel the three commissions expressed the need to improve the data and modelling tools and setting up scenarios, to assess the most important water user(s) and accompanying water allocation, especially under low flow conditions. The outcome will be used by the CHR, as part of the “CHR-SES project” (Figure 3.6) and by the ICPR and CCNR.

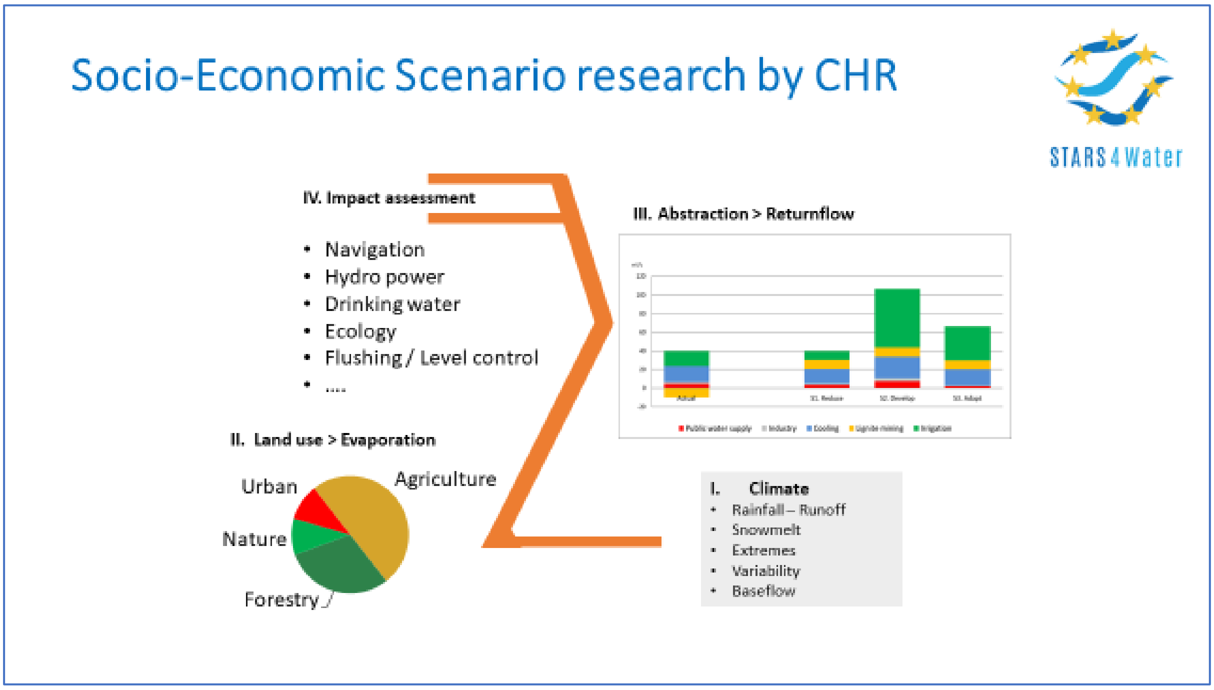


Figure 3.6: Illustration of the CHR research project Socio-Economic Scenarios.

4. Needs for data services, models and information tools.

This chapter presents the output of the needs assessment conducted in the workshops.

4.1. Drammen

During the meeting, stakeholders were asked to formulate user stories with the following format: As <my role>, I need information on <data need> to <task or decision>. The answers are summarized as follows.

Existing data used by stakeholders.
Stakeholders in the Drammen River Basin use the available hydrological data from NVE, meteorological data from MET Norway and Storm (private weather forecast services). The data consists of historical measurements both station data and derived products. Derived 1 km resolution gridded data (SeNorge) is available from 1957, amongst other interpolated precipitation, temperature, and snow and soil moisture model output. Weather forecasts for Norway are available from MET including the ECMWF High-Resolution and ensemble forecasts in addition to the lagged ensemble of AROME MetCoOp regional weather forecast model. In addition, the Norwegian Centre for Climate Services provides projections up to 2100 of daily temperature, precipitation, runoff, snow water equivalent, etc. for Norway at a 1 km grid for RCP4.5 and RCP8.5 and 10 regional climate models based on the 12 km EURO-CORDEX data.

Existing models used by stakeholders.
Different models are used by the different stakeholder champions depending on their specific tasks. The Volue-HBV (conceptual rainfall-runoff model) is used by the hydropower associations, the River Basin District Board uses Agrocat, the Drammen municipality uses MOUSE, and HEC-Ras and MIKE are further used. AQUIS, EPANETT, TEOTIL are also mentioned. The water supply company does not use hydrological model forecasts but monitors water levels and estimates snow storage. They receive the extended (6-week ECMWF) forecast from MET Norway and use the combined information to plan the water extraction for domestic water supply.

Needs for additional data, models, and tools.

- For the hydrological modelling there is a wish to receive data at 1 km and 15 min resolution for P and T.
- Updated/improved land use, soil and water use data are important to reflect current state.
- High quality (controlled) and accessible historical time series are required (already available, but more would be welcome).
- Production planners need an HBV-model or better model to optimize hydropower production and evaluate flood impacts.
- Improvements to the weather and climate models to provide more reliable short-term (0-14 days) and *seasonal* (0-6 months) forecasting data.
- Seasonal forecasts for Norway need to be improved.
- Snow and the change in snow storage is important for the seasonal water balance in the Drammen River basin, and there are still some processes that are not fully described, where

both sublimation and snowmelt to groundwater is mentioned. Improved process description in the models?

- Other desired tools include IDF curves (Intensity-duration-frequency) curves that are useful for dimensioning of overland flow.
- Further, more data for better estimations of low flow and eco/environmental flows for the licensing (e.g., hydropower licenses), and especially for the establishment of thresholds for critical water levels, and the use of simple and scalable measuring techniques.
- The transportation of contamination or nutrition from other sources than sewage is important to describe the total effect on water quality for the Drammen fiord.

Presentation of data.
The use of available data is deeply connected to the accessibility. Is it easy to download? Advanced users wish to use e.g., Phyton or R to read the data directly. Also important is that the data used are experienced as representing what the user is observing, i.e., data with relatively little uncertainty from the location(s) where the stakeholders are responsible for water management.

4.2. Danube

With reference to the identified fields of action and burning issues, a holistic water balance model for the entire Danube basin is desired. For the establishment of such a model, sufficient data on the components in the water cycle and the uses, but also socio-economic data in good quality must be available in the entire basin. Due to the multi-nationality of the Danube and the different administrative and competence structures in the individual countries, many data are not managed centrally. Not all riparian countries make their data available for general use. In many places, the data are locked and are thus not available to stakeholders, or only to a very limited extent. However, the availability of qualitative water data on e.g., precipitation, temperature, soil moisture, runoff is a prerequisite for a consideration of water availability in the entire Danube basin. The stakeholder workshop showed that further efforts are needed to provide and regularly update data across national borders. In addition, the project will consider satellite data as an extension to the national data sets for water balance calculations. This is believed to have great potential. However, the spatial resolution is crucial for the use of Earth Observation Data (EOD).

Many questions require information on water availability at a particular location at a particular time. For example, interest is expressed in determining the number of days with low water discharge for a particular location on the Danube in order to derive the risk of restricted use for navigation, hydropower, or agriculture. In addition, the information should allow the assessment of possible ecological consequences of reduced flows for the Danube ecosystem. Environmental flows have been mentioned repeatedly in this context. While in the field of floods a solid data basis could be established since several years, approaches and procedures in low water modeling are missing. Individual countries have already established measures to deal with droughts and water scarcity, but a coordinated and joint approach in the Danube basin has been sporadic so far (cf. DriDanube Interreg project).
Regarding climate data (EURO-CORDEX, RCM), it is noted that there is great uncertainty in the interpretation and communication of climate scenarios. Many decision makers find it difficult to plan on the basis of scenario analyses. In this respect, the goal must be to break down the climate changes and consequences from a complex level to a tangible, easily communicable level without

loss of evidence. In the sense of the basin-wide approach, this would correspond to: Downscaled projections of water resource availability under climate change impacts.

In summary, a model approach is needed that allows an evidence-based estimation of water availability. Based on the model, it is then possible to develop instruments for water management such as Drought Risk Assessment and Water Scarcity Plan.

Key messages on models:

- There are different models available for addressing water resource availability issues at a basin scale.
- Need to establish or improve low flow modelling approaches.
- Information on available water at a certain location at a point in time (sufficient spatial resolution is important as droughts may occur very regional).
- There are different models available for addressing water resource availability issues at a basin scale (RIBASIM, wflow, SWAT, CwatM, LISFLOOD).
- Question of licensing of models has to be clarified.

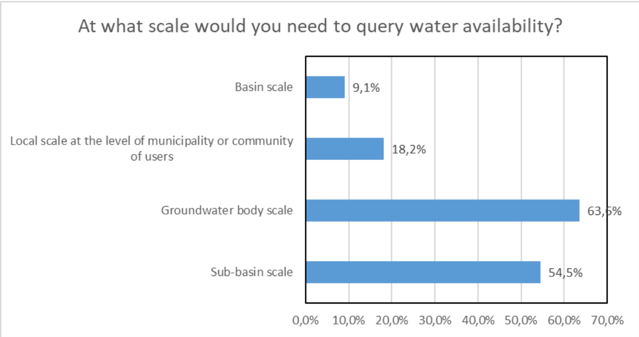
Key messages on data:

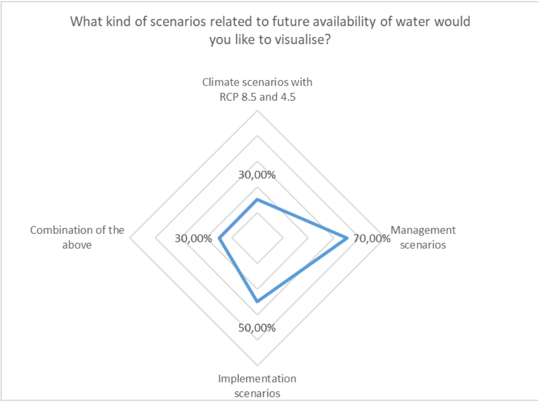
- Hydrological, socio-economic and environmental data needed across the basin for the purpose of modelling.
- National datasets are often owned by state authorities (permission to use, motivation of sharing, benefits for them).
- Issues of illegal water abstraction (availability and reliability of data).
- Unlocked and generated data in STARS4Water could be made accessible by incorporation into the GIS and metadata portals of the RBOs.

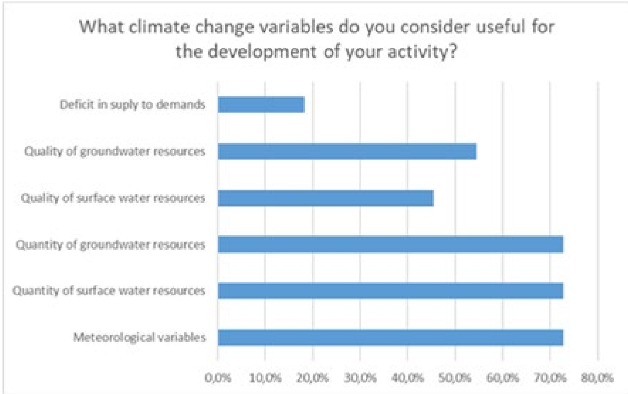
4.3. Duero

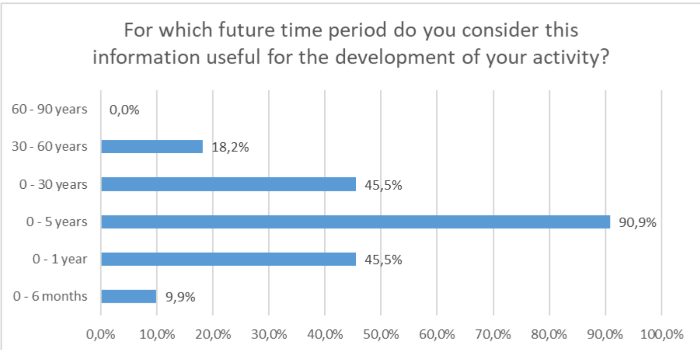
The stakeholders invited to the stakeholder workshop in the Duero basin have different views, needs and interests. The needs have not been yet expressed, as they have their own tools for the processes of decision making in their sector (e.g., urban water supply). The key water manager in the basin is the CHD whose needs must be prioritized to better address the efforts to fulfil the WFD requirements.

The stakeholders meeting was designed to explore their view on three critical themes for STARS4Water project: water availability, climate change and information systems/dashboard. The use of an interview tool called Socrative (https://www.socrative.com/) was applied as a way of guarantee the researchers-stakeholders interactions protecting their anonymity. The interview tool also allows the collection of answers in real time, and it generates a final pdf report of results. The questions were carefully formulated according to the contents covered in the talks. Figure 4.1 provides an overview of the stakeholder responses to the survey.









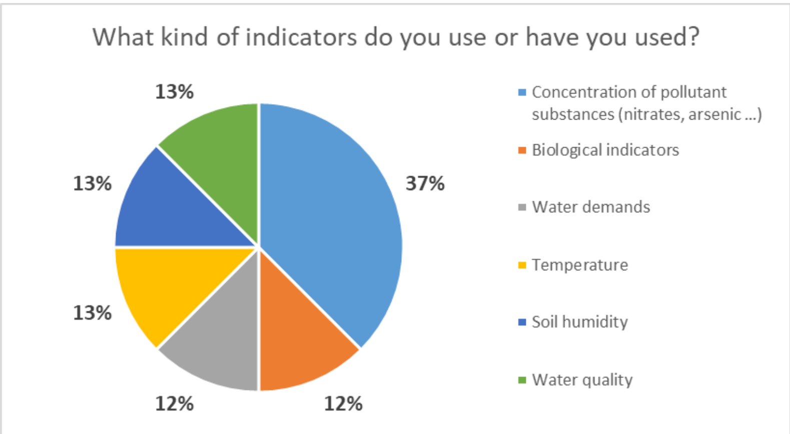


Figure 4.1a: Overview of the responses from the stakeholders at the Duero River Basin workshop.

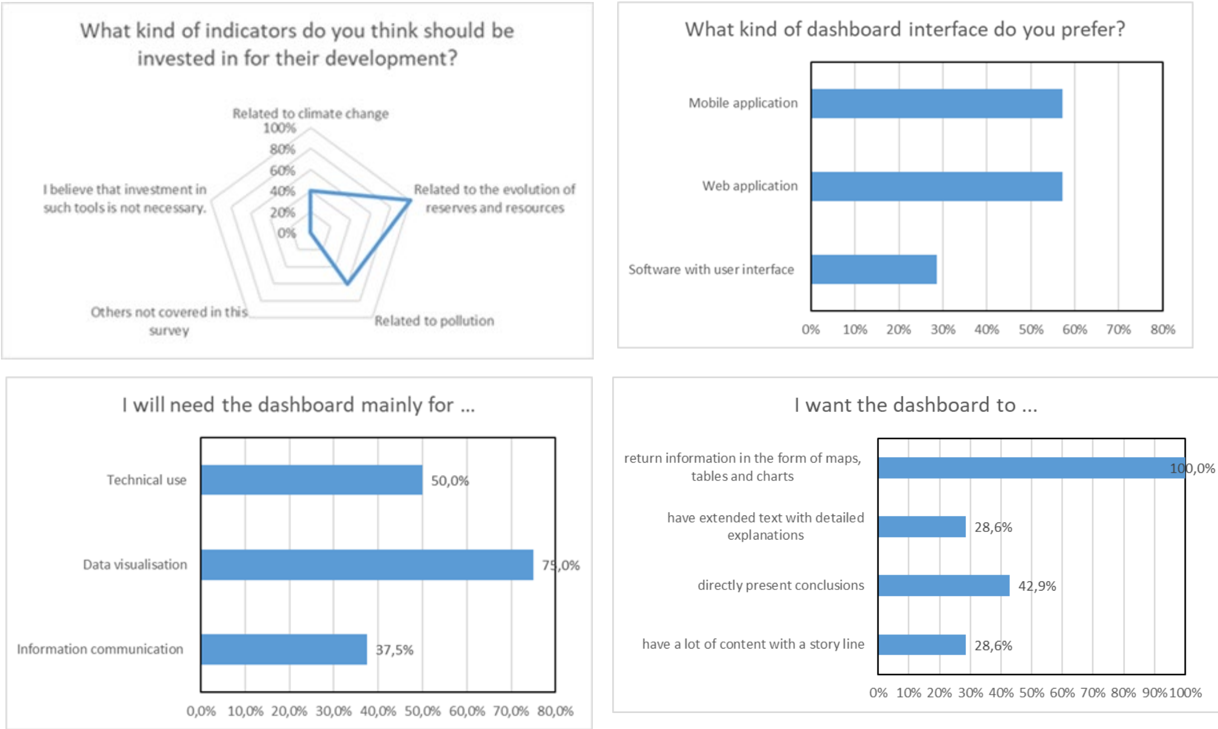


Figure 4.1b: Overview of the responses from the stakeholders at the Duero River Basin workshop.

With respect to the water availability, the stakeholders within the Duero River basin shown a clear need for information on the GWB scale and sub-basin level. The information provided in the MIRAME-Duero Information System need to be updated and, in some cases, reviewed. Stakeholders are aware that climate change will put more pressure on both groundwater and surface water resources, and they expressed their interest in knowing its effects on quality and quantity aspects according to their socio-economic sectors. Future scenarios should also consider management scenarios, perhaps combined with implementation of measurements scenarios. To find out what variables the stakeholders think more useful according to their activities, they indicate a 70% of responses addressed to quantity of water resources (surface and groundwater) and meteorological variables followed by a 55% interested in quality of groundwater resources.

Time scale needed for the development of their activity was also explored with the stakeholders. In this case, the response was 90% addressed to a period of 0-5 years, followed to some distance for a 45,5% of 0-1 year and equally for 0-30 years.

The stakeholders' interest on indicators was also explored during the meeting. 64% of the attenders expressed the use of some type of indicator in his/her activity. Looking to the future, the type of indicators they consider most useful for them are clearly (100%) related to the evolution of reserves and resources and related to pollution (60%).

Regarding the need for a dashboard, it was not well defined as they consider useful the Information System of the CHD (MIRAME-Duero). In this framework they expressed the need to get a visualization of water management scenarios in the context of climate change jointly with hydrological information. The stakeholders have a strong preference for a dashboard presenting information in the form of maps, tables, and charts and preferably in associated to mobile and web applications.

In conclusion, the stakeholder needs for the Duero River basin are summarized as follows, according to final conversations held in the discussions during the meeting:

- Link piezometry to the origin of pressure
- The variety of crop cycles together with a forecast of increased demand due to rising temperatures, causes the need to go towards a seasonal management with less uncertainly to meet future demand.
- Other needs identified by the River Basin Organization: adaptation to a highly changing situation (e.g., use of solar panels to irrigate), risk assessment.
- As indicators, the following were proposed: Arsenic concentrations, cost/benefit ratio, water reserve maps in the soil.

4.4. East Anglia

Within East Anglia there are several tools, including data and models, readily available to understand and manage water resources at a river basin level. A list of commonly used tools in East Anglia are available in Table 4.1. This information was collated from a range of sources including:

- The Adaptation Plan https://www.anglianwater.co.uk/siteassets/household/in-the-community/climate-change-adaptation-report-2020.pdf)
- The Water Resources Management Plan (https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp-report-2019.pdf
- The River Basin Management Plan (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718327/Anglian_RBD_Part_1_river_basin_management_plan.pdf),
- The Flood Risk Report (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1118190/Anglian-FRMP-2021-2027.pdf)
- The WFD report (https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp/sub-report-b---wfd.pdf)
- The Abstraction and Environment Report (https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp/draft-wrmp24-sustainable-abstraction-and-environment.pdf).

Table 4.1: Overview of the data, approaches, models and tools used by the stakeholders in the East Anglia river basin.

Theme	Short description existing situation
Monitoring programs and observational systems	• EA hydrometric (river flows & levels) and groundwater level networks • UK Met Office rain gauge and weather station network • Water quality sampling system - sampling water at about 12k sites a year • Smart meter monitoring to identify leaks within the network and in customer's properties more efficiently

Data sets, services and/or data portals	• UKCP18 national climate change scenarios • HadUK observational data (precipitation, temperature). • River flow: monitored (e.g., National River Flow Archive) and modelled (e.g., UK Hydrological Outlook (seasonal); eFLAG (UKCP18-based future river flows) • Groundwater levels (e.g., National Groundwater Level Archive) • UKCEH Water Resources Portal • Defra/EA Hydrology Data Portal • Reservoir storage and operations data (e.g., EA monthly reports on East Anglia Water situation) • ONS population/household data • Services include dedicated customer portal for smart meter readings
Physical process models	• TETIS models of some catchments.
Real-time information systems	• Extensive SCADA network • Real time operation of assets: real time demand data
Water demand and abstraction data available	• Abstraction licences (issued by EA), pump and pipeline capacities, environmental ambition • Real time hourly and daily household consumption data from smart meters to help inform process to reduce demand • Data sources for demand forecasts include ONS population/household data, analysis of historic connection data, and billing data
Water allocation and prioritization models used	• AQUATOR XV • MISER • PyWR
Reservoir data available and/or models used	• OSAY - Operating Strategy for Assessing Yield (WRMP2019) • MISER • PyWR
Water quality data and models used	• Extensive water quality sampling from EA and Anglian Water • Anglian water in-house laboratory
Vulnerability, impact and/or risk assessment tools	• Use of hydrological models with vulnerability framework
Seasonal Forecasting	• Copernicus data processed and run through GR6J monthly initialised rainfall-runoff models and AquaMod groundwater models
Management and planning tools (scenarios and strategies)	• MO-RDM • Copper leaf (C55)
Decision support / Policy dashboard (showing indicators, targets, scoring, etc.)	• Multi-criteria best value planning framework • Cost-benefit analysis for strategic demand management options and drought interventions • Least worse regrets analysis • Adaptive planning

All the stakeholders consulted agreed that in terms of modelling capacity, most of the models available are fit for purpose. The current needs in terms of tools are more orientated towards data and data services, in particular their use and interpretation across sectors. The themes prioritised during the discussion were as follows:

- Audit of portals/data hubs: available data, identification of reference datasets, identification of potential improvements.
- Water Quality models: for environmental and public consumption purposes (including an improved understanding of water quality impacts).
- Improve groundwater models and integration with other modelling activity in the hub.
- Move beyond 'average' metrics: current planning is based on averages, there is a need to account for actual usage (e.g., real-time data on water usage).
- Better/clearer communication of uncertainty in outputs for a range of stakeholders (e.g., quantification of hydrological model uncertainty).

4.5. Messara

Data and information available in the basin

The follow data and information are available in the Messara basin:

- Hydrometeorological data (timeseries) of daily precipitation, evapotranspiration, streamflow, spring discharge
- Groundwater levels from monitoring wells, and groundwater abstraction and pumping rates
- Aquifer characteristics/properties, groundwater recharge zones
- Reservoir characteristics and operational rules
- Land use (data and shapefiles), irrigated areas, crop mix and relevant crop parameters
- Population data per administrative unit
- Water use data (calculated from proxies and from water meters)
- Data from the water use licenses on the location of wells and the specific amount/volume of water to be abstracted and used within specific time (usually 10 years)
- Schematic representation of the basin and GIS shapefiles (hydrological network, sub-catchments, dams and reservoirs, groundwater bodies, water demand nodes for various users, water canals, irrigation works, irrigation methods, abstraction points, transmission and return flow links, flow requirements, losses)
- Water quality data from monitoring stations, chemical and ecological status classification of the water bodies
- Delineation of nitrates vulnerable zones
- Delineation of flood risk zones
- Ancillary information available within the WFD RPMP and the FRMP

It has been identified that the available data cover a wide range of parameters, have adequate resolution and are of good quality. It has been further identified that there is currently no use of Earth Observation data and the knowledge of the stakeholders on the capabilities of EO data is limited.

Tools and modeling instruments

The following tool and modeling instruments are available:

RIBASIM model: This is a water management/water allocation model and has been used for high level basin planning as a Decision Support System (DSS). It allows for the estimation of water demands under different scenarios that have been incorporated in the modes, for distributed water resource allocation (demand nodes-based) where prioritization is user-defined (within water districts and on distribution network level), as well as for impact analysis (WADIS module: crop production, costs and yields; DELWAQ module: water quality modeling, flow composition on distribution network level). The spatial resolution of the mode is per node and aggregated per catchment, while it runs at a monthly timestep. The following output parameters are provided by the model:

- Per water use/demand node: available water (m^3/s), water demand (m^3/s), ratio (%) of water availability/demand, flow to downstream (m^3/s), water deficit, % of time with water deficit.
- Per hydrological node: storage capacity (Mcm), water level (m), produced and consumed energy (GWh), filling rate (%), available surface and groundwater (m^3/s), streamflow (m^3/s), downstream flow (m^3/s), total surface water availability and demand (m^3/s), total groundwater availability and demand (m^3/s), return flow (m^3/s), groundwater storage (Mcm).
- Per environmental requirement node: % requirement met.

The existing RIBASIM model presents a couple of shortcomings. As it has been developed for the entire island of Crete, it may require further discretization and disaggregation to capture more detailed specificities of the Messara basin. It also needs to be updated and run for the most recent years, and to incorporate new and updated scenarios on future climate and socio-economic changes. Specific side elements could also be improved, like the surface-groundwater interaction and the definition of environmental flows.

SACRAMENTO model: This is a continuous rainfall-runoff model used to generate daily stream flow from daily rainfall and potential evapotranspiration data. It uses soil moisture accounting to simulate the water balance within the catchment (i.e., functional unit). The input data are from existing monitoring stations. The model is run at catchment spatial scale and daily timestep. The following output parameters are provided by the model: daily surface and base flow (m^3/sec), soil moisture depletion by evapotranspiration and soil moisture redistribution, soil moisture replenishment by rainfall and percolation. The existing model needs to be updated and run for the most recent years and also run against future climate change scenarios (altered precipitation and ET patterns).

MODFLOW model: This is a groundwater model simulating and predicting groundwater conditions and groundwater/surface-water interactions. The model is grid-based including the different aquifers and runs at an annual timestep. The current model needs to be updated and run for the most recent years and could also benefit from a monthly temporal resolution.

HYMOS Database: This is an information system for storage, processing, and presentation of hydrological and environmental data. It follows a database structure with additional tolls for Database structure with tools for data entry, validation, completion, analysis, retrieval, and presentation. As an output of specific tools, we can obtain validated and completed hydrometeorological timeseries and PET calculations. The current database is not up to date. Other databases are being used by the different entities that collect the data, based on their data storage and analysis needs.

Additional tools:

- Regional Plan for Adaptation to Climate Change in Crete (PESPKA): https://drive.google.com/file/d/1LLoI7Qn_fA96kFkeFKzReENagYHG_IgT/view
- WFD River Basin Management Plan (RBMP) of Crete: http://wfdver.ypeka.gr/wp-content/uploads/2017/12/EL13_SDLAP_APPROVED.pdf;
- RBMP English summary: http://wfdver.ypeka.gr/wp-content/uploads/2021/02/EL13_1REV_P22b_Perilipsi_EN.pdf
- Detailed WFD Reports (all articles) for Crete: http://wfdver.ypeka.gr/el/management-plans-gr/1revision-approved-management-plans-gr/approved-1revision-el13-gr/
- Action Plan to combat Drought and Water Scarcity in Crete: https://www.apdkritis.gov.gr/sites/default/files/files/Παραδοτέα Σχεδίου Ξηρασίας - Λειψυδρίας.pdf
- EU Floods Directive Flood Risk Management Plan (FRMP) for Crete: https://floods.ypeka.gr/index.php?option=com_content&view=article&id=126&Itemid=521

4.6. Seine

The workshop held in Paris with INRAE and the EPTB SGL on the 15th of February 2023 aimed at discussing the main issues for water resources management in the Seine River of key interest for EPTB SGL. In particular, the discussions focused on the management of the upstream lake-reservoirs, under extreme events and a changing climate, the needs for additional data and/or model output information for better operations, and the needs for accessible and actionable information to support planning and decision making. The main conclusions of the workshop in terms of data and models available at the EPTB SGL are provided below.

Data and information available

Numerous data from various public and private organizations are available at EPTB SGL, INRAE or other sources to carry out the research in STARS4Water:

- Cartographic data from GéoSeineGrandsLacs Portal (EPTB), available at https://sig.seinegrandslacs.fr/portal/apps/sites/#/geosgl.
- Current and past hydrometeorological data and reconstruction of past drought events (DREAL, EPTB SGL, Météo-France, INRAE).
- Current and past piezometric data (https://ades.eaufrance.fr/; INRAE).
- Current and past water quality data: Naïades database (https://naiades.eaufrance.fr/), water quality data and output from water quality models from works carried out by PIREN Seine at specific sites in the river basin (incl. works carried out by INRAE in their experimental catchments), intermittent data measurements from EPTB SGL (approximately four samples per year, upstream, downstream and in the lake-reservoirs, with more frequent analyses during low water periods (twice a week) especially for cyanobacteria).
- Inflow and outflow discharge data from the upstream lake-reservoirs, and guide curves for the lake-reservoirs operations (EPTB SGL).

- Data on water withdrawals on the river basin (EPTB SGL, INRAE, ASNE).
- Hydroclimate projections of future climate and hydrological variables (INRAE, from Explore 2 national wide project and CLIMAWARE project).
- Model output data (e.g., surface and groundwater flows, soil moisture) from PIREN-Seine research modelling studies.

Tools and models available
During the discussions, the focus on modelling issues was on modelling the routing of water from the lake-reservoirs to downstream parts of the river basin to support water users. Upstream modelling and reservoir operations are performed routinely at the EPTB SGL. They rely on hydrological and hydraulic models calibrated using historic time series of hydrometeorological data and guide (filling) curves for the four lake-reservoirs. A model predictive control model for reservoir operations driven by mid-term meteorological forecasts (9-day ahead) has also been tested in the river basin (CLIMAWARE project, work carried out by INRAE).

Other models used in specific research works were also identified: the lumped and semi-distributed GR family of hydrologic models developed by INRAE, including the airGRiwrm used to model water withdraws and injections, the GRP model used for flood forecasting in the river basin by the national SCHAPI/SPC forecasting system, and the GR6J model used in the PREMHYCE platform for low-flow forecasting; the semi-distributed EROS Marne semi-global model used in the Marne river sub-basin (BRGM); and the AquiFR model used to model the filling of reservoirs in the study carried out by Eaucea/EPTB SGL.

Currently, EPTB SGL does not run research models in daily operations. Some challenges were discussed such as the difficulties to understand where water comes from, particularly from gains and losses due to exchanges between groundwater and surface water, and to what extent the operational management of the lake-reservoirs contributes to meeting downstream water needs.

4.7. Rhine

Existing data and models
For the Rhine basin there is a lot of information available, but not in one place or in one system. Each commission has its own data and information portal, and an overview of the existing information is not available. Similar is valid for the models for the Rhine River, tributaries and/or (sub)basin. A lot of research is also executed at universities in the countries or e.g., institutes like JRC of the EU (Lisflood model).

Examples of models that are held by the Commissions:

- ICPR: Home (iksr.org)
    - Real-time monitoring system for low water (https://www.iksr.org/en/topics/low-water/low-water-monitoring)
    - Rhine alarm model
    - “Early warning” system floods / collaboration between forecasting centres

- CHR: home | International Commission for the Hydrology of the Rhine basin (CHR) (chr-khr.org)
  - RIBASIM scenario tool based on global datasets, coupled with "wflow hydrological model" (Van der Krogt et al, 2021)
  - LARSIM model output on snow and glacier melt (ASGI and II studies (Kerstin et al, 2022)

Needs for additional data, models, and tools

In general, the three commissions in the Rhine Basins expressed that they have a need for better understanding and assessment of water availability, water use and water allocation under various scenarios. There is a need for support in:

- Modelling water availability and use for supporting climate adaptation planning.
- Supporting data services for estimating water demand, e.g., agriculture.
- 'What if' scenarios development as a tool for strategic planning.
- Tools for risk assessment of present and future scenarios regarding balancing water resources availability, water use, water allocation and its impact on Rhine River discharge in transboundary water management cooperation context.
- Extended groundwater- and e-flow-modelling approaches as well as ML-modeling technologies for estimating water demand.

Some ideas about cooperation and co-creation between the commissions and STARS4Water that were expressed by the participants (i.e., CHR members, CCNR secretariat and ICBR secretariat) are:

- CHR invites STARS4Water to support in the development of components of the planned Socio-Economic Scenarios research. There is especially a need for the further development of the RIBASIM modelling tool for water availability, water use and water allocation assessments, 'what-if' scenarios development and assessment, water demand data collection. The CHR also wants to explore if earth observation data and or ML techniques can help water demand.
- CHR is developing its own information system. CHR offered to store data (model input and output) in this information system. Dashboard and story map could be communication tools on top of this information system; CHR is open to explore this further.
- ICPR through EG LW could gather data and/or study research with a focus on water demand and use. ICPR wants to use, as an end-user, the new information (scenario narratives, projections, etc.) co-created by the CHR and STARS4Water (probably with other/additional sources). ICPR could also take a more active role and e.g., taking part in discussion on formulating what-if scenarios.
- CCNR can deliver data/information on shipping/navigation conditions, consequences of low water on shipping. CCNR wants to use, as an end-user, the new information (scenario narratives, projections, etc.) co-created by the CHR and STARS4Water (probably with other/additional sources).
- CHR, ICPR and CCNR secretariats are willing to participate in 1 or 2 stakeholder meetings each year, back-to-back to the CHR official meetings to follow up and give feedback on general progress on data services, models, storylines, story-maps, and dashboard for the Rhine basin.
- CHR secretariat is willing to organize three online workshops together with STARS4Water for pre-selected end-users (can include representatives from ICPR and CCNR) of these products. It can facilitate technical meetings organized by STARS4Water to support application and validation of models and tools, and to discuss feedback from end-users provided to developers.

5. Needs for information to support decision making

This chapter presents the needs or wishes for developing tools to support informed decision making.

5.1. Drammen

Water supply
Long-term planning for water supply needs good estimation of floods and long-term forecasts (seasonal to decadal would be good). As one stakeholder said: “The question is when we need to build new water reservoirs?”

- For water supply, planning it is important to show the probability of consecutive years of drought. How often will droughts occur, and how long will they last?
- Changes in availability and water demand.

Floods and droughts:
To reduce the overall impact of floods it is important to identify flood prone areas and estimate consequences for areas at risk. Further, it is important to determine who will do the prioritizing of river flow regulations during flood events. Where to withhold and where to release water to reduce the overall impact where both economic, social, and ecological information is important.
Whereas flood impacts often are short-termed, the management and water allocation during droughts can have large consequences to energy production, water supply and ecology over time. In this aspect there is a need for prioritizing the consequences of maneuvering water for different purposes when it is not possible to secure all elements within the basin.
During droughts it is important to quantify the different needs for water, and the consequences of no or less supply. This includes domestic water supply, supply for irrigation, energy and ecological water demands.

- Clear prioritizations during extreme events. Where should water be withheld or allocated to minimize the overall consequences.
- In order to plan for the future there is a need to establish scenarios/storylines that one can relate to, e.g., reference to historical extremes (e.g., wors than the drought of 2018).

Energy demand:
The high energy production in Drammen is another aspect that needs to be accounted for in the storylines. We need to make different plausible scenarios for the energy demand at the local scale, e.g., the combination on the global/European/regional demand with a local production. Selection of different energy scenarios are e.g., high, business as usual and low demands.

- How will the energy demand affect the water use?
- How will possible changes in runoff seasonality, water availability, and water demand in the future affect the energy production?

Projections
Any changes to society and climate are important for a water demand in the future. Water availability will be estimated by the climate projections providing precipitation and temperature (evaporation) data. The water demand will depend on the future amongst others, population,

agricultural needs, climate changes, anthropogenic land use changes, and energy demand/availability.

One of the key questions is how to combine the SSPs with local information for the development of future scenarios. There is a need for information on shorter time horizons, e.g., include for seasonal and decadal planning. Including seasonal forecasts would require the dashboard to be more often updated, a more frequently used, and thereby more attractive for more active user groups.
This would further add the value of including e.g., satellite data, updating the initial conditions for different variables across the basins, and add value to the modelling tools developed. If there will be a decisions support dashboard for the Drammen River Basin Hub, there will be a need for training in the use of such a system.

5.2. Danube

The value of improved water information is related to its availability for stakeholders and decision makers in the Danube River Basin. The two major River Basin Organizations ICPDR and ISRBC have established their own metadata portals and GIS map services to share the data publicly. An integration of the knowledge and data gained in the STARS4Water into this portal would be desirable and worth considering. Also still under consideration is the development of a dashboard for the Danube River Basin Hub. However, the added value of a dashboard for the Danube depends on the scope of information offered and the timeliness of the data. A provisional dashboard with rudimentary functions and features must be avoided, especially since concerns are expressed that a continuation of the dashboard after the end of the project requires considerable work and responsibilities must be clearly clarified in advance.
The visualization of results in the form of graphics and maps is intended to increase readability and comprehensibility and to present the most important information in a concise and attractive manner. At the same time, the information should be tuned for the individual user so that only the data relevant to him or her is displayed. Appropriate preparation of the data and models is considered a guarantee for use beyond the end of the project. Concrete proposals on how to prepare the data will be developed in the next stakeholder meeting when individual model approaches are available.

5.3. Duero

The MIRAME-Duero Integrated Viewer and Information System is a useful tool, and it is preferable to put effort into improving it, or completing it with a dashboard, rather than developing a new and independent dashboard. In addition, the end user would be both the CHD itself and technicians, farmers, water managers, etc. It is expected to define in the coming workshops what type of information should be shown in case to enhance the MIRAME-Duero viewer.

5.4. East Anglia

Water resources management in East Anglia is supported by a range of models and tools. However, in a region already designated as an area of serious water stress, water resources management is a challenge. The stakeholders have identified a set of priorities with regards to information that the STARS4Water project could contribute to. This information has the potential to facilitate decision making in water resources planning and operational water management:

- A visualization tool for different users (scenario exploration; data extraction): based on the concept of gaming, a dashboard/tool that would help visualize the outcome of various scenarios. Such a tool would not only help identify best practice from a regulator and user perspective, but would also contribute to public engagement and enable a shift in the perception of the value of water and its use.
- Multi-year risk analysis.
- Links between terrestrial and fluvial change/impacts: this would help towards quantifying the implication of land use change on water quality, river habitat and ecosystem services.
- Impact of deregulated abstraction licenses (scenario).

5.5. Messara

The following needs have been prioritized by the Messara basin stakeholders during the Workshop discussions:

- Development of a distributed water allocation decision support system (DSS), incorporating all water supply sources and water demand needs under different climate and socio-economic change scenarios.
- Simulation, within this DSS, of different adaptation measures and interventions in order to carry out ex-ante evaluations and assess their impact on the physical-based system. These measures will include measures which are currently under consideration in the 2nd implementation round of the WFD RBMP. One important measure to evaluate, highly requested by the stakeholders, is the potential diversion of the Platis River in order to supply additional water to the Faneromeni reservoir, as well as for artificial recharge in the Messara basin.
- Development and assessment of scenarios of climate change impacts on agricultural water supply, including the evaluation of uncertainties. These scenarios should also be easily communicated and understandable to the stakeholders.
- Development of an online information and visualization tool (e.g., dashboard) allowing the visualization of key indicators and the dissemination of the relevant information to the stakeholders and the wider public.
- Development of supply-demand Masterplans for the three Local Land Reclamation Organisations (TOEBs) which are responsible for the provision of irrigation water to the farmers.

5.6. Seine

The following needs and priorities were identified during the first stakeholder workshop discussions:

- Improving understanding of how much the upstream lake-reservoirs can mitigate the impact of climate change and enhance downstream services to water users, especially during low flow and drought periods: use of state-of-the-art hydroclimate projections from the national wide project EXPLORE 2; evaluating scenarios of impact.

- Enhancing surface-groundwater modelling, with a focus on identifying water pathways that affect water quality downstream the lake-reservoirs, especially during low flow and drought periods.
- Shedding lights to any novel datasets at the river basin scale or machine-learning data modelling techniques that could be adapted to the operational setting of the lake-reservoirs, comparatively to the currently used guide curves.

5.7. Rhine

From expert to decision maker is an important step, and “informed decision making” is key factor in this. All the three commissions in the Rhine basin have the wish to understand the challenges and to find solutions. The CCNR and ICBR want to develop strategies for water resources planning and climate adaptation in the basin. The information that will be generated in the STARS4Water projects in co-creation with the commissions will further support evidence-based decision making, when it is presented in a way that the data is easy accessible and understandable. First ideas to support informed decision making are:

- Develop story map(s) and publish them on the internet: about the story of the Rhine based on the outcome of the risk assessment.
- Define meaningful indicators for evaluation and scoring: to be discussed with stakeholders, but ASGII already provides some (e.g., signalling low flow discharge below a certain threshold value at location Lobith or minimum water level at Bodensee).
- Develop and assess scenarios, preferrable ‘what if’ scenarios to be defined with stakeholders about plausible future external developments (like population growth, European market) or that are interesting for sensitivity analysis.
- Co-designed dashboard(s): connected to CHR information system for presenting e.g., time series about water demand and water use. Transfer and store the datasets to CHR information system.

More in detail following topics were discussed in the workshop:

- Modelling water availability and use for supporting climate adaptation planning.
- Supporting data services for estimating water demand, e.g., agriculture.
- Risk assessment of present and future scenarios regarding balancing water resources availability, water use, water allocation and its impact on Rhine River discharge in transboundary water management cooperation context.
- In addition to above mentioned items, extended groundwater-, e-flow- and ML-modelling.

6. Priorities for development of data services and next generation of water resources management tools within STARS4Water.

This chapter presents an overview of the key topics for research and development within the STARS4Water project based on the needs assessment conducted in the stakeholder workshops in the river basin hubs (Table 6.1). Key topics may differ between river basin hubs, as the river basins diverse in their geohydrological context, climate vulnerabilities and stakeholder needs for adaptation, amongst other river basin specific characteristics.

The partners within the STARS4Water consortium have selected the priority topics in a project workshop on April 25-26 in Vienna. This first set of priorities are listed in Table 6.2. Next step of the co-creation approach is to discuss the priority topics with the stakeholders to identify the specific requirements for research and development concerning the data services, indicators, models and information tools.

Table 6.1: Stakeholder needs: key topics for improving the understanding on water resources under changing climate, risk assessment, operational management and water resources planning. Legend: X = high priority within STARS4Water project, x = priority, blank = no priority

Priority areas for supporting Stakeholders for Adaptive, Resilient and Sustainable water resources management	Danube	Drammen	Duero	East Anglia	Messara	Rhine	Seine	Europe
• Climate, hydrology and natural water availability (baseline)	X							X
• Land use and (Agricultural) water demand assessment (baseline)	x	X			x	X	X	
• Balancing water availability, supply and demand (baseline)	X					X		
• Groundwater management and conjunctive SW-GW water use (sustainable management)	x		X	X	X	x	X	X
• Low flows, water allocation and prioritization, incl. reservoir management (sustainable management)	x	X			X	X	x	
• Ecological flow and good ecological status (sustainable management)	x	x		X	X	x		
• Flood risk management - early warning and/or planning (resilient water management - too much)				x				
• Drought risk management - early warning and/or planning (resilient water management - too little)	X	x	x			X	x	
• Water quality management (resilient water management - too dirty)			x	X			X	
• Future scenarios for strategic planning (adaptive management regarding climate change, socio-economic changes)	X	X	X		X	X	x	

Table 6.2. Selected key topics for research and development to support the stakeholders needs for adaptative, sustainable and resilient water resources management.
Legend: *X = high priority within STARS4Water project, x = priority, blank = no contributions by Stars4Water. Selected topics for Europe have potential for upscaling.*

Key topics and priorities for research and development	Danube	Drammen	Duero	East Anglia	Messara	Rhine	Seine	Europe
Improve data services								
• Leverage (water demand) data collection and assimilation	x	x		x		x		
• Global datasets and EO services						**X**	**X**	
• National datasets and services	x	x						
• Regional to local (monitoring) datasets and services	x			**X**	**X**		x	
• Integrating EO data in modelling tools					**X**	**X**	**X**	
Improve modelling tools								
• Updating existing modelling tools								
○ RBM (nodes and branches models for river basin simulation)				x	**X**	**X**		
○ DHM (semi or fully-distributed, grid-based hydrological models)	**X**	x		x	x	x	**X**	
• Expanding/connecting new modelling tools								
○ New data-driven modelling (ML)							**X**	
○ Advance Integrated River basin modelling	**X**	**X**	x	x	**X**	**X**	x	
○ Expand with new functionalities	x	x	**X**	**X**	x	x	**X**	
Suggestions to improve model functionality								
• Modelling for climate, hydrology, glacier and snow melt		**X**						
• Modelling for land use and water demand (in general)	x	**X**				**X**	**X**	
• Modelling for agricultural water demand (using EO data)					**X**	**X**		
• Modelling for water allocation and prioritization among water use(rs) for water supply		**X**			**X**	**X**	x	
• Modelling for river flows, especially low flows	**X**	x				**X**		
• Modelling for reservoir management (excl./incl. hydropower)	x	x					**X**	
• Modelling for water quality			x	**X**			**X**	
• Modelling for groundwater, gw/sw interaction and/or conjunctive use			**X**	x	**X**	x	**X**	

Key topics and priorities for research and development	**Danube**	**Drammen**	**Duero**	**East Anglia**	**Messara**	**Rhine**	**Seine**	**Europe**
• Modelling for ecological flow and good ecological status	**X**	x		**X**	**X**	x		
Other considerations to improve modelling tools								
• Spatial and Temporal Scales		X			**X**		x	
• Defining the Management Strategies	**X**		**X**					
• Defining the Future Scenarios: top-down ‘IPCC downscaling’ versus bottom-up ‘stakeholders’ what-if’		**X**	**X**		**X**	**X**	x	
Communication & Visualisation modelling results								
• Story maps	**X**	x	x	x	x	x	x	
• Dashboard	**X**	**X**		**X**	**X**			
• Serious Game				**X**	x			

7. Conclusions and Outlook

7.1. Conclusions

Based upon the results of the workshop we can conclude:

1. That by setting up the river basin hubs and organizing the needs assessment workshops, a solid base has been founded for the STARS4Water project.
2. In all the river basins, STARS4Water is seen as added value and is in some cases the initiator for new contacts and collaborations/networks.
3. The stakeholder community are acknowledged as an arena for knowledge exchange and to improve the understanding of different challenges and aspects of water resource management. The stakeholder communities are also facilitating to learn from each other, and to cooperate especially during extreme events.
4. In all river basins, water availability issues play an important role for the needs of the water managers; they are different for each river basin, and summarized as follows:
    a. In the Drammen, the discussion on future scenarios, including the possibility of having seasonal forecasts (i.e., seamless forecasts from a few days up to the end of the century) among stakeholders is one of the key-issues.
    b. In the Danube, the need for data sharing between all the countries is an important topic.
    c. In the Duero, the primary needs are making tools available to all the stakeholders and provide support in using the tools.
    d. In East Anglia, setting up and visualizing scenarios and measures are the main topics.
    e. In the Messara ground water extraction is one of the most important issues and improved data and modelling is important.
    f. In the Seine reservoir management under climate change and changes in water availability is the main question.
    g. In the Rhine more and better data on water demand in the agriculture sector and reservoir management are important to update the RIBASIM tool.

7.2. Outlook

Organizing the river basin hubs and conducting the needs assessment are the first two steps in the stakeholder involvement within the STARS4Water project. It is the beginning of a process to enlarge knowledge and understanding and the co-creation process with stakeholder and by stakeholders. A first set of priorities has been listed, and there are communalities as well as differences between the 7 river basin hubs. Next step in the co-creation approach is to discuss the specific requirements with respect to data services and tools and a guidance for the research and development activities in STARS4Water.

<u>Outlook for Drammen:</u>

- ✓ Tools to better assess changes in water resources storage and snow.
- ✓ Higher resolution of data for several parameters.
- ✓ Need for integrated river basin model, preferably linked to water quality.
- ✓ Data needs to be collected about water demand, population changes and land use changes.
- ✓ Simple model for operation of hydropower, which displays how the energy needs will change.
- ✓ Scenario and storyline toolbox

Outlook for the Danube:

- ✓ Development of models to assess the whole water balance of the entire Danube region.
    - Groundwater and hydropower need to be integrated into the model(s).
    - Consider low flow situations in these models.
- ✓ Information on the available water at certain locations, important for low flows/droughts.
- ✓ Up-to-date data for management strategies.

Outlook for Duero:

- ✓ Development of a river basin tool on the availability of groundwater on subbasin scale. Would also be useful to include groundwater quality in this.
- ✓ Development of climate change scenarios and display the impact on future water availability.
- ✓ Identify, develop and analyse management scenarios.

Outlook for East Anglia:

- ✓ A visualization tool for data and scenarios.
- ✓ Identify reference datasets and place with other good quality data in a portal.
- ✓ Improve groundwater models/integration with other modelling activities.
- ✓ Modelling and scenario exploration of environmental flows.

Outlook for Messara:

- ✓ Earth Observation data could be used to update the existing models with more recent data.
- ✓ Improve groundwater-surface water interaction in the models.
- ✓ Development and assessment of scenarios of climate change impacts on agricultural water supply, including the evaluation of uncertainties.
- ✓ Development of socio-economic and land-use scenarios and how this will influence groundwater resources and environmental flow in the rivers.

Outlook for the Seine:

- ✓ Improved knowledge on how reservoir management can contribute to climate change adaptation and to coping with extreme events (in particular, low flows and droughts).
- ✓ Better evaluation of the impacts of reservoir releases when routing reservoir outflow to downstream users and needs.
- ✓ Better understanding of interactions between surface and groundwater.
- ✓ Exploring the use of satellite data for large river basin integrated water management and water use scenario building, if pertinent for the scales and needs of local modelling tools.
- ✓ Exploring the use of machine learning techniques that could fit the challenges of water quality evaluation under scarce data time series and/or complement current reservoir operations, if pertinent for the scales and needs of local modelling tools.

Outlook for the Rhine:

- ✓ Projections of low flow situations in the Rhine.
- ✓ Data services to estimate the water demand.
- ✓ Update and improve the RIBASIM model for scenario assessment regarding water availability, water demand, use and water allocation.
- ✓ Development of what-if scenarios.

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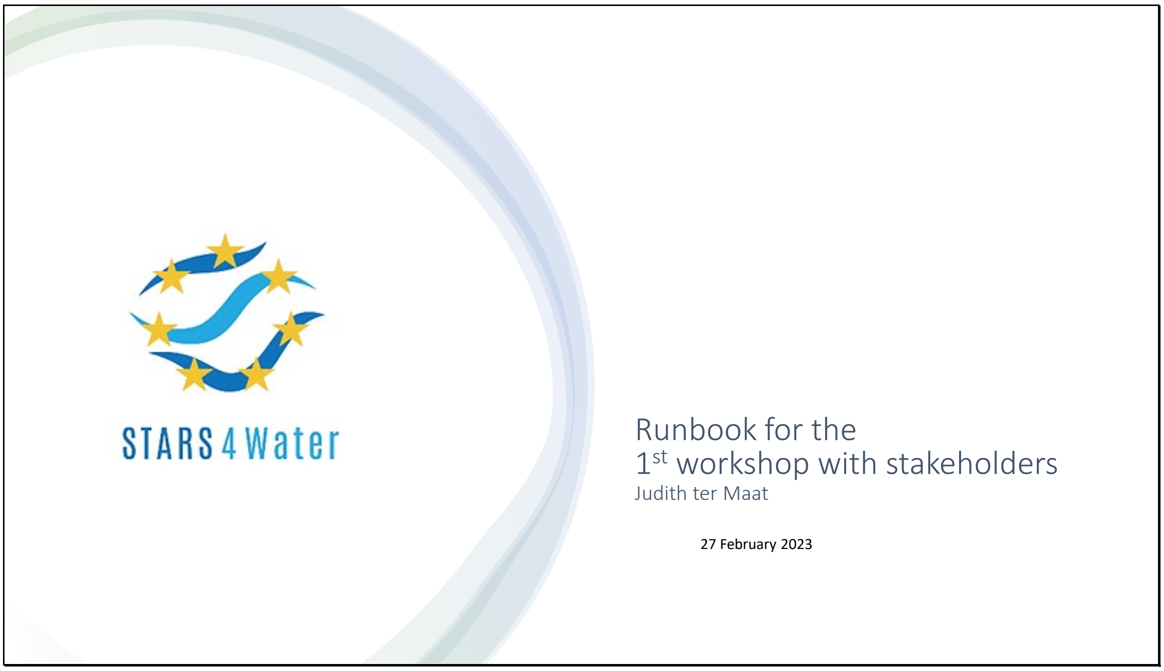
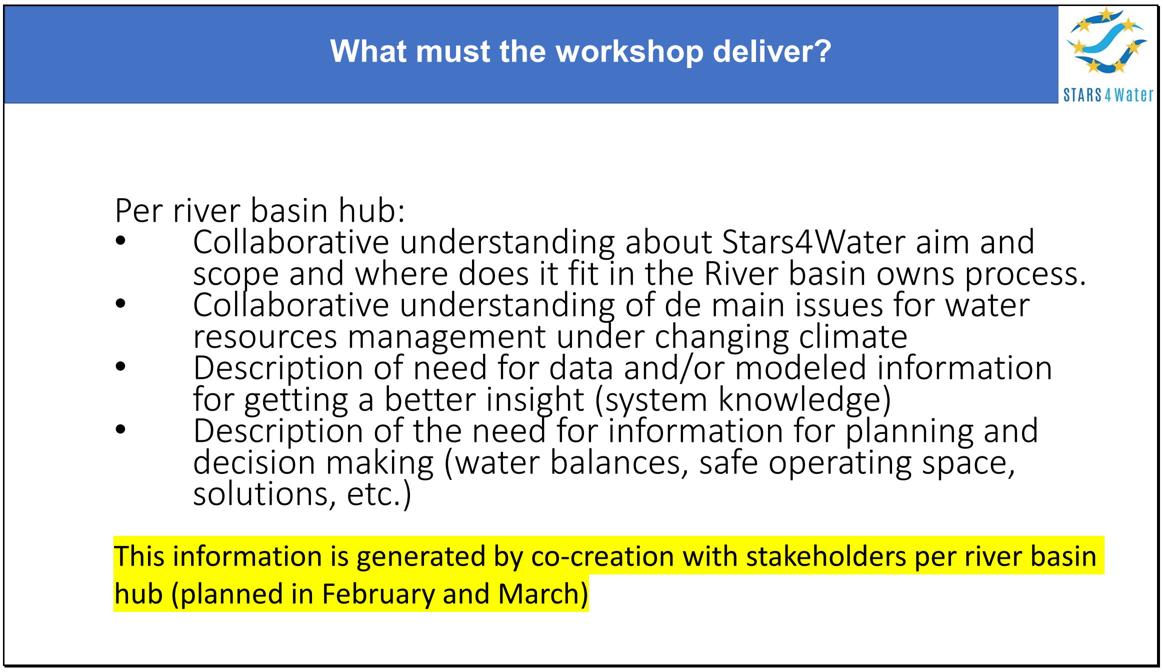
ANNEX 1: Runbook for the 1st workshop with stakeholders

To structure the first stakeholder workshop in the river basin hubs, a runbook was designed. The main objectives of the workshop were the following (a) to provide a presentation to the STARS4Water project; (b) to explore the interest of the participants on the work themes (water availability, climate change, information systems, assessment of risk and vulnerability); and (c) to identify the needs of the stakeholders related to the STARS4Water focus.





What must the workshop deliver?

Overall:

- Selection of indicators to consider in the project
- Input and guidance for the development of water scenarios and risk assessment
- Selection for the development of data services and next generation models
- Selection of information that the dashboard must be able to show

This information is generated by co-creation within the Steering Group + Focus Points (in meeting 25/26 April) based on the output of the workshops per river basin

Guided questions for the 1st stakeholder workshop

- What is the aim and scope of Stars4Water project?
- How is the water resources system in the river basin functioning now?
- What are the main water resources availability related issues and challenges in the river basin according to the stakeholders?
- Which data, modelling tools and/or information do the stakeholders need for a better understanding of the system and for planning and decision making?
- How should the information be accessible and actionable?

Above questions related to the boundaries of the project.

Generic content first stakeholder workshop

STARS4Water

Steps during the workshop	Stakeholders	Research partner
What is Stars4Water? Exchange information on ambition and scope Stars4Water	Familiarize yourself with Stars4Water through the presentation.	Present Stars4Water intro presentation
How is the water resources system in the basin functioning now? Determine the water system, water users, and major themes	Sketch and map the water system including the water users by putting key messages from memos (e.g. online by using Miro) on a(n online) piece of paper.	Set-up a collaborative method to co-map the water system, based on which the issues can be mapped.
What are the main issues and challenges in the river basin? Identification and prioritization of issues that the stakeholders like to address -> input for consortium discussion on indicators	Sketch and map the issues and challenges by putting key messages from memos (e.g. online by using Miro) on a(n online) piece of paper. Prioritize and be as specific as possible (first set of indicators). Preferably including references to literature, expert judgement or other sources.	Set-up a collaborative method to co-map the issues and challenges, and prioritize those together.

Generic content first stakeholder workshop

STARS4Water

Steps during the workshop	Stakeholders	Research partner
Which data, modelling tools and/or information do the stakeholders need? Based on what is already there, what are important short comings according stakeholders -> input for consortium discussion on what we can offer	Answer the questions prepared in the memo about user needs as accurately as possible and participate in discussions that follow from this.	Present an overview of the data, modelling tools and information already collected (in Wp2 and WP3). Present the questions as specified in the prepared memo.
How should the information be presented? Get an eye on what Stars4Water could contribute in daily practice	Participate in the discussions about the mockups. Initial feedback. What are useful aspects of the different envisioned deliverables for your river basin? Would you use them, in what way and in which condition?	Present mock-ups for inspiration on meta-dataportal, dashboards, water scenario narratives, risk assessments, ..

What is needed to make this workshop succesful?

- Tailored content fit to each river basin
- Stakeholders participation
- Research focal points + others?
- Location
- Time: 3 hrs?
- In March or April
- Leaflet
- Stars4Water website
- Workshop input material
- Workshop report
- Input wrap up / next steps workshop 25-26 April

Workshop schedule

Date	River basin	Location	Comments
23 March 2023	East Anglia	Huntingdon? (UK)	
29 March 2023	Rhine	Bienne (CH)	Back to back meeting at official CHR biannual meeting. Check with our PO if Switzerland is allowed for location
28 March	Drammen	Drammen (NO)	
28 March	Douro	?	?
19 April	Danube	Vienna	In contact with IPCDR; start with individual meeting with ICPDR?
15 February 2023	Seine	Paris (FR)	Bilateral meeting with Seine Grand Lac (managers of the reservoir)
28 March 2023	Messara	Crete	Start with bilateral meetings ("road show") and followed by a wrap-up workshop
25-26 April - Wrap up & next steps WP1-2-3-4		**Vienna**	**see invitation H. Duel 24.02.2023**