EU4Environment in Eastern Partnership Countries:
Water Resources and Environmental Data (ENI/2021/425-550)

GUIDE TO QUANTITATIVE WATER MANAGEMENT PLANNING AT LOCAL SCALE IN EASTERN PARTNERSHIP COUNTRIES

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EU4Environment
Water and Data in Eastern Partner Countries

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ABOUT THIS REPORT

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PHOTOGRAPH ON THE COVER PAGE

The photograph on the cover page shows the Arpa River in Djermouk, Armenia. Photo © OiEau (2019).

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IMPRINT

Owner and Editor: EU4Environment-Water and Data Consortium

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September 2024

ABOUT EU4ENVIRONMENT – WATER RESOURCES AND ENVIRONMENTAL DATA

This Programme aims at improving people’s wellbeing in EU’s Eastern Partnership Countries and enabling their green transformation in line with the European Green Deal and the Sustainable Development Goals (SDGs). The programme’s activities are clustered around two specific objectives: 1) support a more sustainable use of water resources and 2) improve the use of sound environmental data and their availability for policy-makers and citizens. It ensures continuity of the Shared Environmental Information System Phase II and the EU Water Initiative Plus for Eastern Partnership programmes.

The programme is implemented by five Partner organisations: Environment Agency Austria (EAA), Austrian Development Agency (ADA), International Office for Water (OIEAU) (France), Organisation for Economic Co-operation and Development (OECD), United Nations Economic Commission for Europe (UNECE). The programme is principally funded by the European Union and co-funded by the Austrian Development Cooperation and the French Artois-Picardie Water Agency based on a budget of EUR 12,75 million (EUR 12 million EU contribution). The implementation period is 2021-2024.

https://eu4waterdata.eu

CONTENTS

List of abbreviations

ADA......................... Austrian Development Agency
BRGM .... French Geological Survey
DTM .... Digital Terrain Model
EAA .... Environment Agency Austria
EaP .... Eastern Partnership
EC............................ European Commission
ETP .... Potential Evapotranspiration
EU .... European Union
EUWI+ .... European Union Water Initiative Plus
FAO .... Food and Agriculture Organisation
HMUC .... Hydrology, Environment, Uses and Climate study
OIEau .... International Office for Water, France
IPCC .... Intergovernmental Panel on Climate Change
KTM .... Key Type Measures
MEA .... Multilateral Environmental Agreement
NBS .... Nature-based Solutions
NPD......................... National Policy Dialogue
OECD....................... Organisation for Economic Cooperation and Development
PoM .... Programme of Measures
PTGE .... Quantitative Water Management Plan at the local scale, France
QMNA..................... Mean monthly low-water flow
QMP........................ Quantitative Water Management Plan
RBD .... River Basin District
RCP .... Representative Concentration Pathways
RBMP .... River Basin Management Plan
SDG .... Sustainable Development Goal
SRTM .... Shuttle Radar Topography Mission
SSP .... Shared Socio-Economic Pathway
UBA......................... Umweltbundesamt GmbH, Environment Agency Austria
UNECE..................... United Nations Economic Commission for Europe
USGS .... United States Geological Survey
VCNx .... Lowest average flow recorded over a consecutive period of x days
WFD .... Water Framework Directive
WTP .... Wastewater Treatment Plant
WHO .... World Health Organisation
ZRE.......................... Water Distribution Zone, France

Executive Summary

Competition to access water resources is intensifying due to population growth, economic development, degraded water quality and climate change. As a result, the issue of how water is allocated among users is moving up the policy agendas of Eastern Partnership (EaP) countries. Armenia, Azerbaijan, Georgia, Moldova and Ukraine are located on terrains featuring highly diverse freshwater ecosystems in floodplains, rivers and lakes. Surface and groundwater resources are vital for supplying water to 60 million people and are essential for maintaining the countries' major economic sectors, such as agriculture, energy and manufacturing. Quantitative Water Management Plans (QMPs) ensure that water resources are fairly allocated and secure sustainable water supplies for the community, agriculture, industry and the environment for future generations.

In line with the implementation of River Basin Management Plans (RBMPs) under the Water Framework Directive, the Eastern Partnership countries are working to achieve good qualitative and quantitative status of water bodies in Armenia, Azerbaijan, Georgia, Moldova and Ukraine. An RBMP consists of several documents, including a programme of measures that identifies various actions to be implemented in the basin to restore deteriorated water bodies. At large river basin scale, the RBMP is an adapted tool to identify the most overexploited water bodies, whereas the local quantitative plan details the necessary actions to mitigate quantitative tensions between local users in case of water scarcity, and structures the management of the drought crises. The quantitative water management plan is part of the programme of measures of an RBMP and can be seen as a meta-measure to tackle quantitative issues in priority areas, simultaneously addressing socio-economic challenges and the preservation of biodiversity and natural resources. Consequently, this guide has been designed to specify the methodology and approach to QMPs; it provides operational guidance to decision-makers and water resource planners in the Eastern Partnership countries on strengthening quantitative water management planning at the local level. QMPs are thus a valuable extension of RBMPs to be applied in priority sub-basins or large groundwater tables facing quantitative challenges.

This guide is designed for regulators and practitioners alike, as well as water system managers, policymakers, river basin administrations and main water users (agriculture, water-intensive industries, municipalities and water utilities, operators of other water infrastructures), international partners, and local communities. It aims to highlight the importance of implementing optimised water allocations and relevant actions to ensure sustainable water management in the territory. It is important to share, discuss, adapt and validate the planning approach with competent authorities in the field of water resources and environmental data management, as well as national bodies responsible for developing the regulatory framework for quantitative water management.

The participatory approach is at the heart of this guide. This kind of approach is designed to improve the sharing and complementarity of knowledge and skills, promote the acceptability of projects, and facilitate the implementation of actions adopted by stakeholders. Furthermore, a participatory approach improves relations between citizens, and in some cases mitigates or even resolves conflicts of use. Citizens are empowered thanks to greater awareness, access to information on water-related issues, and a more transparent decision-making process.

Reader's Guide

This guide is designed to serve as a checklist (Table 1) for the operational implementation and monitoring of quantitative water management planning at the local level taking a participatory approach.

The guide is divided into the following main sections:

- STEP 1: Scoping phase
  Outline the territory and characterise its specific features. Define the scope of the quantitative water management planning approach, including organisation, governance, resources and timetable.
- STEP 2: Water resources status
  Assess available resources in the context of climate change, and the minimum ecological flow, and share the results with stakeholders.
- STEP 3: Water allocation plans
  Assess current water needs and anticipate their evolution, given the socio-economic context and climate change. Determine water allocation volumes by sector of activity and geographical unit.
- STEP 4: Programme of actions
  Identify actions to achieve a balance between needs, resources and the proper functioning of aquatic systems over the long term. Develop a programme of action in consultation with stakeholders based on proportionate assessments, notably economic and financial.
- STEP 5: Implementation and monitoring
  Implement the selected actions and monitor and evaluate their implementation. The quantitative water management plan should be periodically adapted.

This guide includes key methodological points, definitions, case studies, references and guidance, which are highlighted in coloured boxes throughout.

Method
This section describes the main steps of the methodology and provides technical references.

Definition
This section defines technical terms.

Box: A case study
Country, (Source: Author, Year)
This section illustrates the guide with case studies from Eastern Partnership countries.

References
This section provides references related to specific topics that are also listed in the ***bibliography****.*
[NO.] Title, Country

Guidance
This section provides specific guidance on the quantitative water management planning approach.

Table 1 Checklist of the Quantitative Water Management Plan

The purpose of this checklist is to assist in the operational implementation and monitoring of a quantitative water management plan.

ACTIONS TO BE INCLUDED AND DESCRIBED IN THE QUANTITATIVE WATER MANAGEMENT PLAN	YES	PARTIALLY	NO
STEP 1: SCOPING PHASE			
#1 Define the project organisation: governance, financing, timetable			
#2 Engage stakeholder participation from the start			
#3 Define the territory and timescale			
#4 Characterise the legislative context			
#5 Assess data needs and available information			
STEP 2: WATER RESOURCE STATUS			
#6 Characterise freshwater resources in the context of climate change			
#7 Assess the minimum ecological flow			
#8 Share the water resource status with stakeholders			
STEP 3: WATER ALLOCATION PLANS			
#9 Assess water demand			
#10 Assess abstractable volumes			
#11 Establish water allocation targets			
STEP 4: PROGRAMME OF ACTIONS			
#12 Select actions			
#13 Develop a “no-project” scenario			
#14 Co-construct a programme of actions			
STEP 5: IMPLEMENTATION AND MONITORING			
#15 Set up human resources			
#16 Set up financial resources			
#17 Set up a performance monitoring system			
#18 Validate the programme of actions			
#19 Periodically adapt the programme of actions			

1. Introduction

1.1. The international stage and the EU context

As available water resources diminish, decisions over who can use water and how much they can use are becoming more contentious. Quantitative water management must deal with conflicting demands and trade-offs. Economic uses need long-term certainty regarding their authorised access to and use of water to support productive investments, while ecosystems and the good status of water bodies must be safeguarded. These situations are occurring in a context where, depending on local contexts, water scarcity is increasing and/or drought conditions are becoming more intense and frequent. Water scarcity is a seasonal, annual or multi-annual water stress condition. It occurs when water demand frequently exceeds the sustainable supply capacity of the natural system in river basins (EC, 2024).

In line with the Sustainable Development Goals (SDGs), quantitative water management can contribute to sustainable development by addressing public interest objectives and sustainability dimensions simultaneously. Quantitative water management plans are therefore effective instruments for addressing sustainability-related challenges in an integrated manner. The 2030 Agenda and its 17 SDGs, adopted in 2015 by all United Nations member states, represent a comprehensive global plan of action toward a more sustainable future. The 2030 Agenda addresses all three dimensions of sustainability – environmental, social and economic – and emphasises the need to tackle these dimensions in an integrated manner.

SDG 6 is focused on achieving universal and equitable access to drinking water, hygiene and sanitation by 2030, with a particular emphasis on vulnerable populations. The goal also aims for this resource to be sustainably managed in terms of water quality, sustainable and efficient use, and ecosystem protection. It also aims at a reduction in the number of people suffering from water scarcity. Quantitative water management directly contributes to the following specific targets:

- Target 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
- Target 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.
- Target 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.
- Target 6.8: Support and strengthen the participation of local communities in improving water and sanitation management.

Quantitative water management may also enhance cross-sectoral coherence between SDG 6 and other SDGs, including "food security and sustainable agriculture" (SDG2), "water and sanitation" (SDG6), "affordable and clean energy" (SDG7), "responsible consumption and production" (SDG12), "climate action" (SDG13), and "life below water" (SDG14).

In the EU context, quantitative water management planning is of significant importance, as evidenced by the European Commission's 2007 Communication on water scarcity and drought and its 2019 assessment of the second cycle RBMPs. The first of these documents identifies the reform of water allocation regimes as one of seven policy options to make water more "fit for purpose" in light of the EU's environmental and climate agenda. This necessitates the adaptation of water allocation to consider the ecological needs of water-dependent ecosystems (EC, 2012). More recently, the Biodiversity Strategy to 2030 and the EU Adaptation Strategy (published in 2020 and 2021, respectively) under the EU Green Deal highlight the need to review water permit regimes and allocation systems to achieve the combined objective of implementing ecological flows achieving good WFD status, and mitigating the impacts of climate change. The establishment and enforcement of quantitative water management planning in Europe is therefore seen as an important tool for dealing efficiently with water scarcity and drought issues, for achieving good ecological status as required by the WFD, and for providing significant co-benefits for climate change mitigation and adaptation, nature and biodiversity.

The Water Framework Directive (WFD), adopted in 2000, promotes sustainable water use via the long-term protection of available water resources and the mitigation of the effects of droughts, contributing to guaranteeing a sufficient supply of good quality surface water and groundwater and protecting territorial and marine waters. EU countries implement integrated river basin management through River Basin Management Plans required by the Directive, and some have adopted Drought Management Plans for vulnerable river basins. Moreover, under the WFD, Member States are required to establish controls on the use, abstraction and discharge of water (Art. 11.3) in the form of registers and prior authorisation through permitting regimes.

Furthermore, other EU regulations address water quantity management:

- The regulation on minimum requirements for water reuse for agricultural irrigation, establishes new rules to stimulate and facilitate water reuse in the EU
- The recast of the EU Drinking Water Directive addresses leakage in the water supply networks.

Further support for water quantity management is provided by the Commission's proposals to revise the Urban Wastewater Treatment Directive (UWWTD) and the Industrial Emissions Directive.

The Water Directors of the EU Member States introduced several climate adaptation activities in the 2022-2024 Work Programme for the Common Implementation Strategy (CIS) for the Water Framework Directive and the Floods Directive. An ad hoc Task Group on Water Scarcity and Droughts was established, leading to technical discussions on how to improve water management in the changing climate, particularly addressing increasing droughts and water scarcity. The following CIS guidance and thematic documents support water quantity management:

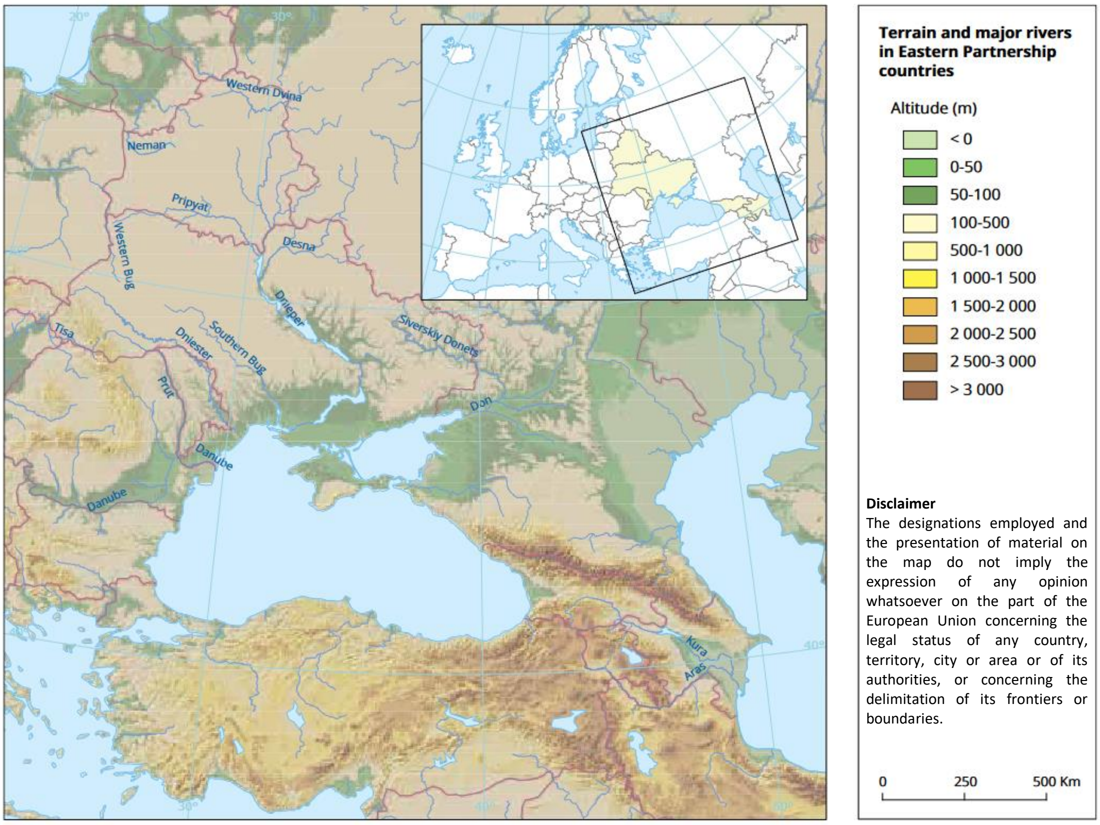
- 2024 Guidance on River Basin Management in a Changing Climate
- 2015 Guidance on Water Balances and the Guidance on Ecological Flows
- 2009 Guidance on River Basin Management in a Changing Climate.

However, water allocation planning strategies in Europe are very diverse and there is currently no specific tool harmonised at the scale of EU Member States dedicated to quantitative water management planning. Current water allocation regimes in EU Member States are largely shaped by historical preferences and usage patterns. They are therefore usually not well equipped to deal with the growing water needs and intensifying competition between the different water use sectors, or the impacts of climate change, especially water scarcity and/or shifts in societal preferences, such as increasing value placed on water-related ecological services.

1.2. The context of the Eastern Partnership countries

The Eastern Partnership (EaP) countries are located on terrains where freshwater ecosystems are highly diverse, featuring floodplains, rivers and lakes (Figure 1). Surface water and groundwater are strategic natural resources that supply 60 million people and are vital to sustain these countries' key economic sectors, such as agriculture, energy, and manufacturing industries. Renewable freshwater resources are unevenly distributed throughout the five Eastern Partnership (EaP) countries due to natural conditions. In 2017, Georgia (12,000 m3/capita) was regarded as a water-abundant country, whereas Armenia (3,000 m3/capita) possessed sufficient renewable water resources. The Republic of Moldova (1,800 m3/capita) and Azerbaijan (1,730 m3/capita) were prone to water scarcity over the period 2000-2017. Quantitative water management planning in the context of Eastern Partnership countries aims to ensure that water resources are fairly allocated and to secure sustainable water supplies for the community, agriculture, industry, and the environment for future generations.

Figure 1 Terrain and major rivers in Eastern Partnership countries



Reference data: ©ESRI

Source: Water availability, surface water quality and water use in the Eastern Partnership countries: An indicator-based assessment (EEA Report No 14/2020)

In 2014, Moldova, Georgia and Ukraine signed agreements with the EU and its Member States, marking the start of a gradual process of adjusting their national legislation to European environmental standards and principles. A significant number of existing national water laws are being updated to align with the EU water acquis, particularly the EU Water Framework Directive and its associated directives. Armenia and Azerbaijan also participate in the European Neighbourhood Policy.

The EaP countries have made significant progress in several areas of water policy reform. Since 2016, the European Union has assisted in the refinement or development of River Basin Management Plans for 11 pilot river basins. Regular multi-stakeholder National Policy Dialogues (NPDs) and peer-to-peer international exchanges have enabled the implementation of water sector reforms. Transboundary cooperation has been ongoing in the Kura and its sub-basins, including the Khrami-Debeda, Neman, Dniester/Nistru, Western Dvina/Daugava, and Danube River basins. The development of data management platforms in the six countries has led to increased transparency and access to water information. The EaP countries are working to align their water indicators with those set out by the EU and with best international practice. Furthermore, the ratification and implementation of Multilateral Environmental Agreements (MEAs) has progressed, and river basin management plans are coordinated in some transboundary basins.

The **strategies of Quantitative Water Management Planning in Eastern Partnership Countries** are described in **Appendix 1.**

1.3. The link with the Programme of Measures of River Basin Management Plans

In the frame of the programme EU4Environment Water and Data in Eastern Partnership countries, the implementation of River Basin Management Plans (RBMPs) must achieve the good qualitative and quantitative status of water bodies in Armenia, Azerbaijan, Georgia, Moldova and Ukraine. The preparation of a River Basin Management Plan in line with the WFD follows a formal process with different steps at large basin scale. An RBMP consists of several documents, among which the programme of measures identifies various actions to be implemented in the basin to restore deteriorated water bodies.

Among the measures to be included in the programme of measures of an RBMP, quantitative water management plans can be seen as a meta-measure to tackle quantitative issues in priority areas, simultaneously addressing socio-economic challenges and the preservation of biodiversity and natural resources. RBMPs include insufficient quantitative aspects, while the resources and scales of RBMP basins are too vast to deal in detail with allocation and quantitative tensions over water resources. Consequently, this guide has been designed to specify the methodology and approach to QMPs to provide operational guidance to decision-makers and water resource planners in the Eastern Partnership countries on how to strengthen quantitative water management planning at the local level. QMPs are thus a valuable extension of RBMPs to be applied in priority sub-basins or large groundwater tables that face quantitative challenges.

Figure 2 Integrated water resources management cycle (© EUWI + East project)

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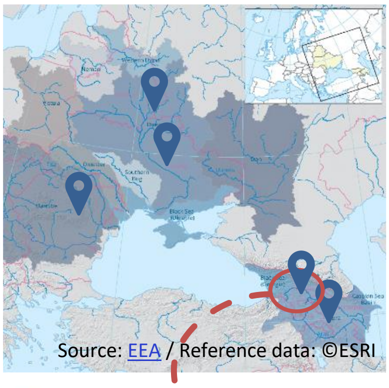
What is the link between Quantitative Water Management Plans (QMPs) and River Basin Management Plans (RBMPs)?

The implementation of RBMPs must achieve good qualitative and quantitative status of water bodies. Among the measures to be included in the programme of measures of a RBMP, QMPs are relevant as they address simultaneously socio-economic challenges and preservation of biodiversity and natural resources. However, scales of RBMP basins are too vast to deal in details with allocation and quantitative tension over water resources. As a result, QMPs are a good complement to RBMPs in targeted sub-basins that experience quantitative challenges over water resources.

River Basin Management Plan (RBMP)

Basin scale

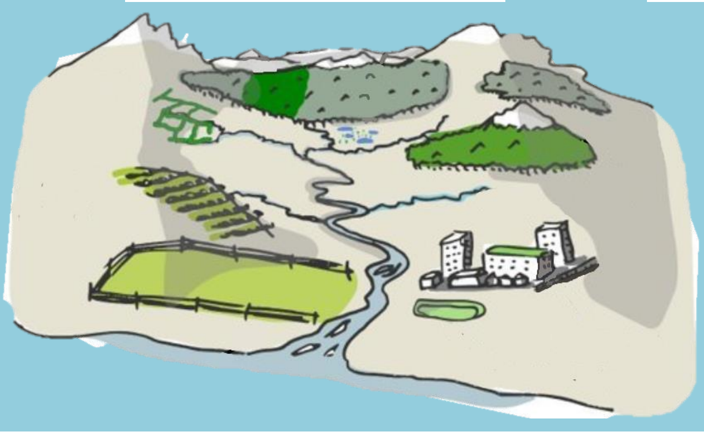


Sub-basin with quantitative challenges

Source: UNCCD / Reference data: EUWI+, 2021

Quantitative Water Management Plan (QMP)

Sub-basin scale + *Quantitative challenges*



Quantitative water management consists of measures and methods that mitigate the pressures from water abstraction on surface and groundwater, as well as on the surrounding natural habitats for reaching or maintaining their good status.

Quantitative water management planning develops a comprehensive and coordinated strategy, that unites all stakeholders in an area with the goal to achieve a sustainable, long-term balance between available resources, the demands of water users, and the needs of the environment. This takes into account the past and current situation, as well as anticipates developments due to external factors like climate change and adapted use and respective water resources allocation.

2. Aim and scope of the Guide

Water quantity

Water quantity is most commonly specified as the average volume of water (per year, month or other period) at a certain location. It may also be defined as an average, as a minimum volume, as a percentage of available supplies (a share of flow or the volume in storage), or by a particular rule on access (e.g. legal right or entitlement to abstract a certain volume in particular circumstances) (UNECE, 2021).

2.1. Objective

This guide aims to assist local stakeholders in the operational implementation of water allocation planning at the local level taking a participatory approach. It provides an adaptable, evolving basis for developing quantitative water management strategies and implementing water allocation plans at the sub-basin level. The guide answers the following questions: What is the territory? Why act in this area? Where should we act? What are the objectives? With whom should the action take place? What are the conditions for effective action? When should different actions be programmed?

The guide provides decision-makers and water resource planners in the Eastern Partnership countries with systematic guidance on how to improve quantitative water management planning.

The QMP guide will be equally useful for regulators and practitioners, water system managers, policy-makers, river basin administrations and major water users (agriculture, water-intensive industries, municipalities and water utilities, operators of other water infrastructure), international partners and local communities. The guide highlights the importance of implementing optimised water allocation and related measures to ensure sustainable water management on the territory. It emphasises the importance of sharing, discussing, adapting and validating the planning approach with the competent authorities in the field of water resources and environmental data management and with the national bodies responsible for developing the regulatory framework for quantitative water management.

The specific objectives of the guide are to:

- Provide local stakeholders with a detailed method for understanding water resources availability and needs in the basin/sub-basin.
- Ensure that planning and water management tools are consistent with the water management planning approach that is being developed at a larger scale (national, RBMP, etc).
- Support regulators and decision-makers to anticipate and adapt to climate change, giving priority to "no-regrets" solutions, i.e. solutions that are beneficial whatever the extent of climate change.
- Support regulators and decision-makers to develop a quantitative water management plan that reflects a shared political vision of the territory and that includes each type of user in the action plan.
- Distinguish between the long-term management of water scarcity and the drought risk management. The latter can be structured by monitoring river flow crisis management thresholds at the strategic river node and observing the time return between low-water crises.

2.2. Methodology

This report was developed in a step-by-step process, driven by the International Office for Water and steered by the partners of the EU4Environment – Water and Data consortium, involving regulators and practitioners in the water management sector in EaP countries. The main steps of the process were:

1. Analysis of the literature by OIEAU, including scientific publications, planning documents, evaluation reports and other sources to identify water allocation strategies and quantitative water management approaches.
2. Development of a draft version of the guide on quantitative water management planning largely based on the French example.
3. Presentation of a draft version of the Guide and consultation of the stakeholders of the water management and environment sector, regulators and practitioners from EaP countries during a workshop on 8 July 2024.
4. Integration of discussion and feedback from the workshop into the Guide.
5. Validation of a final version of the Guide.

2.3. French example of quantitative water management planning

The numerous ongoing initiatives in Europe aiming at improving the balance between available water resources and needs have resulted in the generation of an extensive **bibliography** comprising guides, feedback, and project descriptions.

The Quantitative Water Management Planning Guide is largely based on the French example of the local quantitative management plan (PTGE), which is a participative planning tool developed in a context of water scarcity in order to achieve a jointly constructed water resources balance across a homogenous hydrological or hydrogeological system. France was a pioneer in the development of its own quantitative water management plan in line with the WFD. This plan involves a commitment by all users of a territory (drinking water, agriculture, industries, navigation, energy, fisheries, recreational uses, etc.) to achieve, over time, a balance between needs and available resources while respecting the good functionality of aquatic ecosystems by anticipating and adapting to them. The aim is to mobilise local solutions that focus on synergies between socio-economic benefits and positive environmental externalities, with a view to the sustainable development of the territory. The document is generally used by public authorities to strengthen drought risk management procedures.

The French context of quantitative water management
[1] Water allocation system in Southern France
[2] The French policy approach to the management of water resources and aquatic biodiversity
[3] Water resources allocation in France
[4] Water distribution in the French regions
[5] Quantitative water management in times of climate change

Article L. 210-1 of the French Environmental Code emphasises that "*the protection of water, its promotion and the development of usable resources while respecting natural balances, are issues of general interest*". To ensure the protection of this heritage, public policy must maintain the proper functioning of the water cycle, ensuring the renewal of the resource and the satisfaction of the needs of the natural environment and humans. Quantitative water management consists in ensuring that abstraction from water resources is conducive to maintaining the good status of natural environments, groundwater and watercourses.

The notion of a quantitative water management planning approach as applied in this guide is defined as an approach based on a global, and a co-constructed strategy that leads to a commitment by all users in a localised territory to achieve a sustainable, long-term balance between needs and available resources while respecting ecosystems, and anticipating and adapting to climate change[1].

The quantitative water management planning approach inspired by the PTGE emphasises the following aspects:

- A participative process: This is a concerted territorial approach co-constructed by and for the stakeholders of the basin or sub-basin, who are committed to taking actions to optimise quantitative water management. A participatory process must find solutions that anticipate the growing difficulties surrounding water availability to share water resources evenly across regions and preserve ecosystems. To achieve this involves developing a concise base of knowledge and definitions, and sharing the findings and diagnosis between the various users, socio-professional categories or members of civil society; the aim is for everyone to be able to express their views and work towards the emergence of solutions best suited to each local context. One of the challenges of the quantitative water management planning approach is to bring together a wide range of players (agriculture, forestry, urban planning, energy, transport, tourism, biodiversity, health, etc.), in particular by integrating stakeholders involved in local land-use planning.
- A programme of actions: A QMP involves defining a programme of actions proposing solutions to achieve a balance between needs, resources and the sustainable functioning of aquatic environments, taking into account climate change at various time horizons. This document includes specific actions tailored to the territory, such as alternatives to water use and abstraction, sobriety of use, and better upstream resource management.
- Knowledge and foresight: To achieve these objectives, the quantitative water management planning approach must be able to rely on good knowledge of the quantitative aspects of the local territory. This is established through a background report and diagnosis of current and future needs and available resources, a water allocation plan, and a forward-looking analysis taking into account the impacts of climate change.
- Selection of a programme of actions: The economic and financial analysis should help to discriminate between the various proposed actions by supporting territorial dialogue and providing objective information on the sustainability and cost of each action. Financial analysis should help funders project the profitability of their investment, while economic analysis enables them to select those programmes with the greatest positive impact on the community as a whole. The selection process should be made in consultation with local stakeholders.

2.4. Steps of the quantitative water management planning approach

The development of a quantitative water management plan aims to address a quantitative management issue in a defined area, either currently or in anticipation of future deadlines, through the implementation

[1] Based on the definition of territorial project for water management, French government instruction, May 2019.

of a programme of actions to achieve a long-term balance between needs and available resources, while respecting the proper functioning of aquatic ecosystems.

In this guide, the term "quantitative water management planning" refers to the work process, while the final deliverable is referred to as the programme of action.

Thus, the quantitative water management planning approach is a series of steps that allow progress from understanding the water management imbalance in the area to implementing of a programme of action.

Guidance on quantitative water management planning

[9] Handbook on water allocation in a transboundary context

[10] Basin water allocation planning, principles, procedures and approaches for basin allocation planning

[11] Implementation of water allocation in the EU

[12] Sharing water, the role of robust water-sharing arrangements in integrated water resources management

[13] Water resources allocation, sharing risks and opportunities

[14] Water allocation in 2050: tools and examples

[15] Guidelines for the preparation of the Drought Management Plans, development and implementation in the context of the EU Water Framework Directive

[16] Guidance document on the application of water balances for supporting the implementation of the WFD

Figure 3 The five steps of the quantitative water management planning approach (OIEAU, 2024)

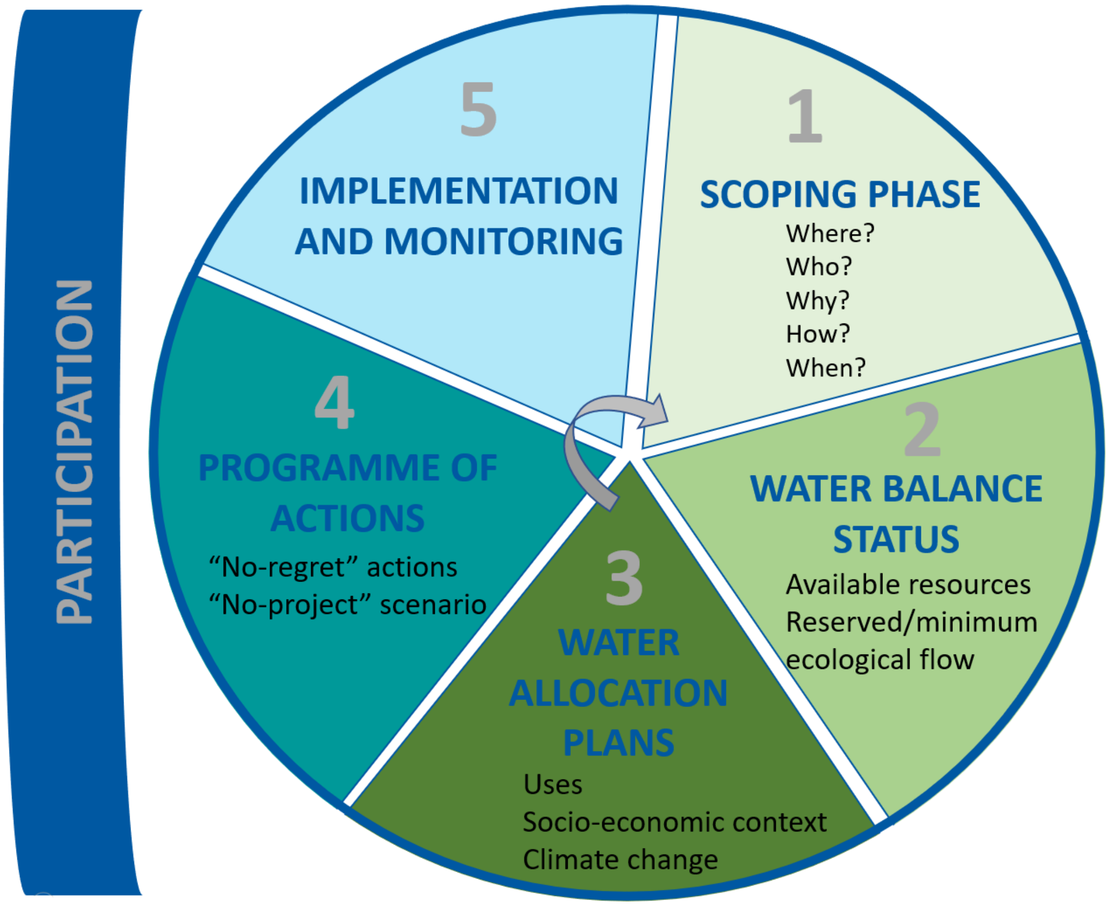


Figure 4 Quantitative water management plan development road map,
With objectives + stakeholder involvement + participation + adoption process

	STEP1 SCOPING PHASE	STEP 2 WATER BALANCE STATUS	STEP 3 WATER ALLOCATION PLANS	STEP 4 PROGRAMME OF ACTION	STEP 5 IMPLEMENTATION AND MONITORING
Objectives	Set: • Perimeter • Timetable • Project governance • Data needs	Provide a detailed overview of freshwater resources availability in a context of climate change	Set water allocation volumes by sector of activity and by geographical area, and crisis procedure	Develop a programme of action to sustainably manage water resources	Implement the programme of action and monitor and evaluate the actions in order to periodically adapt the programme
Roles of stakeholders *Who does what?* • Technical support • Financing • Implementation	**Technical support**: producers of data **Financing**: Local authorities **Implementation**: Steering committee	**Technical support**: Experts, in particular hydrologists **Financing**: Local authorities **Implementation**: Steering committee	**Technical support**: Experts **Financing**: Local authorities **Implementation**: Steering committee	**Technical support**: Experts **Financing**: Local authorities **Implementation**: Steering committee	**Technical support**: Experts **Financing**: Local authorities **Implementation**: Steering committee
Participation	**Consultation & information**	**Information**	**Dialogue**	**Co-construction**	**Consultation & information**
Stakeholder involvement	Workshop/ meeting with stakeholders *Presentation of the approach and involvement expected of participants*	Workshop/meeting with stakeholders *Clear and concise presentation of scientific and technical results*	Workshop/meeting with stakeholders *Consultation with a representative panel to select: priority management zones and water allocation targets*	Working session with stakeholders *Selection and ranking of the actions with a representative panel.* *Final descision made by the steering committee*	Working session with stakeholders *Presentation and validation of the programme of actions.* *Information to all citizens.*
Adoption process	Stakeholder commitment	Ownership of quantitative issues	Acceptance of water allocation plans by ALL stakeholders	Approval and choice of the actions by ALL stakeholders	Awareness raising of citizens

3. Guide

STEP 1: Scoping phase

The objective of the scoping phase is to establish the main contextual and methodological elements. The scope of the quantitative water management planning approach must be defined during this phase, including the organisational structure, the system of governance, the resources available and the timetable. Furthermore, it is necessary to outline the territory and characterise its specificities.

Prerequisites of Quantitative Water Management Planning

The development of a quantitative water management plan is the most upstream stage and marks the beginning of the implementation and monitoring process. It presupposes the presence of the following three elements:

- A quantitative water management problem (e.g. recurrent summer crises jeopardising certain uses), requiring immediate action or in anticipation of future deadlines (legal deadlines, climate change, etc.). This issue is inextricably linked to the challenges of water quality and environmental functionality. It should be remembered that quantitative water management planning must take into account the need to preserve water quality (drinking and environmental water).
- A territory that is both the place where these issues arise and the place where they can be tackled.
- Political convergence between institutions (territorial project owner, state, water committees, water user associations, etc.) to initiate a process of ownership.

Is there an existing quantitative water management plan in my territory?

⇨ **NO**: Refer to this guide to implement a programme of action.

⇨ **YES**: The quantitative water management planning approach is an iterative process. The programme of action should be revised after a defined period (e.g. 2-3 years in France).

#1 Define the project organisation: governance, financing, timetable

Governance strategies

[17] National drought plan in Azerbaijan, chapter 4: Organisations and assignment of responsibilities
[18] National drought plan of the Republic of Moldova, chapter 4.4: Governance and coordination
[19] Water allocation and governance in multi-stakeholder environments: insights from Axios Delta, Greece
[20] OECD Principles on Water Governance
[21] Toolkit for Water Policies and Governance: Converging Towards the OECD Council Recommendation on Water. 6 Ensuring good water governance
[22] A Handbook of what works: Solutions for the local implementation of OECD Principles on Wate Governance

The establishment of governance is essential to steer the work process and lead to the adoption and implementation of an action programme. In particular, it is essential to ensure that all players are fully committed to the approach and that their roles are clearly defined at each stage:

- The local authorities are responsible for enforcing and applying the law.
- Users and their representatives are tasked with highlighting the socio-economic issues associated with each type of water use.
- Experts, particularly hydrologists, are responsible for producing and projecting quantitative balances.
- The animation team is responsible for giving a voice to the different categories of users, collecting their opinions, and highlighting the specific challenges of the different sectors of activity in relation to the satisfaction of water demand in each sector.

It is up to the local authorities (state, municipalities, etc.) to define or create the appropriate governance framework, collectively defined around issues and objectives that are geographically consistent with the resources concerned, and supported by a Steering Committee. This framework should ensure that all uses are considered (drinking water, agriculture, industry, navigation, energy, fishing, recreation, etc.) and ensure a balanced representation of society as a whole in the development of the project and the resulting action plans. The national authorities can ask the Steering Committee to give its opinion on local water-related projects and decisions.

Who? The composition of the Steering Committee should include government departments, local authorities, public and private economic actors, relevant operators and representatives of the various water users, with a balanced representation allowing each category to have its point of view heard and thus to participate actively in the work of developing and then selecting the final scenario. The steering committee should be set up using existing local bodies.

How? The Steering Committee should be in charge of monitoring the quantitative resource management process, and should define the conditions for:

- Monitoring the minimum annual frequency.
- Establishing a monitoring committee to ensure more regular, operational monitoring.
- Creating a dashboard with indicators to monitor the implementation of actions.

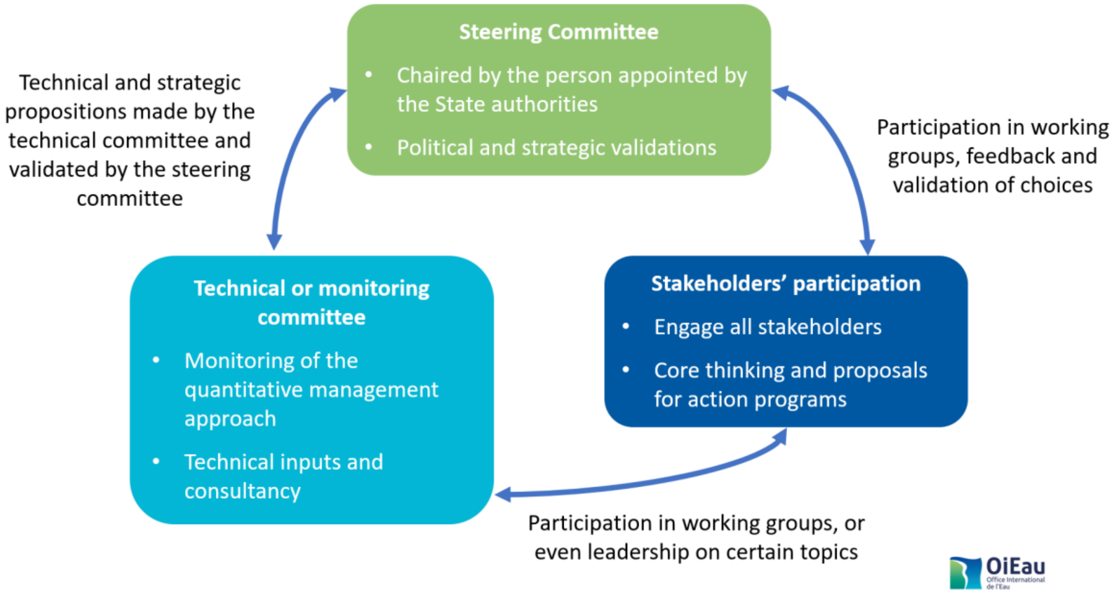
Two bodies should be set up, one plenary, the other more restricted and therefore more operational on a day-to-day basis.

The **Steering Committee** is chaired by an individual appointed by the public authorities and is a forum for discussion, debate and negotiation. The aim of this body is to bring to the fore:

- Any difficulties or conflicts that need to be resolved in a concerted manner with all stakeholders in the area, while respecting the regulations;
- Any type of local solution for any type of use (agricultural, industrial, domestic, hydroelectric, leisure, etc.).

The **Technical or Monitoring Committee** ensures regular monitoring of the development of water abstraction licences or water use contracts, and the implementation of the action programme in direct contact with the members of the technical team of the management structure and the consulting firms in charge of collecting data and drawing up proposals. This committee assists the Steering Committee on specific issues (e.g.: technical or strategic choices, synthesis of studies, expert advice, etc.).

Figure 5 Bodies in charge of the development of a quantitative water management planning approach



The creation of a roadmap could assist in defining the objectives and principles of the approach and describing the governance structure in place. The roadmap should establish the new studies to be launched and set a timetable. It should also set deadlines for validating the work process, delivering studies and implementing an action programme. The timetable could be divided into three phases: (1) set-up/scoping phase (6-18 months), (2) development (18-36 months), and (3) implementation (ongoing, with update periods every 1-2 years).

As financial leverage is essential to support the work process and to bring the programme of action to fruition, it is recommended that, from the outset of the project, the project leader should:

- Assess the cost of implementing the approach (coordination, additional studies, etc.) up to the adoption of the quantitative water management plan.
- Identify funding opportunities and start approaching the feasibility and funding conditions for certain actions that could potentially be included in the programme of action.

#2 Engage stakeholder participation from the start

A **typology of stakeholders** is available in Appendix 2 and describes the natural or legal persons who have an influence on the quantities of water available or used, and who are impacted by the availability of the resource. The identification and description of stakeholders are intended to provide a comprehensive characterisation of all parties involved in quantitative water management.

Stakeholder mapping

Stakeholder mapping is a valuable tool for identifying stakeholders' interests, potential risks and misunderstandings, mechanisms to positively influence other stakeholders, key people to be informed about the project during the execution phase and negative stakeholders and their adverse effects on the project. It provides a visual representation and enables the development of a categorised list of the members of the stakeholder community.

[65] Construction Stakeholder Management. Chapter 7: Mapping Stakeholders (2009).

[66] Governance Tool for sustainable water resources allocation in the Mediterranean through stakeholder collaboration. Stakeholder mapping and analysis (2021).

The participatory approach is essential to improve the sharing and complementarity of knowledge and skills, promote the acceptability of projects, and facilitate the implementation of actions resulting from the decision through their adoption by citizens. Furthermore, the participatory approach facilitates improved relations between citizens, and in some cases mitigates or even resolves conflicts of use. Citizens are empowered thanks to greater awareness, access to information on water-related issues, and a more transparent decision-making process

A specific feature of this guide is that it encourages implementing a participatory approach at every stage of the quantitative management planning process.

Why? The participation of stakeholders, and sometimes citizens, is an essential component of the quantitative management of water resources. This participation should foster support for the action programme and further implementing actions, and improve societal acceptability.

How? The Steering Committee should be in charge of monitoring the quantitative resource management process and should define the conditions for monitoring.

Table 2 Participatory strategy, source: PTGE, 2023

Information	Consultation	Dialogue	Co-construction
The project leader decides to carry out a study on a given subject, writes the specifications, announces to the steering committee that they are launching a study on this subject, and informs them of the timetable.	The project leader presents their intention to carry out a study to the steering committee and submits a draft specification for approval, inviting criticism and proposals.	The project leader leads a steering committee discussion on the benefits of carrying out the study and proposes a working group to draw up the specifications.	The project leader sets up a working group led by a facilitator, who works with a team of experts to consider the various studies to be carried out and proposes a framework for these studies to the Steering Committee.

Resources on stakeholder participation

[23] Public participation: contributing to better water management. Experiences from eight case studies across Europe
[24] Designing participation processes for water management and beyond
[25] *European Commission, Directorate-General for Environment, Public participation about the water framework directive.* Guidance Document No 8
[26] Guidance document: public participation in River Basin Management Planning, *European Union Water Initiative Plus for Eastern Partnership Countries Programme*
[27] *Guidance document for establishing and updating river basin management plans in Armenia.* Chapter 9: Public participation and consultation

Figure 6 Public and stakeholder consultations were organised by the EUWI+ programme to collect feedback on River Basin Management Plans for pilot basins, including the programme of measures (Armenia, Azerbaijan, Georgia, Moldova, Ukraine)

Box 1 The value of a participatory approach in the ASPIRED USAID project in Armenia

ASPIRED USAID Project – Armenia (2015-2021)

The ASPIRED project successfully implemented 17 pilot projects in the Ararat Valley, showcasing the application of water and energy-saving solutions to communities and fish farmers. Eleven communities in the Ararat and Armavir regions were involved in the implementation of drinking and irrigation water projects. The projects will save over 13 million m^3 of groundwater and 1380 megawatt-hours of energy annually, representing financial savings of nearly USD 125,000.

In the context of the ASPIRE project, USAID provided support to the government to form a cross-sectoral working group representing agricultural operations, fish farms, the national nuclear plant, and water regulatory authorities within the Ministries of the Environment and Territorial Administration and Infrastructure. The group's input has led to the government adopting the "Programme of Measures for Effective Management of Water Resources," which defines groundwater management targets in the Ararat Valley. (Source: USAID)

#3 Define the territory and timescale

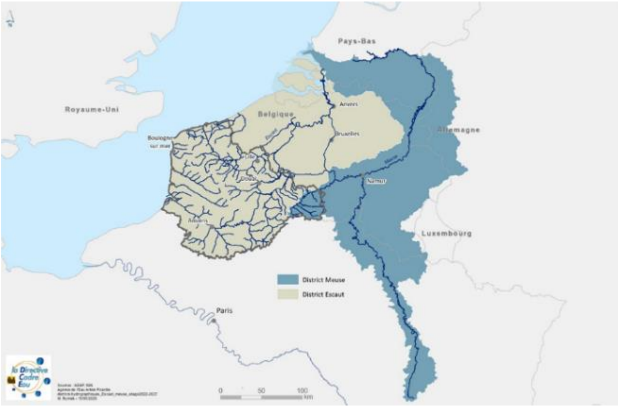
Outline the territory

In general, the **spatial perimeter is a sub-basin that is characterised by an imbalance between available resources and water abstraction**, whether known or anticipated. The perimeter can also be defined based on the water table's perimeter, in order to prevent its interannual decline. The groundwater recharge system must then be characterised to establish the link with its recharge from surface water. In both cases, the approach, based on clear water accountability is well adapted for transboundary hydrographic units.

It is recommended that a **map be created to identify the sub-basins with the greatest resource-demand imbalances**, as part of the River Basin Management Plan (RBMP).

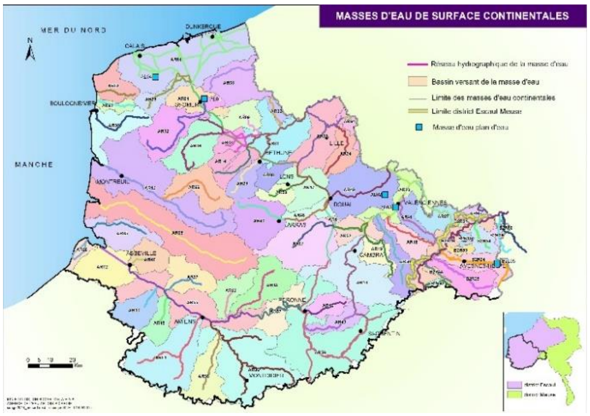
Box 2 Example of spatial scales in Artois-Picardie River Basin (France)
Water Agency Artois-Picardie

River basin districts: Meuse and Escaut cross-country districts



River basin: Artois-Picardie

Surface water bodies of the Artois-Picardie basin



Groundwater bodies of the Artois-Picardie basin

Establish the temporal framework: timescale and horizons

a. **Establish the timescale**: It is crucial to have a detailed knowledge of water resources and needs at **annual or monthly frequencies**. This requires significant effort to collect, structure and analyse existing data, as well as additional investigation and fieldwork in the case of incomplete data.

- **Daily data are useful for hydrological calculations**.
- **Why should the temporal scale be at least seasonal or monthly?** An annual approach may reveal a surplus situation while masking a seasonal imbalance between available resources and demand from different sectors.
- **Dry and wet periods:** The availability of water resources and the needs of various uses, particularly in agriculture, are highly seasonal. Monthly data should be aggregated according to dry and wet periods in order to gain a comprehensive overview of the seasonal availability of resources and the demand of different sectors.

b. **Establish the time horizons**:

- **Short-term horizons** (typically 10 to 20 years) are frequently employed to evaluate short-term impacts and risks for water resources. These horizons can be useful for operational planning and prompt decision-making.
- **Medium-term horizons** (typically spanning 30 to 50 years) facilitate the incorporation of progressive, longer-term changes in water resources. They are employed to assess future water requirements, infrastructure adaptation, and medium-term management policies.
- **Long-term horizons** (typically spanning 50 to 100 years or more) are valuable for assessing long-term structural shifts, such as the impact of climate change on water resources, ecosystem adaptation, strategic planning and long-term investments.

The choice of time horizons will depend on the specific context and the objectives of the quantitative water management plan. It is crucial to consider the timeframes relevant to management decisions, while accounting for the uncertainties associated with longer-term projections.

It is also important to note that quantitative water resource management is a continuous and iterative process. As new information and data become available, it may be necessary to reassess and adjust time horizons.

#4 Characterise the legislative context

This characterisation assesses how the law identifies the individuals in charge and how the responsibilities are distributed for quantitative water resource management amongst these individuals.

In particular, it is necessary to determine how the following administrative responsibilities and missions are distributed:

- Monitoring the river flow
- Monitoring the qualitative status of watercourses
- Monitoring the quantitative status of groundwater
- Monitoring the qualitative status of groundwater bodies
- Monitoring water withdrawals
- Issue of crisis orders
- Calculation of volumes available for abstraction
- Administration of abstraction authorisations

It should also be determined how the following competencies are distributed:

- Abstraction, treatment, transport, and distribution of drinking water
- Collection, transport, and treatment of wastewater
- Abstraction, treatment, transport, and distribution of raw water for agricultural use
- Development strategies for water resource management infrastructures, in particular dams, reservoirs and canals
- Financing infrastructures
- Technical support for users by sector of activity

#5 Assess data needs and available information

List the required data

a. **Water resources data**

- River flows: GIS for rivers and catchment areas, historical (month by month) and real-time data on river flows, including seasonal variations.

- Groundwater levels: data on groundwater levels to assess groundwater availability.
- Precipitation: data on historical and current precipitation to assess water inputs to the watershed.
- Evapotranspiration: data on plant evaporation and transpiration to assess water losses.
- Water quality: data on physical, chemical and biological water quality to assess pollution and the availability of quality water.

b. Water use data

- Domestic use: list and demography of towns, data on drinking water consumption, household water requirements and drinking water supply systems.
- Agricultural use: data on irrigation water consumption, planting schedule, crops grown, irrigation methods used and water use efficiency, soil texture and useful capacity.
- Industrial use: data on industrial water requirements, production processes and industrial water discharges, and main uses of water in industrial processes.
- Environmental use: data on the water requirements of ecosystems, aquatic habitats and water-dependent species.

c. Water infrastructure data

- Reservoirs and dams: data on storage capacity, height data, stored water volumes and reservoir and dam management rules.
- Water distribution networks: map and data on pipe networks, water losses, distribution capacities and water demand inside and outside the areas supplied.

d. Demographic and socio-economic data

- Population: data on resident population and population growth estimates to assess future and current (if not measured) anticipated water demand.
- Economic activities: data on economic sectors (number of workers, profits, fees, etc.), such as agriculture, industry and tourism, to assess water requirements related to these activities.

e. Climate data and climate change

- Historical climate data: data on temperatures, precipitation, reference evapotranspiration, extreme events, etc.
- Climate projections: data on future climate change scenarios, including temperatures, reference evapotranspiration, precipitation and potential impacts on water resources.

f. The territory

- Topography
- Geology and hydrogeology
- Land use

An inventory of the data and methods available and used could be drawn up and formalised in a summary table. For each data item listed above, the following aspects will be specified:

- Data availability
- Source or assessment method used
- Spatial resolution
- Temporal resolution
- Comments on the reliability of the data
- Additional requirements

Establish a common starting point

The first step in characterising basins and sub-basins is to utilise publicly available data, which can be accessed online.

Refer to **Appendix 3 – Global open data sources** for a list of some of the data sources available to the general public. The data sources listed in Appendix 3 have been assigned a recommendation level based on the following criteria:

- Resolution of spatial data
- Length of time ranges of climatological data
- Geographical coverage

The proposed method consists of combining homogeneous data available worldwide with better quality data (better spatial resolution, more relevant typologies, better-mastered data sources and production methods) produced at national or sub-national levels.

Identify and characterise local data sources

It is necessary to characterise the existing monitoring networks by describing the data produced, to use the data to make assessments, to operate forecasting tools and, ultimately to contribute to the choice of policies and decisions related to water management.

An inventory should describe the monitoring networks, the actors involved in data production, the method used to produce the data and the sustainability of the data production systems. The data produced should be characterised (type, accuracy, frequency, reliability).

Finally, all the data should be summarised in an easily comprehensible submission in order to share the state of play with each actor. This submission will be ratified by the Steering Committee or the Technical Committee.

STEP 2: Water resource status

The initial state of play of water resources describes the territory and its evolution, in terms of freshwater resources, ecological flows and aquatic environments. It provides an overview of water availability in the area and a future-oriented section on the evolution of water resources subject to climate change.

Glossary

Freshwater resources: Total volume of water available in an area, resulting from internal flow (water from precipitation minus evapotranspiration in an area) as well as external inflow (water inflow from neighbouring areas).

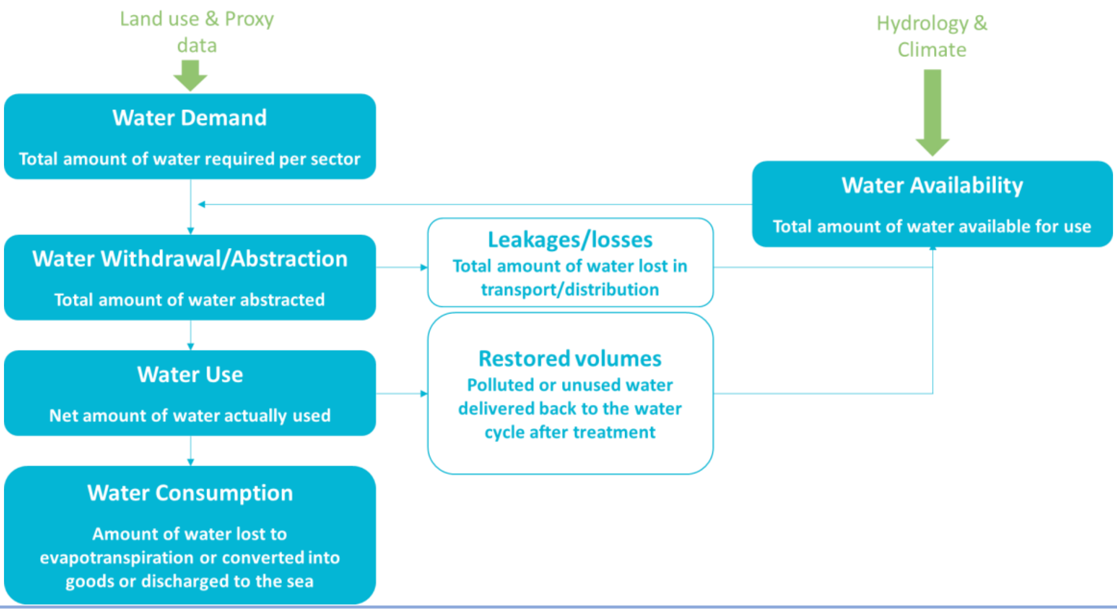
Water withdrawal/abstraction (observed or statistical): The process of withdrawing water from a source. For statistical purposes in the European Union (EU), this is the groundwater and surface water abstracted for domestic, industrial (including energy production) or agricultural use. It may be returned to the environment and its water bodies (although often as wastewater with impaired quality).

Water use: Water used by end users (e.g. households, services, agriculture, industry) within an area for a specific purpose such as domestic use, irrigation or industrial processing, and not returned to the environment.

Restored volume: A quantity of water withdrawn is not necessarily consumed in its entirety, but may be returned to the natural system in liquid form, where it continues to participate in the hydrological cycle. For example, water pumped from a drinking water supply plant may be returned to the natural environment a little further downstream via the effluent of a wastewater treatment plant. In this case, the location of the abstraction and the return is reported to determine whether any part of the river is locally affected by this abstraction.

Source: Eurostat

Figure 7 Water volumes (OIEAU, 2024)



#6 Characterise freshwater resources in the context of climate change

Delineate geographical units for water management

Methodology on identification and delineation of water bodies[2]

[28] Guidance No.2 - *Identification of Water Bodies*
This guidance document provides both definitions of, and practical guidelines for identifying WFD water body types, considering groundwater and surface water bodies.

[29] Guidance document on the identification, delineation and characterisation of surface water bodies, *European Union Initiative Plus for the Eastern Partnership Countries programme*
[30] Guidance document on the identification, delineation and characterisation of groundwater bodies, *European Union Initiative Plus for the Eastern Partnership Countries programme*

[31] *Development and demonstration of a structured hydrological feature coding system for Europe*
Proposition of coding system inspired by the work of Otto Pfafstette covering Europe to the Urals and including Turkey
[32] *Catchment Characterisation and Modelling (CCM)*

The delineation of geographical water management units must satisfy several constraints:

- They must be consistent with the spatial functioning of water resources.
- They must not overlap or consist of surface water or groundwater elements that are not contiguous.
- The sum of the geographical water management units must cover the whole territory.
- The perimeters must not be too large to ensure a good homogeneity of the issues, nor too small to ensure that the issues are sufficient to implement the means of action.

Given the constraints identified and the need to establish consistency between the geographical water management units, this stage is part of a process carried out at the RBMP development scale.

The definition of geographical water management units is most often based on the division of a territory into river basins and sub-basins. However, it should be noted that several aquifers may be interconnected.

Catchment areas are defined using digital terrain models. This expert work requires technical decisions and settings to be made. Several projects on a global or continental scale propose complete data sets including river courses, an inventory of the nodes of the hydrographic network and the delineation of catchment areas. On a continental scale, the Catchment Characterisation and Modelling (CCM) project provides a complete cartographic dataset (watercourses, nodes, sub-catchments). Each geographical unit is associated with a code according to the coding system proposed by Pfafstetter.

[2] The **Water Framework Directive (WFD) 2000/60/EC of 23 October 2000** has set up spatial units for implementing the quantitative management planning. The totality of waters covered by the Water Framework Directive (WFD) is attributed to geographical or administrative units, in particular the river basin, the river basin district, and the “water body”. The unit for assessing water status, based on the division of aquatic environments into homogeneous units in terms of ecological functioning and pressures caused by human activities. The water body must be a coherent sub-unit of the river basin to which the environmental objectives of the directive are to be applied. Using the term "water body" in any other context could lead to confusion.

a. **Delineate surface water management sectors**:
  - Category: Water management sectors must not be split between different water categories (rivers, lakes, transitional waters and coastal waters).
  - Typology: A surface water management sector must be of a specific type since one purpose of characterising surface water sectors is to differentiate them into types.
  - Significant physical features: Physical features (geographical or hydromorphological) that are likely to be significant should be used to identify the water management sector.
  - Heavily modified surface water resources and artificial water resources must be identified during the characterisation of water management sectors.
  - Ecological and chemical status should be accurately described.
  - Pressures, impacts and uses should be considered.
  - Protected areas may be considered.

b. **Delineate groundwater management sectors**:
  - Identification of all relevant aquifers:
  - Check if more than 10m³/day groundwater could be abstracted.
  - Check whether surface waters or terrestrial ecosystems (wetlands) are connected to the groundwater within the aquifer and could be damaged if the groundwater quantity (levels or flow direction) or groundwater chemistry in the aquifer changes.
  - Separate high-productive aquifers from low-productive aquifers.
  - Delineation of groundwater management sectors – horizontal dimensions:
    - Start delineation along hydrogeological boundaries.
    - Consider groundwater flow divides or river catchments and geological boundaries.
    - Consider variations of human pressures on groundwater.
    - A coastline can be a boundary, as long as the groundwater beyond the coastline is not an important resource.
    - Consider existing boundaries of hydrographical entities that are already subject to a local management plan.
    - Identify groundwater management sectors so that there is only minor groundwater flow from one GWB to another.
  - Delineation of groundwater management sectors – horizontal dimensions:
    - Delineate the groundwater management sector in three dimensions.

Guidance No. 1: Characterisation of geographical units and identification of strategical river node

- Characterisation: geology, climatology, occurrences of droughts and crisis management, land uses, water abstraction.
- Identification of sub-basins (or units of quantitative water management) and strategic river nodes.
- River node calculation (abstractions/consumptions, hydrology, needs of aquatic ecosystem, monthly flow objectives).
- Selection of 2 or 3 strategic points to be inserted in the quantitative management plan and become legal requirements.

Characterise natural freshwater resources

The water resources available in a river vary in time and space and depend on the groundwater connected to the river. It is essential to determine the volume of resources available in the river and in the aquifers, and the relationship between these two resources. These calculations can be carried out for the whole basin or for individual sub-basins. This phase consists of three stages:

- **Analysis of rainfall and runoff volumes**: A simple statistical approach can be used to study precipitation (volumes of falling water) and runoff volumes over the year or seasons (i.e., dry and wet seasons), as well as flow values at very low water levels. This approach can be applied at different points in the sub-basin, based on data from gauging stations and spatialised precipitation data.
- **Assessing the contribution of the aquifer**: To understand why certain sectors are subject to more intense low-water periods than others, it is useful to describe the hydrogeological functioning of the catchment and its sub-basins, by calculating the time during which the aquifers are able to support the low-water levels of the rivers connected to them.
- **Hydrological modelling of the basin and/or sub-basins (optional stage)**: In certain situations (major issues in the area), it may be necessary to carry out modelling to refine the knowledge of the hydrological and hydrogeological functioning of the basin. For example, hydrological modelling can be used to simulate the flow of a river based on climate data and work on a finer time scale (monthly), taking into account the variability of rainfall events. This makes it possible, for example, to approximate the natural flow by simulating the evolution of the stream flow as a function of time.

Analysis of rainfall and runoff volumes

Methods for characterising rainfall and runoff volumes are described in detail in Appendix 4. The aim is to provide indicators of water volume and flow at different points in the catchment and during different seasons, to understand the hydrological regime. In particular, it is important to describe the situation during periods of low water, based on volumes of runoff over different durations, return frequencies and duration of rainfall.

Source: [67] Minimum Ecological Flow and quantitative water resource management (FR)
[68] Low water flows, OFB (FR)

Assessment of the contribution of the aquifer

Methods for assessing the contribution of the aquifer to the system dynamics are detailed in Appendix 5.
This approach requires making an estimate of the time it takes for aquifers to discharge to support the watercourse(s), particularly during low-flow periods. The general idea is therefore to determine the number of days that an aquifer will support the base flow of a river, even without the addition of meteoric water (i.e. water from atmospheric precipitation that has not yet reached the earth's surface).

Source: [67] Minimum Ecological Flow and quantitative water resource management (FR)

Hydrological modelling

Methods for modelling the hydrosystem are described in detail in Appendix 6.

This modelling estimates the maximum volume that can be abstracted while respecting characteristic flow thresholds. Taking into account the complexity of a hydrosystem is only possible with a numerical model, either spatialised or global (the choice depends on the objectives of the model).

Source: [69] Contribution to the characterisation of interactions between groundwater, surface water and associated ecosystems in relation to the WFD, BRGM (FR)

Box 3: A new operational and interactive method for assessing water resources
Azerbaïdjan, (source : Makhmudov R., Aliyev V., Teymurov M., Gafarov E., 2023)

A new **method for calculating water balance and water resources** was developed in Azerbaijan and applied to 113 river basins. The comparison between the current data and the data calculated using this new method showed a flow error of 10% for 92 rivers and 10-15% for 21 rivers.
This new method includes the following:

- A study of complex flow mechanisms considering the soil-water-air environment (SWA) environment as a single mechanism.
- The quantitative expression of the impact of each factor on water resources, separately and together.
- Elimination of spatio-temporal restrictions and dependence on observational data.
- Studies carried out in three stages (past, present, future), allowing rapid and appropriate responses to any changes and multi-scenario forecasting.
- In all river basins with different physical-geographical conditions, it is possible to estimate the total discharge both separately and as the sum of surface discharge and base flow.

Guidance No. 2: Monitoring water quantity

- Upgrading meteorological stations
- Upgrading hydrological stations
- Upgrading groundwater monitoring stations

Produce trend scenarios for each freshwater resource in the context of climate change

[33] River basin management in a changing climate. Guidance document No 24.
[34] Resource guide for advanced learning on predicting and projecting climate change
[35] Projections of future total renewable water resources by country for different climate change scenarios available
[36] Climate change and Europe's water resources
[37] Climate Change adaptation and integrated water resources management
[38] Modelling climate change impact on water resources of the Upper Indus Basin
[39] Multi-model ensemble climate change projection for Kunduz River Basin, Afghanistan under Representative Concentration Pathways

Assessing the impacts of climate change requires the use of climate projections. Since the Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), the Representative Concentration Pathways (RCPs) have been replaced by Shared Socio-economic Pathways (SSPs).

Figure 8 Global warming trajectories according to the five SSPx-y scenarios used in the IPCC Summary for Decision Makers (source: AR6 IPCC)

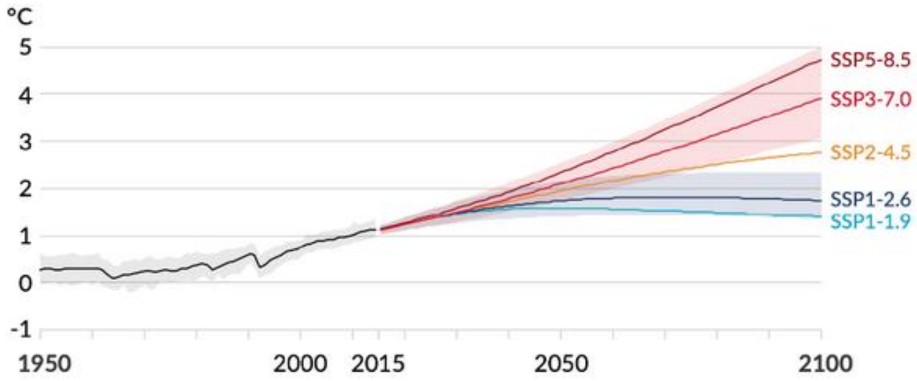
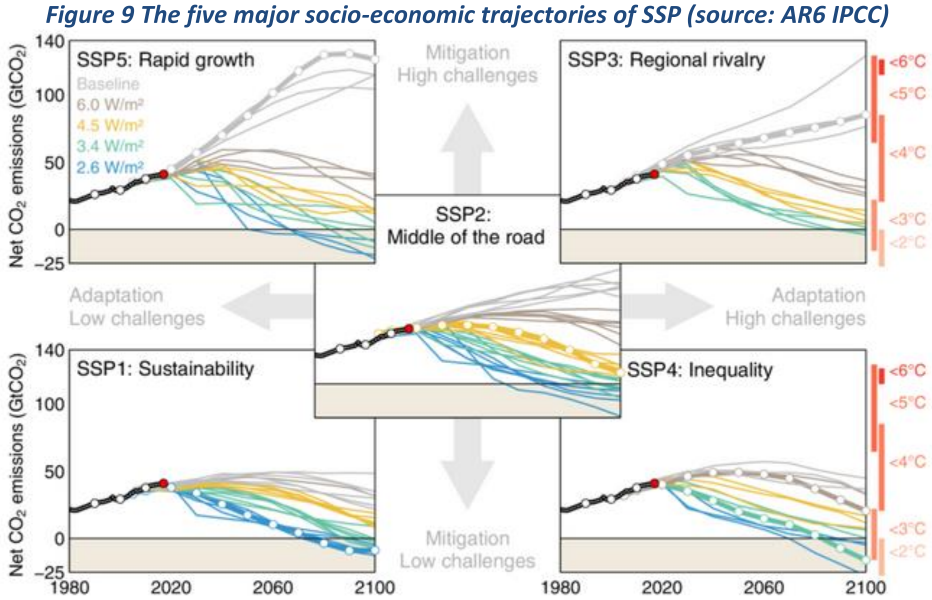


Figure 9 The five major socio-economic trajectories of SSP (source: AR6 IPCC)



Climate assessment for water resources

Methods to develop a climate assessment for water resources are detailed in Appendix 7.

Source: [70] A methodological approach to territorial climate diagnosis under the "water resource" dimension (2021) (FR)

#7 Assess the minimum ecological flow

Estimating the minimum ecological flow makes it possible to determine the threshold above which the proper functioning of the aquatic environment is threatened. The needs of the natural environment must be taken into account when estimating allocable flows, as they may limit the amount of water available for use. Knowing and respecting ecological minimum flows in a river basin allows for better management of low-flow periods, especially on sensitive tributaries. The allocation of water resources between the natural environment and uses must be rational. Water abstraction must be based on both available resources and the flow to be left in the river.

- Evaluate existing methods for assessing the minimum ecological flows, including regulations

- Integrate minimum ecological flow values into existing warning systems to justify restrictions on use
- Organise a campaign to raise user awareness of the importance of maintaining these flows for aquatic life

Methods for estimating minimum ecological flows

Several methods have been developed and can be used to define minimum ecological flows. These methods differ mainly in terms of integration of ecological aspects, scale, complexity and data requirements.

The assessment of minimum ecological flows is an expert task that can be carried out using one of three methods:

- The hydrological method analyses different flow regimes (e.g. the minimum monthly flow observed once every 5 years can be chosen as the environmental flow).
- The hydraulic method focuses on stream morphology, velocities and flow regimes.
- The habitat method focuses on the living conditions of a panel of species representative of the area under consideration.

These 3 methods for estimating minimum ecological flows are described in detail in **Appendix 8**.

The choice of the most appropriate method will depend on the resources available and the severity of the pressures. Purely hydrological methods may be a reasonable approach for the whole river basin; a more detailed approach will be required for specific measures likely to have socio-economic impacts.

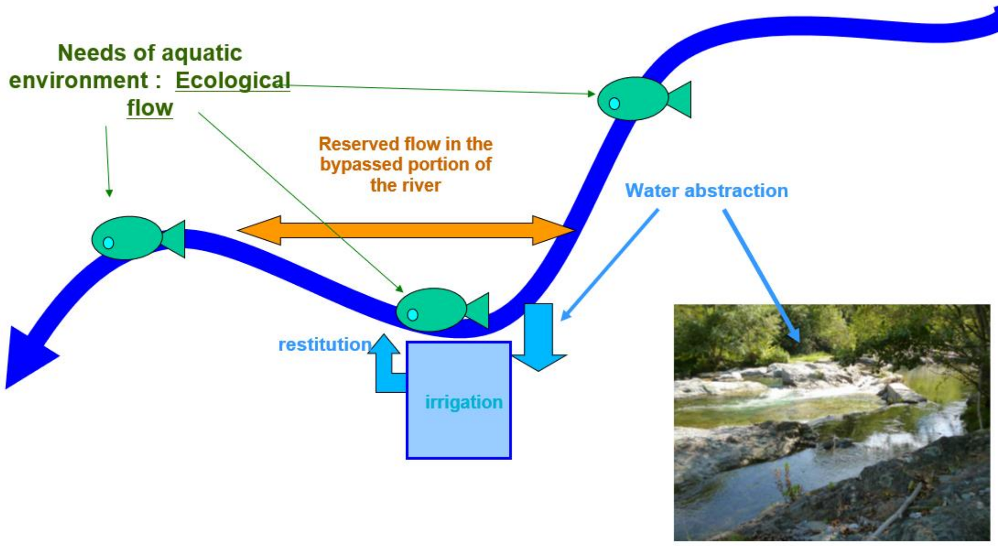
All or part of the rules for calculating environmental flows may be described in national legislation or at the RBMP level. The choice of calculation rules for setting thresholds must be based on expert advice and be the subject of a political compromise where environmental and human activity issues may conflict.

[40] Flow, the essentials of ecological flows

[41] Ecological flows: concepts and methods

Minimum ecological flow is defined as the percentage of a river's mean annual flow, or base flow, that must be allocated to freshwater-dependent ecosystems to maintain them in good ecological condition. The minimum ecological or ecological flow must guarantee 1. movement, 2. feeding, 3. growth, and 4. reproduction of aquatic organisms. These values may vary according to the hydrological, morphological and ecological context of the water bodies, as well as according to ecological issues (maintenance of habitats and/or ecological continuity). It is recommended that ecological flow values and any seasonal variations be established for the main rivers in the river basin.

Figure 10 Needs of aquatic environment: ecological flow



Low-water flow: Minimum flow of a watercourse calculated over a given period during low-water flow periods. Thus, for a given year, we speak of the daily low-water flow, low-water flow for n consecutive days, and monthly low flow (average daily flow for the month of the lowest flow).

Target low-water flow: Average monthly flow value at the strategic river node (key management point) above which, in the area of influence of the strategic river node, all uses (activities, abstractions, discharges, etc.) are considered to be in balance with the proper functioning of the aquatic environment. Low-water target flow is the minimum flow that those involved in water management agree to leave in watercourses at strategic river nodes.

Crisis flow, Alarm flow: Low-water flow value below which the supply of drinking water for the essential needs of human and animal life and the survival of species present in the environment is compromised. At this low water level, all possible measures to restrict consumption and discharge must have been implemented (contingency plan).

Allocable volumes and flows: The total volume that the environment is capable of providing while maintaining the proper functioning of the aquatic environment in relation to the need for remaining low-water flows.

#8 Share the water resource status with stakeholders

The results of initial inventory and technical studies should be shared with the stakeholders. The presentation should be clear and concise, backed up by scientific evidence where appropriate, and should enable stakeholders to take ownership of quantitative water management issues and work together to develop balanced scenarios for sustainable resource management that take account of climate change. Each report should be summarised in a document of a few pages in order to present different conclusions in an easily understandable way.

Level of participation: Information

Objective: To validate the results of the initial inventory and technical studies and to enable stakeholders to take ownership of quantitative water management issues.

Tool: Workshop/meeting with stakeholders

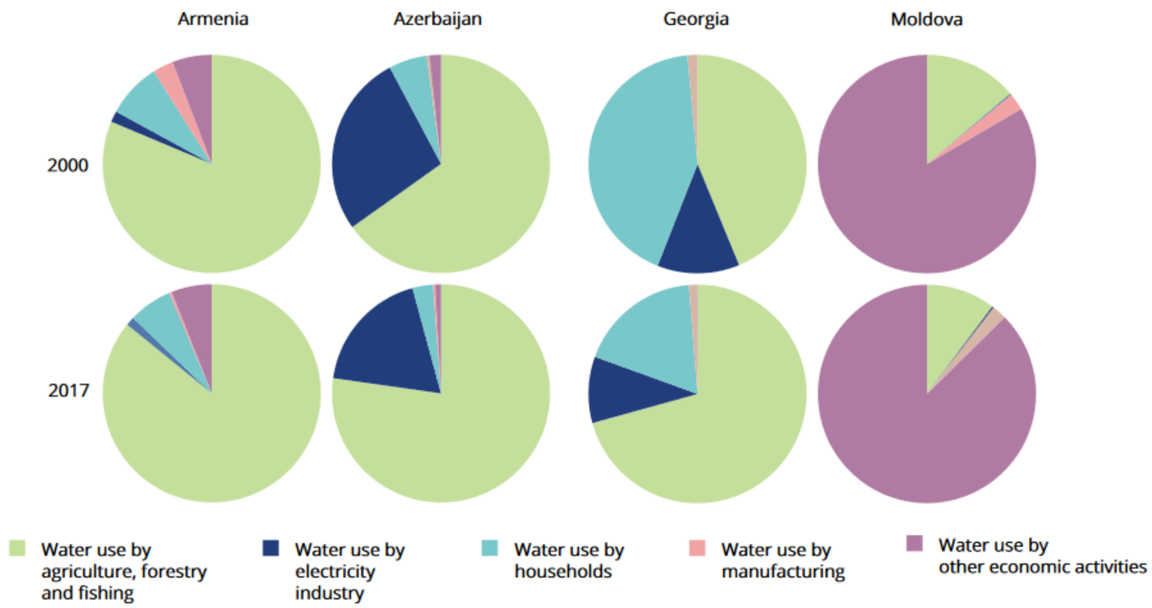
- Use participatory tools to get stakeholders to formulate the outcomes they expect from the initial inventory of water resources
- Present the results of the initial inventory and technical studies in a clear and concise manner, supported by scientific evidence where appropriate
- Open discussion to gather feedback

STEP 3: Water allocation plans

#9 Assess water demand

The aim is to characterise current and future demand for the sectors of drinking water, agriculture, industry and energy. In this assessment, it is important to identify inter-annual and seasonal variations and to distinguish between surface water pumping in rivers and groundwater pumping.

Figure 11 Water use by economic sector in Eastern Partnership countries (2017) (source: EEA report No 14/2020)



Note: Data for Georgia 2016. Data made available to the EEA under the ENI SEIS II East project
Data source: Armenia: ArmStatBank (Statistical Committee of the Republic of Armenia; Azerbaijan: Az STAT (State Statistical Committee of the Republic of Azerbaijan); Georgia: Water Division of the Department of Environment and Climate Change and the Integrated Management Division of the Department of Environmental Assessment - Ministry of Environmental Protection and Agriculture; Moldova: Statistica Moldovei (Statistical Databank of the National Bureau of Statistics of the Republic of Moldova) and Agency Apele Moldovei.

Irrigation and aquaculture (fish farming) are two major sub-sectors of agricultural that require large volumes of water abstraction and and water use. This is particularly true in Armenia which is a landlocked country where fish is very important in the food supply chain.

Required data:

- Summary of drinking water, agricultural and industrial abstractions, by use. Agricultural and industrial needs may be drawn from drinking water resources at certain times of the year. They should be reported separately to avoid double counting.
- Summary of discharges from agricultural and industrial wastewater treatment plant (WWTP), by use, also to estimate the rate of return to the system and the net loss for the hydrological system.
- Summary of water imports and exports outside the river basin, e.g. for the water supply of a large city outside the river basin.

Methodology:

- Collect volumes and changes over time on a monthly time step.
- Collect data over the same period as precipitation and flow data.
- Take into account "recycling" processes or "rates of return to the system" or “restored volumes”.

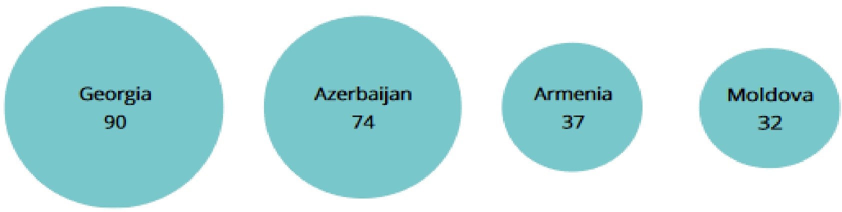
- Separate river pumping from groundwater pumping, which have different impacts on the water cycle.
- Estimate unreported abstractions as accurately as possible. During low-water periods, if the wells and/or catchments normally used are no longer sufficiently productive, the water supply network may be solicited more heavily for industrial or agricultural purposes.

Domestic sector: assess abstracted, used and restored volumes

[42] Domestic water quantity, service level and health (2020)
[43] Defining domestic water consumption based on personal water use activities (2021)
[44] Medium- and long-term forecasting of demand for drinking water: a review of current methods and practices (FR)

Domestic water consumption includes flushing toilets, bathing and showering, washing clothes, dishwashing and other less water-intensive or less frequent uses: cooking, drinking, gardening, car washing, etc.

Figure 12 Water use per capita by household supplied by a public water supply (m3/capita/year in 2017) (source: EEA report No 14/2020)



Note: Data for Georgia: 2018. Data made available to the EEA under the ENI SEIS II East project.

Data source: Armenia: ArmStatBank (Statistical Committee of the Republic of Armenia); Azerbaijan: Az STST (State Statistical Committee of the Republic of Azerbaijan); Georgia: National Statistics Office of Georgia; Moldova: Statistica Moldovei (Statistical Databank of the National Bureau of Statistics of the Republic of Moldova) and Agency Apele Moldovei

Among EaP countries, Georgia exhibits the highest water use per capita due to high water loss in the conveyance system.

The volume of abstracted water is based on water demand.

It is commonly agreed that:

Water demand = Water Consumption + Water leakages

- **Estimate domestic water consumption**: Water consumption is a function of specific demand (unit consumption per capita) and the number of consumers. The methodology for estimating water consumption may vary depending on the data available.

Table 3 Example of indicators and data to estimate water consumption

WATER CONSUMPTION = f(Number of consumers, specific demand)	
Number of consumers	• Number of house connections • Average number of inhabitants per house
	• Delineation of distribution areas • Number of inhabitants per distribution areas
	• Population/dwelling

	• Dwelling/ha • Distribution area (ha)
Specific demand	• Coefficient of consumption based on level of standing • Geographical distribution of dwellings per level of standing
	• Coefficient of consumption based on socio-economic categories • Geographical distribution of dwellings per socio-economic category
	• Volumes of water used based on access level • Geographical distribution of dwellings per access level

- **Estimate water leakages**

Leaks are often caused by old pipes or excessive pressure, but also by soil movement.

The "drinking water network efficiency" indicator takes leakage into account. This indicator measures the ratio between the volume of water consumed by users (private individuals, public institutions, businesses, etc.) and the volume of drinking water introduced into the distribution network. Its value and evolution reflect the company's policy of combating water losses in the distribution network. Losses range from 5% to more than 50% of abstracted volumes. Losses are restored to water resources.

$$\text{Drinking water network efficiency} = \frac{Consumption\ volume + export\ volume}{Production\ volume + import\ volume} \times 100$$

Guidance No. 3: Orders of magnitude to estimate water consumption

It is useful to keep in mind orders of magnitude when estimating water consumption. According to WHO, 20 L/person/day is often sufficient for drinking, cooking, food hygiene, handwashing and face washing, but not other hygiene practices.

Table 4 Summary of typical volumes of water used depending on access level (WHO, 2020)

Access level	Accessibility of water supply	Typical volumes of water used in the home (l/person/day)
Inadequate access	More than 100 m in distance or 30 minutes total collection time	5.3
Access level	**Accessibility of water supply**	**Typical volumes of water used in the home (l/person/day)**
Basic access	100 – 1000 m in distance or 5-30 minutes total collection time	20
Intermediate access	Water delivered through one on-site tap, or within 100 m or 5 minutes total collection time	50
Optimal access	Water supplied through multiple taps and continuously available	>100

- The expected value of basic water consumption for a healthy urban lifestyle is 92 L/person/day, which includes restrictions on everyday activities.
- A more realistic expected value for water consumption is 175 L/person/day across all water-use locations during a typical day.

Source: Defining domestic water consumption based on personal water use activities (2021)

Agricultural sector: assess abstracted, used and restored volumes

[45] FAO Irrigation and Drainage Paper / No. 56 CROp Evapotranspiration
[46] FAO Yield response to water / No. 33
[47] FAO CropWat
[48] AQUASTAT – FAO's Global Information System on Water and Agriculture
[49] Irrigation water management – training manual No.3

Agriculture, and in particular irrigated agriculture, is by far the largest sector in terms of water consumption and abstraction. In order to estimate the pressure of irrigation on the available water resources, it is necessary to assess both the irrigation water demand and the irrigation water abstraction.

Crop water requirements could be expressed by the following equation:

Crop water requirements = [ETo (monthly) *Kc (month, date planted, type of crop)] – Pe (monthly)

Determination of crop water need

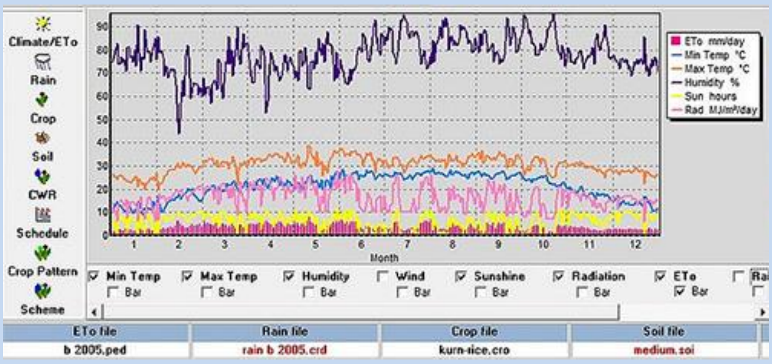
The method for estimating crop water requirements is described in detail in Appendix 9.

- **Reference evapotranspiration (ETo)** is calculated using the FAO Penman-Monteith method. Many software packages already use the FAO Penman-Monteith equation to evaluate reference evapotranspiration. A recommended example is the output of CROPWAT, the FAO irrigation scheduling software. Reference evapotranspiration (ETo) is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. It ranges between 0 and 8 mm/day. Grass is used as a reference crop. ETo is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm high, growing actively, fully shading the ground and not lacking in water.
- **Effective rainfall or precipitation (Pe)** is estimated each month using measured rainfall data and a formula or table to determine the effective rainfall. Such a formula takes into account factors such as rainfall reliability, topography, prevailing soil type etc. If such formulas or other local data are available, they should be used.
- **Crop coefficient (Kc)** depends mainly on the climate (month), the type of crop (which influences the water needs depending on the daily crop water needs and the duration of the entire growing season), and the stage of growth.
- **Crop evapotranspiration (Etm)** is the product of the crop coefficient (Kc) and the reference evapotranspiration (Eto). It is calculated on a daily basis to estimate the amount of water that a crop can lose if the soil reserve allows it.

Box 5: CROPWAT: A computer program for irrigation planning and management
(source: FAO)

CROPWAT is a decision support tool developed by FAO's Land and Water Development Division. CROPWAT 8.0 for Windows is a computer program for calculating crop water requirements and irrigation needs based on soil, climate and crop data. It can be used to produce irrigation schedules for different management conditions and to calculate system water supply for different cropping patterns. CROPWAT 8.0 can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions.

Figure 13 CROPWAT 8.0 for Windows is a computer program for the calculation of crop water requirements and irrigation requirements (source: FAO)



Other agricultural sectors, such as livestock and fish farming, are also major users of water resources. The livestock sector is estimated to use an equivalent of 11,900 km³ of freshwater per year, or about 10 per cent of the estimated annual global water flow (111,000 km³) (FAO).

References for livestock water requirements:
[50] Livestock water requirements, 2021
[51] Water requirements for beef cattle, 2022
[52] Water requirements of livestock

References for fish farming water requirements:
[53] Selected aspects of warm water fish culture

Industrial sector: assess abstracted, used and restored volumes

[54] *W*ater uses in industries (FR)
[55] *W*ater uses by industrial sectors (FR)

For most industries, water is a production factor. Water is present in virtually the entire product processing chain, and is also used to clean factories, machinery and finished products. Energy production involves very large abstractions, but most of the water is returned, representing only a small percentage of net consumption. Industries can draw water directly from the environment or use raw or drinking water distributors.

Assessment of abstracted, used and restored volumes in the industrial sector

Methods for assessing abstracted, used and restored volumes in the industrial sector are detailed in Appendix 10. Activities may include:

- Identify the main industrial activities in the area
- Understand the main water uses by sector of activity
- Use available statistical data and estimate missing data
- Characterise and estimate water use by category of industry

Table 5 Examples of orders of magnitude of water demand in industries (source: Gesteau)

Type of activity	Water demand (m^3/d/ha)
Logistics	1.5
Tertiary activities	4
Shops and crafts	4
Small and medium industries	8
Industries	10
Car industries	15
Agri-food industries	100-150

It should be noted that the volumes shown in the table above are abstracted. In most industrial sectors, a percentage of the abstracted water is returned to the natural environment.

Table 6 Examples of orders of magnitude of water demand in industrial areas (source: Gesteau)

Type of industrial area	Estimated number of people	Water demand (in the equivalent of individual specific water demand)
Business park: shops and crafts	Average of 20 people/ha (no permanently in the area)	5/ha
Business park: industries and tertiary activities (offices)	Average of 60 people/ha (permanently in the area)	20/ha

Table 7 Examples of orders of magnitude of volumes of water needed to manufacture products (source: CNRS)

Type of manufactured product	Volume of water (l)
1 kg of rayon (viscose)	400-11,000 l
1 kg of steel	300-600 l
1 kg of sugar	300-400 l
1l of alcohol	100 l
1kg of cardboard	60-400 l
1 kg of cement	35 l
1kg of soap	1-35 l
1 kg of plastic material	1-2 l

Energy sector: assess abstracted, used and restored volumes

[56] *An analysis of water consumption in Europe's energy production sector*
[57] 2. Water and energy. Energy in the open (FR)

Water and aquatic environments are employed in a variety of ways to generate electricity. Thermal power stations use large volumes of water for cooling; hydroelectric power stations use the flow of rivers, and marine energy uses currents and tides.

- **Cooling of power plants**: Most of the water abstracted is used to cool the equipment. This water is taken from aquatic environments, usually rivers, and is discharged almost entirely near the abstraction point. In the case of distant discharge, it is necessary to know the distance in order to determine whether a part of the river is short-circuited

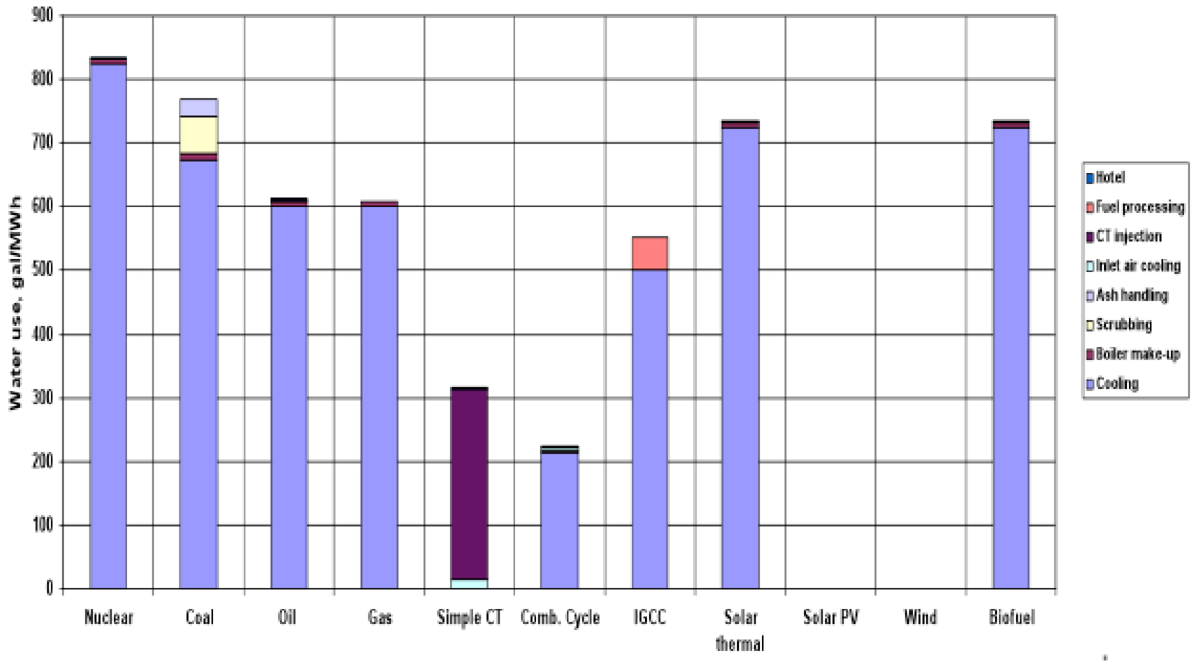
  There are two types of cooling circuits: open and closed.

  - In the first case, water is pumped from the environment, circulated through the plant to cool it and discharged directly: this circuit uses very large quantities of water, which is then returned to the environment.
  - In the second case, the water circulates several times through the plant before being discharged: the quantities of water used are therefore smaller, but some is lost through evaporation or leakage.

Table 8 Water requirements of power generation units for different energy sources in m3/MWh (source: US Department of Energy, 2006 from CNRS, 2013)

Type of power plant	Cooling process	Steam condensation		Other uses (cooling turbines, washing equipment, treating effluent, toilets)
		Withdrawals	Consumption	
Fossil fuels and biomass	Open circuit Closed circuit Dry air	76-189 1.1-2.3 0	1.1 1.1-1.8 0	0.1
Nuclear	Open circuit Closed circuit	95-227 1.9-4.2	1.5 1.5-2.7	0.1
Natural gas Combined cycle	Open circuit Closed circuit Dry air	28.4-75.7 0.9 0	0.4 0.7 0	0.03-0.04
Gasification Combined cycle	Closed circuit	0.9	0.8	0.49-0.53
High-temperature geothermal energy	Closed circuit	7.6	5.3	
Concentrated solar power, satellite dishes	Closed circuit Dry air	2.9-3.5 0	2.9-3.5 0	0.03 0.3
Concentrated solar power, towers	Closed circuit Dry air	2.8 0	2.8 0	0.03 0.34

Figure 14 Water use by plant type (source: EPRI 2010)
Some 15% of coal plant waste heat is discharged through the stack, rather than cooling water).
NB US gal =3.79 litres



- **Hydropower**: the flow of water in a river is used as a driving force. This is not an abstraction in the strict sense, as the water is not removed from the environment, but rather a transformation of the river's form and function. There are three types of hydroelectric schemes:
  - "Run-of-river" plants where the flow of water in a river is immediately turbined without any major impoundment.
  - Lake plants, where water stored in an artificial reservoir is turbined (on demand) to exploit a fall of varying sizes.
  - "Pumped-storage" plants between two reservoirs located at different elevations, which include a pumping system to raise a volume of water using excess electricity during off-peak periods and turbine the same volume during peak periods.

The water footprint of hydropower is quite small, almost zero in the case of "run-of-river" plants, essentially due to evaporation in reservoirs, and often shared with other uses. However, the development of rivers for hydropower can have negative, sometimes harmful, effects on the environment and aquatic ecosystems. Along the river, the creation of reservoirs and the alteration of the hydrological regime disrupts the flow regime. In stretches of the river downstream of dams: lower flows during periods of non-disturbance ("instream flow") modify sediment transport (siltation), temperature (warming in summer), and more generally all the physico-chemical conditions of the aquatic ecosystem and biodiversity. In reservoirs, the low water turnover in the large bodies of water created can give rise to complex thermal stratification phenomena, progressive algal growth (eutrophication), that is sometimes sudden and toxic, and sometimes temporary (blooms), accompanied by a reduction in dissolved oxygen.

Produce trend scenarios to forecast the demand

[58] Modelling water demand and availability scenarios for current and future land use and climate in the Sava River Basin

[59] Medium- and long-term forecasting of demand for drinking water: a review of current methods and practices (FR)

Table 9 Factors relating to evolution in water demand (source: Eau France)

Factor	Consequence of climate change on water demand forecast
Climate change	Increased frequency of showers due to rising temperature, increased use of water-cooling systems, increased water use for gardens and swimming pools, increased water requirements for crops and livestock
Population	Increase in the population
Household equipments	Technical evolution of equipment (e.g. household appliances). Changes in standards for taps, toilet flushes
Development of alternative resources	Development of technical solutions and their cost (rainwater harvesting individual drilling, wastewater recycling). Changes in regulations
Water price	Evolution of water price
Urbanism	Greater densification of urban development, decrease of water uses related to individual gardens.
Economic activities	Developments in industrial processes lead to a sharp reduction in the consumption of large customers, and changes in economic activity and employment that may lead to the substitution of water-intensive activities by tertiary activities
Politics	Changes in the strategic choices of customer communities that purchase large volumes of water and may opt for alternative supplies

Climate change is likely to have an impact on the availability of this resource, as discussed in the previous section Produce trend scenarios for each freshwater resource in the context of climate change, for each quantitative management sector. However, climate change is also likely to affect the demand for drinking water associated with indoor and outdoor uses, certain industrial activities, and water requirements for agricultural activities. Rising temperatures could increase the frequency of showers and the use of water-cooling systems. Outdoor water use for gardens and swimming pools will increase in response to rising evapotranspiration and reduced precipitation. In the agricultural sector, water demand for crops and livestock will increase in response to rising evapotranspiration.

#10 Assess abstractable volumes

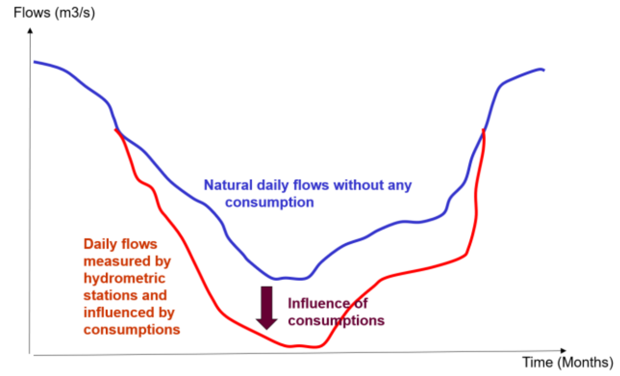
Characterise the balance between resources and uses

A comparison of the evolution of the natural flow, the current river flow and the "future scenario" flows over the course of a year, and in particular during low-water flow periods, should make it possible to establish a first, simple analysis of the impact of current and future water withdrawals.

Natural hydrology is impacted by consumption:

Natural hydrology = influenced flows + consumptions

Figure 15 Natural daily flow and influence of consumption

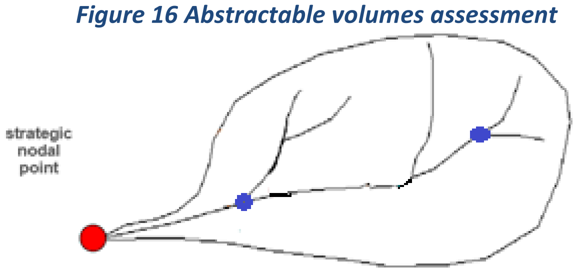


Characterise the balance between resources and uses, and examine possible developments in the hydrological system:

- Balance between uses and resources: Comparing total demand and flows during critical periods provides a first indication of the level of risk involved. Depending on the issues in the area, it may be worth, for example, applying the analysis by comparing the QMNA5 with monthly summer water abstraction.
- Modelling the impact of current anthropogenic pressures: To take this modelling one step further, it can be interesting to use the developed model to characterise freshwater resources in the context of climate change and add current anthropogenic pressures.
- Integration of future water resource management and climate change scenarios: To obtain a predictive vision, the developed model can be used to characterise freshwater resources in the context of climate change, adding future anthropogenic pressures and climate change projections to simulate the impact on river flows. By comparing the different simulated flows before and after the addition, it is possible to measure the level of risk associated with the management scenarios envisaged.
- Assessment of abstractable volumes

Abstractable volumes = natural hydrology – ecological needs

Figure 16 Abstractable volumes assessment



Box 6: Water balance between resources and uses in the Ellé-Isole-Laïta basin

Ellé isole Laïta basin, (source: CRESEB, 2015)

The main annual flows and water demand for the Ellé -Isole - Laïta basin, taken from the water balance between resources and uses (Egis Eau, 2013), are shown in the tables below. While natural flows are net flows, the rate of return to the system must be estimated for abstractions. On average, 20% to 30% of water abstractions are used in this basin, which represents a net loss for natural functioning.

Table 10 Synthesis of annual water flows in the Ellé Isole Laïta basin

Water flows	Total in the river basin (Mm^3/year) (a)	Total in the river basin (mm/year) = (a)/surface of the river basin
Precipitations	829 Mm^3/year	1,050 mm/year
Evapotranspiration	457 Mm^3/year	550 mm/year
Watercourses	416 Mm^3/year	500 mm/year
QMNA5	69.3 Mm^3/year	84 mm/year i.e. 7mm/month
10^{th} of the module	41.6 Mm^3/year	50.4 mm/year i.e. 4.2 mm/month

Table 11 Synthesis of annual water needs in the Ellé Isole Laïta basin

Water needs	Total (m^3/year)	At the river basin scale	Return rate	Net loss for the basin
Domestic needs	2.6 Mm^3/year	3.1 mm/year	See WTP discharges 80%	0.62 mm/year (20%)
Agricultural needs	2.42 Mm^3/year	2.9 mm/year	10% (irrigation) – 80% (livestock)	0.87 mm/year (30%)
Industrial needs	9.3 Mm^3/year	11 mm/year	70%	3.3 mm/year (30%)
Total needs	14 Mm^3/year	17.2 mm/year i.e. 1.5 mm/month	75%	4.3 mm/year (25%) i.e. 0.4 mm/month

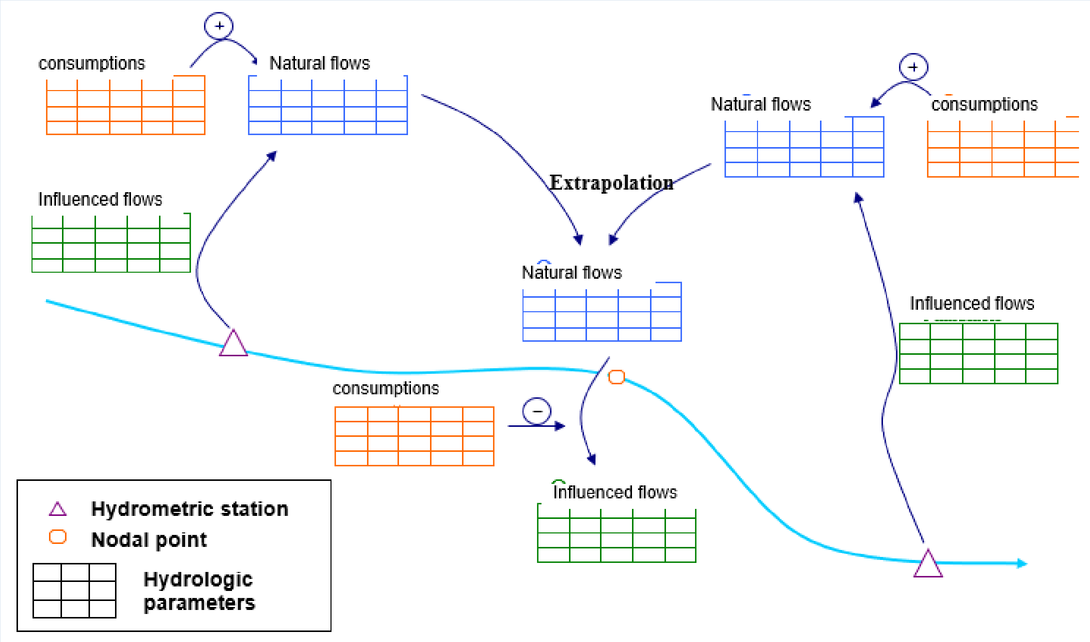
At first sight, for the Ellé-Isole Laïta basin, the total annual needs (17.2 mm/year) are negligible compared to the total rainfall (1050 mm/year) and the river discharge (500 mm/year).

However, to estimate the impact of human activity on low-water flows, we need to compare needs (at least monthly) with the low-water flow (QMNA5 = 7 mm/month). Thus, total needs (17 mm/year or 1.5 mm/month) represent 20% of the QMNA5 and are not negligible. However, in terms of net loss, requirements now only represent 4.3 mm/year or 0.4 mm/month (6% of QMNA5) in terms of net losses for the basin, given the high overall recycling rate, estimated at 75% in this basin where irrigation represents only a small surface area.

The above tables are a first step. The information they provide can only be interpreted on an annual scale, while the analysis of base flows and their comparison with abstractions requires concentration on the summer period. To obtain a first order of magnitude, it is possible to compare the QMNA5 with the net loss for the basin. The net loss for the basin represents almost 10% of the low-water flows, so that abstraction should be taken into account when examining minimum flows. For greater precision on a monthly scale (or even on a finer time scale to characterise certain uses), it is necessary to specify the phase of the different flows and the flow capacity of the water.

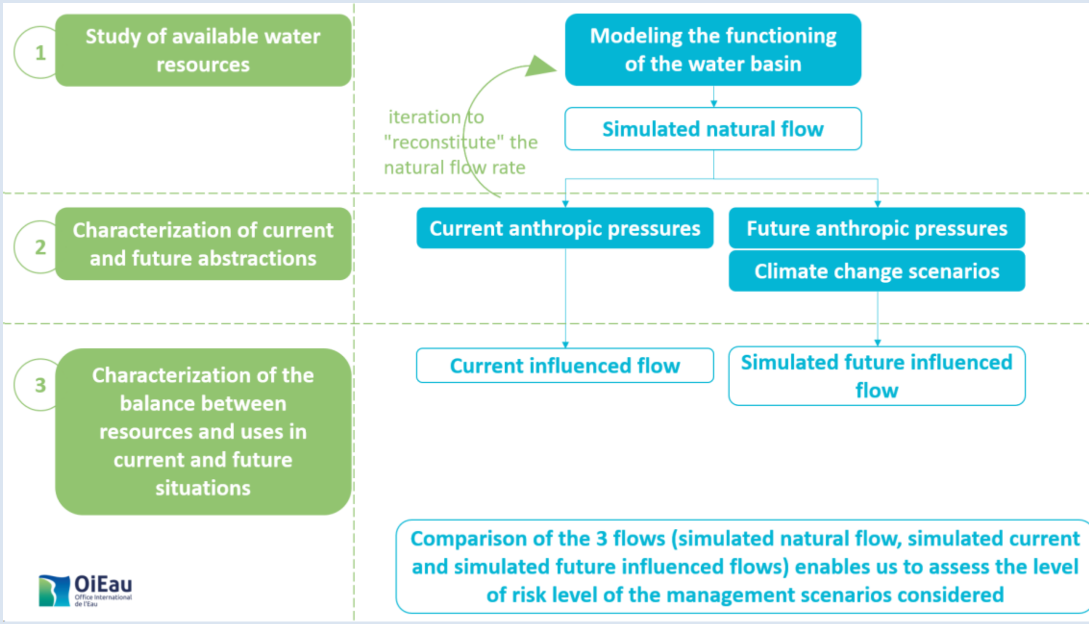
Guidance No. 4: Surface extrapolation from the hydrometric stations to obtain the hydrology (influenced and natural) at the strategic river nodes

Figure 17 Surface extrapolation from the hydrometric stations



Guidance No. 5: Characterisation of the balance between resources and uses in current and future situations

Figure 18 Balance between resources and uses in current and future situations



Establish water allocation volumes

[1] Water allocation system in Southern France
[16] Guidance document on the application of water balances for supporting the implementation of the WFD

□ **Collective water-saving management**

The purpose of collective water-saving management is to adapt water demand to the total available resources and to avoid crisis management. This approach should make it possible to define abstraction levels in "normal" situations.

The establishment of a water-saving strategy in "normal" situations aims at preserving the natural hydrology. If a deficit is identified, prioritisation of uses and reduction of consumption should be applied.

□ **Crisis management**

Water management systems generally allocate water according to priority uses and progressive restrictions in terms of percentage, timing or discharge. They include alert and crisis thresholds according to which, for example, regulatory restrictions are imposed by the competent authorities:

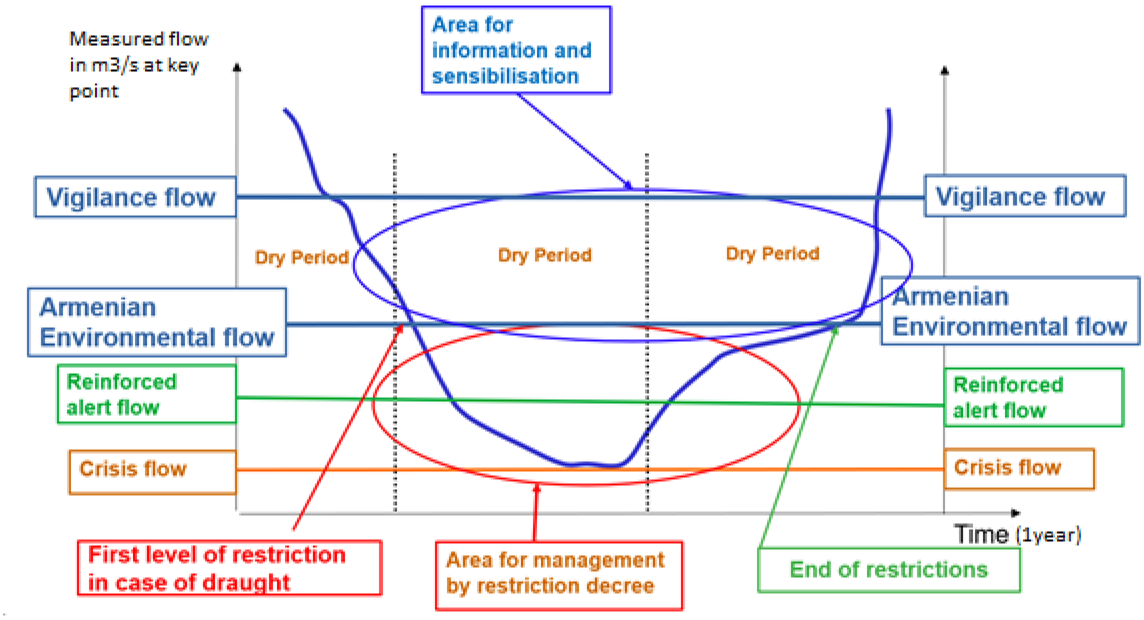
- Level 1: limited measures, restricting water abstraction to 1 day per week or less or to 15% of the water volume of at least one river basin.
- Level 2: more stringent measures, restricting water abstraction to 1 to 5 days per week.
- Level 3: very stringent measures, restricting water abstraction to 5 days or forbidding abstraction.

Proposed methodology for managing water use during periods of water scarcity: Crisis flows are calculated on the basis of ecological flows (cf. Estimate minimum ecological flows).

- **Vigilance Flow**: Ecological Flow + 25%
- **Reinforced Alert Flow**: Ecological Flow – 25%
- **Crisis Flow**: Ecological Flow – 50%

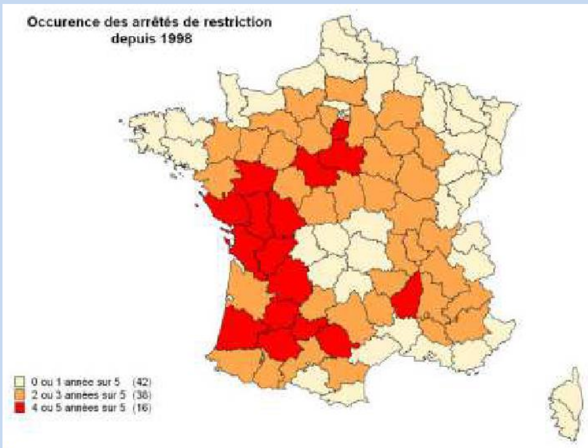
When crisis flow thresholds are exceeded, specific measures are taken, depending on the degree of urgency associated with the exceeded flow.

Figure 19 Example of crisis management thresholds from the drought management proposal for Armenia (source: OiEau, Kazakh quantitative management proposal)



Box 7: Administrative restrictions due to water scarcity since 1998, France
(source: Water allocation systems, France)

In 2011, 71 départements in France were affected by at least one regulatory restriction on water use. Level 3 restrictions affected river basins in 11 départements. All water abstraction, in particular for irrigation, was prohibited, except for the production of drinking water, fire-fighting, specific industrial processes, and water for livestock in the case of rivers not fed by dams upstream.



This crisis management based on surface water abstraction led to the development of individual groundwater irrigation and pumping at overcapacity to compensate for the reduction in hours.

In the 1990s, voluntary initiatives were taken to avoid the legal restrictions and their negative impact on agricultural production, such as advice on irrigation planning, the organisation of water exchanges between farmers, and a mix of individual and collective responses. The Irri-mieux initiative was launched in 1997-1998 to promote better dialogue between farmers and other users on the implementation of water sharing. Measures included volumetric management of groundwater, irrigation scheduling, technological equipment, collective decision-making processes and conflict resolution. The results enabled more efficient water-sharing mechanisms, but not necessarily a reduction in abstractions, and consequently no evidence of conservation of water and aquatic life.

Determine priority management zones

Priority management zones: Areas comprising basins, sub-basins, aquifer systems, or parts thereof, characterised by a non-exceptional shortage of water resources relative to demand, also known as a chronic quantitative deficit.

The definition and selection of priority management zones should be done in dialogue with stakeholders.

Level of participation: Dialogue

Objective: Define and select priority management zones, and enabe stakeholders to take ownership of quantitative water management approach

Approach: Workshop/meeting with stakeholders

- Involve stakeholders in formulating the objectives for the delimitation of priority management zones, using participatory tools. Describe prioritisation criteria to indicate what makes an area a priority management area. Examples of prioritisation criteria:
  - Minimum flow < ecological flow over several years (e.g. more than 3 years in 10).
  - Minimum flow < QMNA5 over several years (e.g. occurs more than 3 years in 10).
- Validate the definition of priority management zones with the stakeholders.
- Engage stakeholders in delineating priority management areas using participatory tools and sub-basin maps.
- Make available to the public the elements justifying the designation as a priority management zone, together with the context and objectives. Ensure that the public can express their opinions or requests (e.g., by setting up a dedicated e-mail address to receive feedback or by organising public meetings).
- Provide a summary of the comments, together with the document setting out the reasons for the decision.

Box 8: Areas with insufficient water resources (ZRE) in France
(source: Rhône-Mediterranée)

In France, the classification of water distribution zones (ZRE which mean areas with insufficient water resources) is a strong signal recognising the long-term imbalance between the resource and existing water abstractions. The inclusion of a resource (hydrological basin or aquifer system) in a ZRE is a means of ensuring more refined, reinforced management of the demand for water abstraction from this resource, in application of section 1.3.1.0. of Title 1 of Article R214-1 relating to the system of authorisation and declaration procedures for water resource abstractions. In areas classified as ZRE, any abstraction greater than or equal to 8 m^3/h from groundwater, surface water and their associated aquifers is subject to authorisation, except:

- abstractions subject to an agreement on the allocated flow (art. R211-73 of the Environment Code).
- abstractions of less than 1000 m3/year which are considered domestic.

Box 9: Revision of the Water Distribution Zones (ZRE) in the Rhône-Méditerranée Basin following stakeholder consultations
(source: Rhône-Mediterranée)

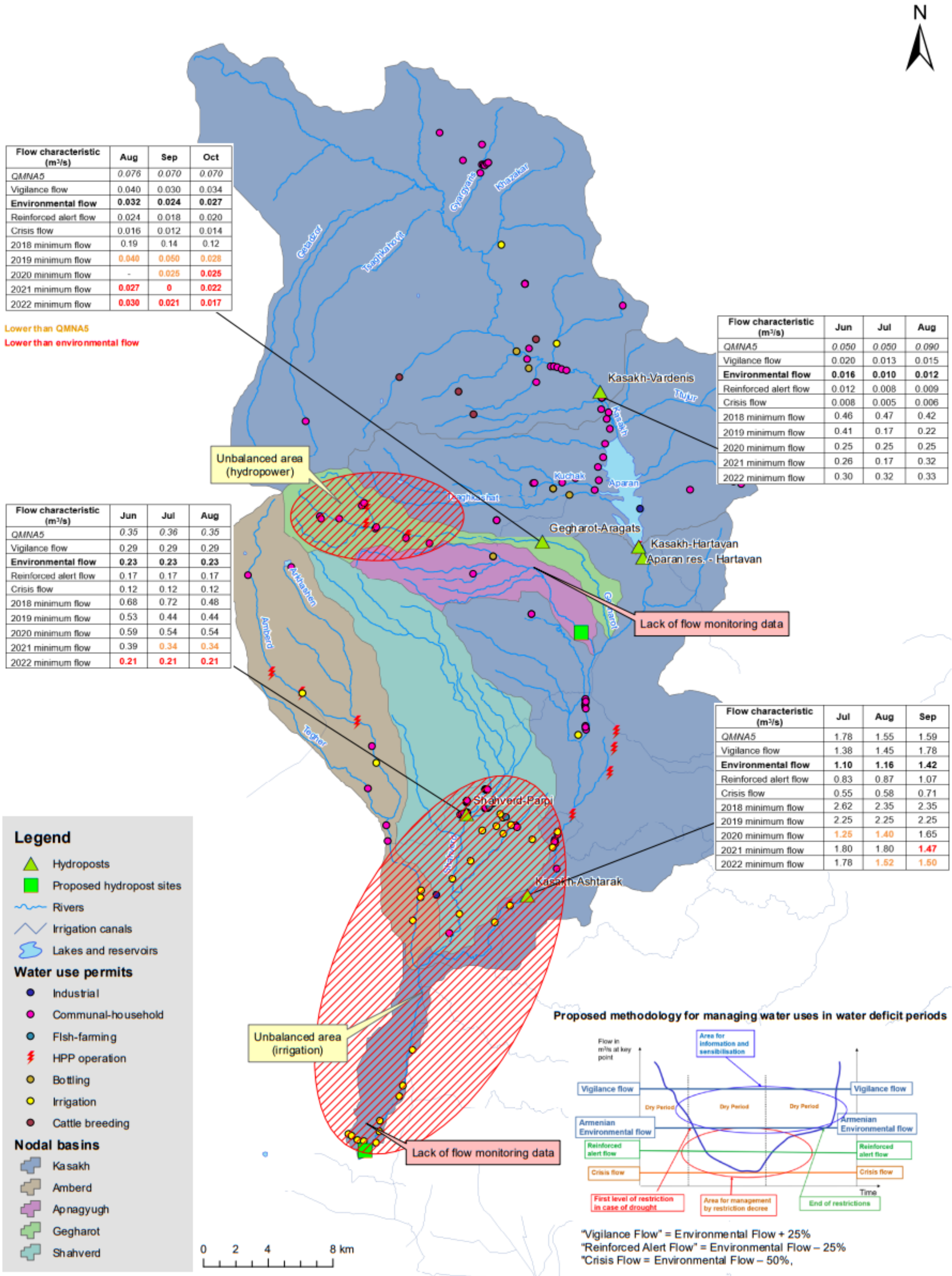
A public participation phase was carried out in application of Article 7 of the Ecological Law No.2012-1460 of 27 December 2012 on the implementation of the principle of public participation. In France, this obligation to participate has applied since 1 January 2013 to all public decisions, in particular those with an impact on the environment.

In application of this principle, the elements justifying the classification were made available to the public on the Rhône-Méditerranée Basin website from 26 April to 15 June 2018.

In addition to the draft order itself, a file containing the context and objectives of the amendment in question was made available for consultation. The procedure lasted 51 days, in accordance with the minimum period of 21 days established by the law of 27 December 2012. Hard copies were made available to the public on request at the relevant local council offices. Comments were received electronically and by mail.

The summary of the comments, together with the document setting out the reasons for the decision, was made available online for 3 months from the date on which the amendment order was signed by the coordinating prefect of the basin.

Figure 20 Water Use Management in the Dry Season in Kazakh River Basin: unbalanced areas (hydropower and irrigation) are delineated as priority management zones (source: OIEAU, 2023)



Flow characteristic (m^3/s)	Aug	Sep	Oct
QMNA5	*0.076*	*0.070*	*0.070*
Vigilance flow	0.040	0.030	0.034
Environmental flow	**0.032**	**0.024**	**0.027**
Reinforced alert flow	0.024	0.018	0.020
Crisis flow	0.016	0.012	0.014
2018 minimum flow	0.19	0.14	0.12
2019 minimum flow	0.040	0.050	0.028
2020 minimum flow	-	0.025	**0.025**
2021 minimum flow	**0.027**	**0**	**0.022**
2022 minimum flow	**0.030**	**0.021**	**0.017**

Flow characteristic (m^3/s)	Jun	Jul	Aug
QMNA5	*0.050*	*0.050*	*0.090*
Vigilance flow	0.020	0.013	0.015
Environmental flow	**0.016**	**0.010**	**0.012**
Reinforced alert flow	0.012	0.008	0.009
Crisis flow	0.008	0.005	0.006
2018 minimum flow	0.46	0.47	0.42
2019 minimum flow	0.41	0.17	0.22
2020 minimum flow	0.25	0.25	0.25
2021 minimum flow	0.26	0.17	0.32
2022 minimum flow	0.30	0.32	0.33

Flow characteristic (m^3/s)	Jun	Jul	Aug
QMNA5	*0.35*	*0.36*	*0.35*
Vigilance flow	0.29	0.29	0.29
Environmental flow	**0.23**	**0.23**	**0.23**
Reinforced alert flow	0.17	0.17	0.17
Crisis flow	0.12	0.12	0.12
2018 minimum flow	0.68	0.72	0.48
2019 minimum flow	0.53	0.44	0.44
2020 minimum flow	0.59	0.54	0.54
2021 minimum flow	0.39	0.34	0.34
2022 minimum flow	**0.21**	**0.21**	**0.21**

Flow characteristic (m^3/s)	Jul	Aug	Sep
QMNA5	1.78	1.55	1.59
Vigilance flow	1.38	1.45	1.78
Environmental flow	**1.10**	**1.16**	**1.42**
Reinforced alert flow	0.83	0.87	1.07
Crisis flow	0.55	0.58	0.71
2018 minimum flow	2.62	2.35	2.35
2019 minimum flow	2.25	2.25	2.25
2020 minimum flow	1.25	1.40	1.65
2021 minimum flow	1.80	1.80	**1.47**
2022 minimum flow	1.78	1.52	1.50

#11 Establish water allocation targets

Establish water allocation targets by sector of activity

After defining the boundaries of the area affected by regular water shortages or major risks, water allocation targets can be set by the relevant authorities (e.g. the local water commission) and distributed by sector of activity. During periods of drought, the resource allocation rules may need to be prioritised by sector of activity. The prioritisation of sectors of activity may be subject to a participatory approach governed by rules established at RBMP or national level to maintain a minimum balance between social and economic issues.

Level of participation: Dialogue

Objective: To define criteria for prioritising water resources by sector of activity and to enable stakeholders to take ownership of a quantitative approach to water management, in compliance with rules established at RBMP or national level.

Approach: Workshop/meeting with stakeholders

- Encourage stakeholders to formulate the criteria for prioritisation by sector of activity, using participatory tools. For example, it is common for a proportion of allocable water to be allocated or reserved for priority uses such as drinking water, fire safety, priority industrial processes and hospitals. Some sectors of activity may be subject to water restrictions, depending on the local context.
- Validate the definition of prioritisation criteria with the stakeholders
- Encourage stakeholders to establish water allocation targets by sector of activity, using participatory tools
- Make available to the public the elements justifying the classification as a priority sector of activity, together with the context and objectives. Ensure that the public can express opinions or requests (e.g. by providing an e-mail address to receive feedback).
- Provide a summary of the comments, together with the document explaining the reasons for the decision.

Box 10: Sequence of priority uses in water allocation in selected countries
(source: OECD, Policy highlights – Water Resources Allocation)

The OECD has carried a Survey of Water Resources Allocation covering 37 examples of allocation regimes from 27 OECD and key partner countries. The information captured in the OECD survey provides a varied view of the current allocation landscape across a range of countries with diverse water endowments, different types of challenges relating to freshwater supply and demand, and varying legal, institutional and policy settings.

Allocation regimes are generally used to establish priority access to water during times of scarcity, when "exceptional circumstances" have been declared, such as in the case of drought. Some allocation regimes use the sequence of priority uses to determine which uses should receive water entitlements in cases where there is competition for access to water even in average conditions.

Nearly all allocation regimes surveyed have an established sequence of priority uses. Most allocation regime examples define domestic and human needs as the highest priority use. Exceptions include the Netherlands and Peru. Several countries indicate several uses among the highest priority use. For instance, in Brazil, both human and animal water consumption are designated among the highest priority uses. A number of countries include water uses for national security purposes among the sequence of priority uses. In the Netherlands, for example, safety (preventing dyke collapse) and

Box 10: Sequence of priority uses in water allocation in selected countries
(source: OECD, Policy highlights – Water Resources Allocation)

preventing irreversible damage to the environment are the highest priority use. In France, the cooling of nuclear power plants is considered a national security use.

The table below provides an overview of sequences of priority uses in water allocation in selected countries.

	High Priority ←					→ Low Priority
Australia The Murray-Darling Basin	1. Critical Human Water Needs	2. Environment and Transfer to the Sea or Another System	3. Agriculture, Domestic and Industrial			
Brazil São Marcos River Basin	1. Human and Animal Water Consumption	2. Highly Efficient Irrigation	3. Hydropower Production	4. Others		
Canada Manitoba	1. Human Health and Safety	2. Environment	3. Domestic	4. Agriculture	5. Industrial	
Colombia Ubaté – Suárez Basin	1. Human Community Consumption (Urban or Rural)	2. Individual Domestic Needs	3. Farming Community Uses (Aquaculture and Fisheries)	4.Others (Hydro power, industry,etc)		
France Single Collective Management Bodies for Irrigation (OUGC)	1. Domestic + National Security (drinking water, health-related issues, civil safety (including cooling of nuclear power plants))	2. Environment (balance between ecosystems and economic uses)	3. Agriculture, Industrial, Energy Production and Transfer to the Sea or Another System			
Israel Large scale desalination and municipal/ regional water corporations	1. Domestic	2. Agriculture	3. Industrial	4. Environment		
Korea Surface Water Systems under the River Act	1. Domestic	2. Industrial	3. Agriculture			
Mexico	1. Domestic	2. Agriculture	3. Environment	4. Energy Production	5. Industrial, National Security	6. Transfer to the Sea or Other System
The Netherlands Polder System (in the western part)	1. Safety and Preventing Irreversible Damage	2. Utilities	3. Small-Scale, High Quality Use	4. Other (economic uses and nature)		
Peru Parón River's Sub-Basin	1. Environment	2. National Security	3. Domestic	4. Agriculture	5. Energy production	6. Industrial + Transfer to the Sea or Other System
Portugal Tejo River Basin	1. Domestic	2. Agriculture	3. Industrial	4. Energy Production		
Spain	1. Urban Supply (incl. low levels for urban industries)	2. Irrigation and Agricultural Uses	3. Industrial Uses for Electrical Energy Production	4. Other Industrial Uses	5. Aquiculture, Recreational Uses and Navigation and Aquatic Transport	

STEP 4: Programme of Actions

The programme of actions of the quantitative water management plan is a list of actions that sets out the approach and means to achieve specific objectives. Each action is defined by its technical content, a sponsor and a deadline for implementation. Once the actions and costs have been listed, scenarios are identified based on a prospective approach and consultation with stakeholders. Each scenario is a combination of actions within a timeframe and with allocated resources.

#12 Select actions

Addressing and preventing imbalances between water resources and the needs of ecosystems and human populations requires stakeholders to manage water uses and resources with a dual focus:

1. corrective, when a situation of imbalance between available resources and abstracted quantities threatens the health of resources and aquatic ecosystems, leading to conflicts of use.
2. prospective, which allows stakeholders to envision the future by controlling the factors of equilibrium to which the territory will be exposed, thus integrating water considerations into urban planning and initiatives, as well as into the various activities that contribute to its economic and social development.

What is an action? An action is a transformation that can be carried out on any characteristic of the water cycle, including human activities. This transformation is understood as the evolution of a parameter, a variable that describes the infrastructures, equipment, tools and practices of the initial situation. The calculation of the volume of water that can be abstracted (#10) based on minimum environmental flows is an effective method for prioritising the preservation of ecosystems.

Reduction actions: aimed at achieving the targets for the allocation of water resources by sector of activity.

Mitigation actions: Aim to reduce the effects of the water reductions set by the targets for the allocation of water resources by sector of activity.

The objective of the proposed actions is to reduce the current and future quantitative imbalance, to preserve aquatic ecosystems and to mitigate the impact of reduced water availability on human activities within the perimeter. The actions may have the following effects:

- Reducing demand (abstractions, uses)
  - Changes in practices (e.g. adjusting irrigation volumes and timing, improving the detection of leaks, optimising industrial processes, especially cooling processes, etc.).
  - Changes in activity and production (shifting cropping periods, adopting less water-consuming and more resilient crops).
- Modifying the distribution of available water volumes in space
  - Facilities for moving water (like canals)
- Modifying the distribution of available water volumes over time
  - Facilities for storing water (like dams, reservoirs)

Guidance No. 6: Develop "no-regrets" actions
During the initial phase of the quantitative water management plan, "no-regrets" actions should be identified, i.e. actions that will have a positive impact on water resources regardless of the extent of climate change (e.g. improvement of water quality, water savings, improvement of soil humus content, etc.).

Action sheets

What? It is advisable for the project leader and stakeholders to have "action sheets" containing the following information: description of the action, steps and main stages of implementation (e.g. impact study, etc.), performance indicators, monitoring points, timeframe and geographical scope of implementation, stakeholders and technical partner(s), costs and potential funding, expected benefits/effects on water resources in terms of quantity, link to case studies in several countries, preferably in Eastern Partnership countries, and technical references.

The "action sheet" below is a template that provides as much detail as possible on the actions so that they can be quickly implemented.

Why? The purpose of the action sheets is to provide the Steering Committee with summary information that gives an overview of the actions that can be developed, their effects/impacts on water resources in terms of quantity and other characteristics that are essential for the selection and implementation of the action programme.

How? The selection of actions for which it would be interesting to develop action sheets can be made by the technical committee based on the challenges and the socio-economic context of the territory.

Who? In the action sheet, it is essential to identify which players will fulfil the following roles:

- The individual or entity accountable for the action (users, local authority, user group), who is responsible for implementing the action in practice.
- The institution tasked with monitoring and promoting the said action.
- The institution that is responsible for financing the action.
- The technical solution providers (service providers, companies, equipment dealers, etc.).
- The beneficiaries of the action.

© Author of the photo, Date

Action sheet No.#: Title of the action

Description of the action: *This section defines the action. It aims to provide the reader with an overview of what the action consists of, in a few sentences.*

Steps of implementation:
This section aims to give an overview of the steps needed to implement the action. This description is non-exhaustive. The reader may refer to technical references to obtain more details about the implementation process of this action.

Performance indicators:
The objective is to measure the local level of appropriation and maturity of the actions. This entails determining the number of situations where the action can be carried out, the number of potential partners, the number of partners made aware, the number of partners who have started implementation, the number of partners who benefit from technical support, the number of tests carried out, and the number of actions in the process of being set up.

Points of vigilance:
Risks or undesirable effects to keep in mind when implementing.

Examples
One sentence describing a similar action that is ongoing, or has been developed, with the estimated cost and its estimated effect on water quantity management (country, date). Examples are preferred when the context is similar to the targeted sub-basin.

Technical references
[EN] Title of the technical reference
[EN] Title of the technical reference

Case-studies
Title of the case study, date
Title of the case study, date

TECHNICAL DESCRIPTION

Category: *Technical category of the action*

X	**Water supply**
	Regulation
	Agricultural demand
	Domestic demand
	Industrial demand
	Abstraction, storage, transport
	Nature-based solutions

Time frame: *Time frame of implementation of the action.*

1-2 years	2-4 years	>4 years

Existing technical standards locally

YES	NO

Scale:

X	**City/municipality**
	Field/farm
X	**Building**
	Sub-basin

Stakeholders: *Non-exhaustive list of the categories of stakeholders that are mobilised for the implementation, financing and technical support of this action.*

Implementation	
Monitoring/Promotion	
Financing	
Technical support	
Beneficiaries	

Cost calculation: *This section gives an overview of the type of costs that should be taken into account as inputs for the cost estimation of the implementation of this action.*

OPEX
Personnel
Monitoring
Subcontracting

CAPEX
Interests
Leasing financing
Amortisation

Expected benefits/effects:
This section gives an overview of the expected benefits/effects of this action on water resources in terms of quantity, with numerical estimations.

#13 Develop a "no-project" scenario

A **"no project" scenario**, assumes that no action other than reducing water abstraction is taken to remedy the current situation and meet environmental objectives. This is the reference scenario against which the different scenarios are compared. It describes the state of the area in the future without quantitative management measures. This scenario should include the following elements:

- The impact of climate change on water demand and availability.
- The application of regulatory measures (which may entail a reduction in abstraction).
- The impact of other foreseeable changes (societal expectations, other dynamics, etc.).
- The ability of water users to adapt to these changes (which often means reducing their abstractions).
- The impact of an imbalance on the various categories of water users.

Guidance No. 7: Develop "no-project scenarios" to put a cost on inaction
The development of "no-project scenarios", in which the allocated volumes in low-water periods are projected as only being achievable by reducing abstraction without any further action on the quantity side, makes it possible to quantify the impact of inaction on the area and thus provides a basis for the cost-benefit analysis of "project-based scenarios".

Guidance documents for scenario development:
[59] Scenario development for decision-making in water resources planning and management
[60] Scenario development for water resources planning and management

#14 Co-construct a programme of actions

Programme of actions:

- Actions, and associated costs
- Timetable (e.g. short/medium/long-term)
- Stakeholders
- Beneficiaries

The programme of action should be consensual and lead to the formalisation of commitments on quantitative management of water resources. Various other scenarios (i.e., minimum and ambitious) may be useful to build a broad consensus among stakeholders on a final scenario. The selection and endorsement of the programme of action by the vast majority of stakeholders, built on the consensus scenario, is an essential step in the process of securing funding.

Level of participation: Co-construction

Objective: Develop an action programme for quantitative water management that is agreed upon and selected with stakeholders.

Approach: Working session with stakeholders

- Prepare a list of all relevant users who are likely to support the proposed action, including their roles (e.g., water utility, farmer, industrial user). Additionally, outline the transmission chain (relays) for promoting and monitoring the action.

- Get the stakeholders to select and rank the actions of the programme, based on a pre-selected list to be completed and modified. Use the "no project" scenario as a starting point for ranking the actions. Use participative tools to get stakeholders to discuss the relevance of the listed actions in the local context.

- Validate the highest-ranked actions with stakeholders.

- At this stage, compare the scenarios. A SWOT matrix can be applied to the highest ranked actions. Each scenario should be subject to an economic and financial analysis to feed into the co-construction process and to inform the final choice of the programme of action so that it can be validated by the stakeholders. The financial implications of implementing these measures for users can be taken into account (cost recovery, incentives to save water, etc.).
- Share the results of the comparison of scenarios, supported by financial, economic, and technical elements and, if necessary, by regulations.
- Encourage stakeholders to associate each action with a timeframe and the name of the person/group responsible for implementation, using participatory tools.
- Make available to the public the elements justifying the ranking of the actions, together with the context and objectives. Ensure that the public can express their opinions or requests (e.g. by organising public meetings and, if possible, setting up a dedicated e-mail address to receive feedback).
- Provide a summary of the opinions together with the document explaining the reasons for the decision.

Comparison of scenarios

There is no *a priori* good combination of methods, nor is one method better than another. It is up to the project leader to make the methodological choice in full knowledge of the advantages and disadvantages of each method, the resources at their disposal, the skills available within their structure, the information available and the need to inform stakeholders about the economic dimension of actions. Some methodologies are presented below:

- **Cost-effectiveness analyses carried out for each action**: These make it possible to quantify the profits or water savings of the different actions in order to assess their respective efficiency (their contribution to achieving the desired quantitative objective). Once the cost of each action is established, they can be ranked them in ascending order of cost-effectiveness, and this ranking can then be used to prioritise the actions to be implemented.
- **Cost-benefit analyses of scenarios**: These consist in comparing one or more scenarios with the "no project" scenario to see if they add more value (benefits) than they destroy (costs).
- **Cost recovery analyses for each infrastructure project**: The aim is to verify that the expected revenue from water tariffs charged to infrastructure users will enable the infrastructure owner to cover its operating costs, and that in addition to operating costs, the revenue will cover the amortisation of the unsubsidised investment component (i.e., to ensure that the project owner will set up a pricing system to cover replacement provisions and will be able to ensure a good level of infrastructure maintenance).
- **Multi-criteria analysis**: This allows the direct and indirect economic, social and environmental impacts on the territory to be taken into account simultaneously. As not all costs and benefits of actions can be adequately monetised (in particular NBS), a multi-criteria analysis is recommended to assess all possible impacts of the scenarios, beyond the analysis of water volumes, economic aspects and acceptability.

Guidance documents for the cost of the actions:
[61] Economics of water allocation (chapter 3). Economic valuation of water resources in agriculture from the sectoral to a functional perspective of natural resource management

Guidance No. 8: Promote the use of a "cost-benefit" approach
Encourage stakeholders to use the cost-benefit approach and make it a real tool for dialogue and co-design of the quantitative water management plan and its action programme: (1) train coordinating structures in cost-benefit analysis; (2) systematise the identification of several possible territorial water management scenarios, including a "no project" scenario, and then (3) carry out a cost-benefit assessment of each one to justify the choice of the scenario chosen.

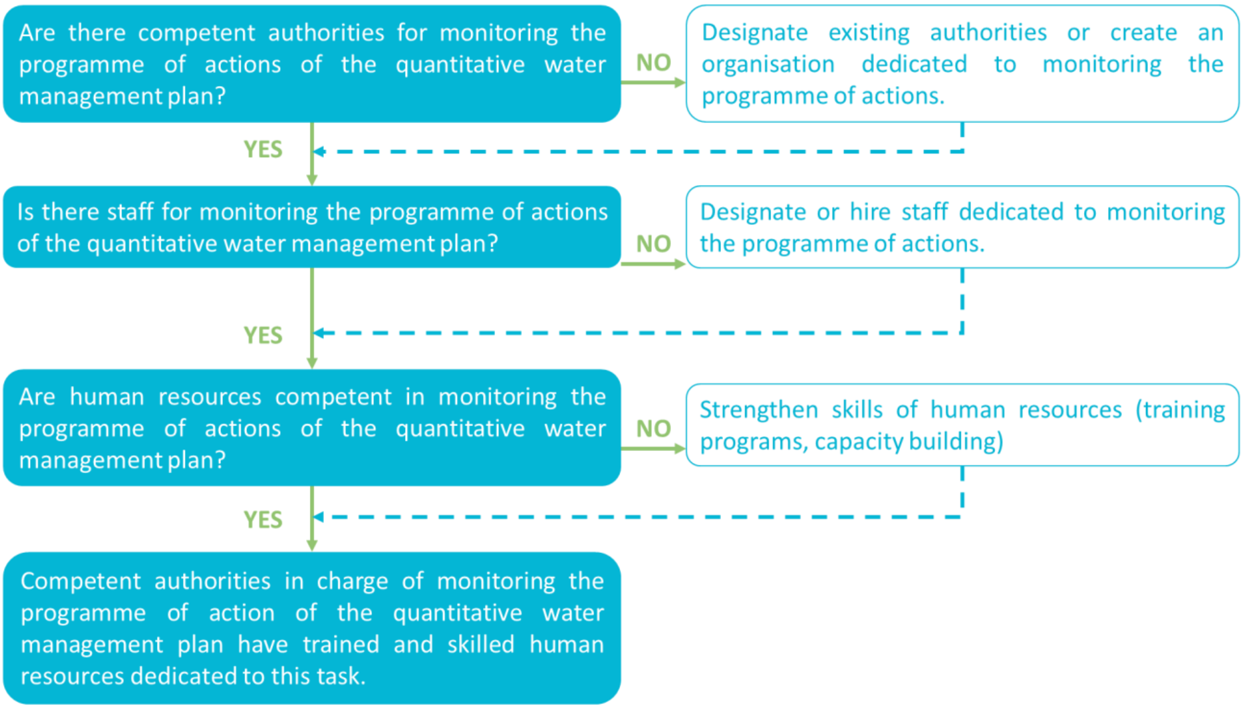
STEP 5: Implementation and monitoring

#15 Set up human resources

To ensure that a robust programme of action is effectively implemented and enforced, competent authorities must be designated and staffed. Their activities are as follows:

- Identify actions that meet the challenges and constraints of the users.
- Identify the users likely to implement these actions.
- Promote the actions to the users identified.
- Offer technical support (training, advice).
- Participate in the sizing, implementation and appraisal of financial support.
- Monitor the implementation and results of actions and propose adjustments.

Figure 21 Process of assessing the staff needs and training of competent authorities in charge of monitoring the programme of action of the quantitative water management plan (OIEAU, 2024)



Technical support systems play a crucial role in the successful implementation of a programme of action for quantitative water management, and may include:

- Awareness-raising programmes for local authorities, water and wastewater utilities, and agricultural users.
- Training programmes and capacity building for technicians and professionals to improve their skills and knowledge, for example on water-saving techniques.
- Demonstration projects (concrete examples of proven techniques whose dissemination is essential for the success of the quantitative water management plan).

- Pilot projects (testing of new techniques and actions with potentially significant implications for inclusion in the quantitative water management plan).
- Assessment of the availability of the necessary technology, tools, and expertise to carry out the actions effectively.
- Infrastructure support to enable the implementation of the actions.
- Research and development support to promote innovation and improve technical capabilities.

Guidance No. 9: The “winners” approach
The "winners" approach consists in putting the front-runners in the limelight in order to promote "good practices" in quantitative water management. This approach is didactic in that it presents sustainable water management examples (e.g. farmers practising agro-ecology, industrial companies reusing wastewater, etc.), for example through field visits.

#16 Set up financial resources

Once the economic and financial analyses have been carried out to support the final choice of the most appropriate scenario and to enable the programme of actions to be approved and formalised, the financial package must be finalised.

The project leader will need to identify funding opportunities for the development phases (territorial coordination, technical studies, communication, etc.) and assess the feasibility and funding conditions for certain actions in the programme of action. However, if the project leaders do not have sufficient self-financing capacity for certain actions, they will have to look for other sources of funding or seek new financial arrangements with the usual funders. If external funding cannot be increased, the actions will not be carried out and the project will have to be revised.

In addition to funders, it may also be useful to investigate the financial capacity of stakeholders who are likely to be project owners or beneficiaries of the programme of action.

Funding must be found to carry out the following activities:

- Monitoring water resource flows.
- Monitoring abstractions and ensuring compliance with abstraction authorisations, particularly during low-water periods.
- Establishment of technical standards and carrying out recommendation campaigns.
- Providing advice to users.
- Providing financial support to users for the implementation of actions.
- Monitoring actions, and assessing their effectiveness and efficiency (particularly financially).

Guidance No. 10: Explore financing options at an early stage
(1) Require early consideration of actions that can realistically be financed. (2) Explore the possibility of setting up very long-term loans to finance heavy infrastructure. (3) Contribute to the selection of realistic actions: mobilise and, if necessary, strengthen the financial engineering capacity of the territories involved in a quantitative water management plan; involve the financial backers from the outset; operate a departmental technical body for consultation and coordination of financing; and ensure financial solidity of collective project owners.

[61] Economics of water allocation (chapter 3). Economic valuation of water resources in agriculture from the sectoral to a functional perspective of natural resource management
[63] Role of economic instruments in water allocation reform: lessons from Europe

#17 Set up a performance monitoring system

Set up a monitoring committee

The steering committee ensures that the programme of actions is monitored at least annually by a **monitoring committee**, and based on precise and exploitable indicators.

The role of the monitoring committee is to:

- evaluate the actions carried out
- monitor the impact on the resource
- verify that the objectives have been achieved
- communicate the results to local stakeholders

The costs and resources required for this monitoring must be anticipated to avoid the risk of an unevaluated and inefficient quantitative water management plan, making it difficult to envisage the next steps.

Set up a dashboard to ensure the effectiveness and efficiency of the quantitative water management plan

Guidance documents for setting up a dashboard:
[62] Dashboard for monitoring of RBMP implementation: Guidance document

Example of indicators:
Appendix 11: Dashboard: Example of indicators

The dashboard is a management tool for monitoring progress in the implementation of the programme's actions. It measures the effectiveness and efficiency of the action programme and allows its specific objectives to be readjusted.

a. **Which indicators to choose?**

- Indicator selection and data access: choose indicators for which data will be easily accessible and exploitable
- Total number of indicators: limit the total number of indicators used (10-15 indicators) to enable regular updating and to facilitate data access. The selection process may focus on indicators that provide essential information for annual monitoring, and for which data are accessible and regularly updated.
- Nature of indicators:
    - Indicators of implementation: interventions and actions directly carried out by the steering committee of the quantitative management plan (financial and human resources, compliance with timetable, level of completion of actions, agricultural areas committed to low-input practices, etc.)

- Indicators of result: effects produced by the actions in the short and medium term for all local stakeholders, and target audiences;
- Indicators of impact: the positive and negative long-term effects of implementing the actions (water flow, piezometric levels, etc.) and water allocation rules.

- Indicator construction: They should be easily measurable to facilitate updating of the dashboard (based on either quantitative or qualitative criteria). These indicators are intended to evolve between two editions of the dashboard. The revision of the programme of actions may provide an opportunity to adapt the monitoring indicators (identify the actors involved in the production of indicators including data collection, variable production, processing, validation, indicator calculation, etc.).

b. How should data be collected?

The monitoring committee is responsible for collecting and storing the data needed to monitor the action programme. It is highly recommended to capitalise the volumes abstracted over an annual period, especially during the low water months. These data could be collected in "observatory" type databases. The key to success is the ability to mobilise partnerships between stakeholders to ensure the availability of these data.

Examples of indicators are described in **Appendix 11**.

c. How should datasets be managed and processed?

The management and processing of the available dataset should be based, as far as possible, on an efficient information system that allows the integration, processing, quality control and analysis of the various datasets provided by the different partners, as well as the visualisation and dissemination of the information produced.

Guidance documents for setting up a water information system:
[64] Handbook on water information systems

d. What format should the dashboard take?

The dashboard can take the form of a table, a map or a report.

- Introduction: Explains how the indicators were chosen. It can specify the changes made each time the indicators are updated: which indicators have been deleted, created or modified, and why.
- Dashboard body: The value of the indicator should be indicated using explicit graphics (e.g. colour coding, arrows indicating progress over the past years, a numerical value, etc.)

The specific objective of the plan	Action engaged during year n	Project manager	Sources of financing	Monitoring of the action	Status of the action

- Conclusion: Sets out annual results for comparison with previous years. This enables the identification of any regressive or progressive trends. In addition, it may include lessons to be learned and prospects for the years ahead.

e. How should the dashboard be communicated and promoted ?

- Frequency of dashboard updates: The dashboard can be updated annually, depending on available resources. In addition, the frequency with which indicators are updated should be defined.
- Dissemination and promotion to the local stakeholders involved in water management: The dashboard must be communicated and promoted as an operational tool for steering and monitoring the implementation of the quantitative management plan.
- Communication with the general public: The dashboard remains a technical tool, which means that it is difficult to disseminate to the general public. It is therefore advisable to produce a summary of the dashboard in a more didactic format. In addition, newsletters, articles and news items using non-expert language will also help to keep the public informed of quantitative management plan implementation throughout the year.

Box 17 Observatory and dashboard of agricultural practices
France, Quantitative management plan (PTGE) of Sèvre Niortaise Mignon – Chambre d'agriculture des Deux-Sèvres et Société Coopérative Anonyme de l'Eau des Deux-Sèvres

The Observatory of Agricultural Practices and Actions in Favour of Aquatic and Terrestrial Biodiversity is run by the Chambre d'Agriculture des Deux-Sèvres and the Établissement Public du Marais Poitevin. The Observatory has four objectives:

- To identify the crop rotation in the perimeter of the quantitative management plan (PTGE) and the volume of irrigation of crops planted by irrigators.
- To monitor water quality in drinking water catchments.
- To learn about the agricultural practices and actions implemented to promote aquatic and terrestrial biodiversity through the individual commitments of irrigating farmers.
- To present biodiversity issues and priority areas for action.

#18 Validate the programme of actions

The action programme should be consensual and validated by stakeholders. The approval of the action programme by all stakeholders is an essential stage in the process of securing funding.

Level of participation: Consultation and information

Objective: Validation of a programme of actions on quantitative water management by stakeholders

Approach: Working session with stakeholders and information to citizens

- Present the co-constructed programme of actions, including the timetable, the budget, and the person in charge, supported by financial, economic, and technical elements and, if necessary, by regulations.
- Make available to the public the elements explaining and justifying the co-construction of the programme of actions, together with the context and objectives. Ensure that the public can express opinions or requests (e.g. by providing an e-mail address to receive feedback).
- Provide a summary of the opinions together with the document explaining the reasons for the decision.

#19 Periodically adapt the programme of actions

The programme of actions should be adapted periodically. The monitoring committee will decide on the follow-up of the quantitative water management plan:

- Termination of the quantitative water management plan if a sustainable quantitative balance is achieved.
- Update of the quantitative water management plan with updated actions (abandonment or continuation of certain actions, identification of new actions).

It is recommended that this update of the quantitative water management plan be carried out within a few months following the full assessment.

If the actions are substantially modified, the new quantitative water management plan will be subject to an adoption procedure adopted by the Steering Committee.

If hydrological and hydrogeological data and knowledge improve during the implementation of the quantitative water management plan (new hydrometric station, improved reliability of low-water data, acquisition of minimum 5-year data chronicles, etc.), the Steering Committee may be able to update some actions of the quantitative water management plan in the light of the reassessment of values such as the quantitative objectives to be reached.

Lessons learnt from Armenia: The Kazakh case study

Within the EU4Environment programme, it was proposed to develop a local quantitative water resources management planning experience for Kazakh sub-basin in Armenia. Lessons learned of this pilot experience can be later included as a mandatory component of each RBMP and or inspire future legislative reform.

The Kazakh basin is located in the Aragatsotn, Armavir, and Kotayq regions, and very partially in the Lori and Shirak regions of the Republic of Armenia. The length of the Kazakh river is 89 km, and the catchment area is 1480 km². The sources of the Kazakh River are three tributaries, of which Karaghbyur, Dazkend and Tsaghkahovit.

In this Quantitative Water Resources Management Plan for Kazakh Sub-basin of Armenia, the main tools for assessment of water deficit and water saving objectives are ensuring the preservation of environmental flows. The way it is determined is a key factor, which vary from countries and their data and knowledge availability context.

Monthly environmental flow is being approached in Armenia using a standardized hydrological calculation presented in the provisions of RA Gov't Decision 57-N from January 25, 2018, (non-official translation below):
When estimating the value of the environmental flow in the areas of the currently operating hydrological observation points of the studied rivers, the average discharge of 10 consecutive days with the multi-year lowest discharge in the winter period is taken as a basis.
Taking into account the fact that there are no hydrobiological, hydrogeological and hydrochemical monitoring data in the rivers of the Republic of Armenia, the monthly values of the environmental flow at the hydrological observation point are determined by adding to the average discharge value of the 10 consecutive days with the lowest discharges in the winter period, the multi-year natural minimum average monthly of the given month 1/3 of the output value, 33%, which is a "safety factor", ensures the hydromorphological, oxygen and thermal conditions of the river, which ensure the survival and reproduction of aquatic organisms. If the monthly calculated value of the environmental flow is greater than the value of the natural minimum flow of the given month, then the value of the natural minimum flow of the given month is selected as the environmental output. In the case of reservoirs with a volume of 20 million sq. m and more, when determining the environmental discharge, the average discharge of 10 consecutive days with the lowest discharge during the multi-year winter period is taken as a basis.

Lessons Learned from the Pilot Study

- Successes:
  - Delineation of the Kazakh in 8 sub-basin areas closed by 8 nodal points. With the calculation of the reference flows in these nodal points and introduction of real time monitoring, this opens the possibility to enter in a more proactive management of water uses, that can be further focused in water deficit periods (dry period where irrigation takes place) and draught risk management. The calculation of specific thresholds for taking decisions on limitations of water use (alert system) has been done and open the possibility to development draught risk management procedures and organization to be run by the water department if the thresholds are broken. The same king of approach could be develop by the monitoring teams for flood even if usually the measurement of high waters and low waters required specific approaches.
  - A data management test has been run successfully by OIEAU data management team in collaboration with Hydromet in order to test the feasibility of real-time monitoring and analysis of water flow at key nodal point versus the set thresholds. More political impetus is advised to

support effort for real-time transparency of data produced, that allows a very important gain in the cost efficiency of the public money invested in monitoring.

- A programme of measures on achieving more efficient quantitative water resources management has been proposed. On top of it, the structure of the program of measure table has been worked out as a model to initiate a harmonized program of measure data base. This tool opens the possibility of developing implementation monitoring at both national, basin and local scale so the connection with financing mechanism can be better work out in particular.
- Preparation of an information at a scale adapted to stakeholder involvement and engagement in concrete measures implementation. Nevertheless, this can be seen as an extra effort and necessary work intensive, which should be reserved to area where quantitative tension is the most acute.

□ Challenges:

- The current ecological flow calculation formula in use in Armenia has the advantage of a standardized approach, but face the important limitation that it does not reflect the diversity of the cases or integrate field observation of ecological needs from reference species. It is advised to revised it based on the international best available practice. In practice to be open to the possibility of using different value than the current threshold calculation formula when more precise information and argumentation can be made available. The reform would simply open the possibility to the revision based on a decision-making process backed up by various alternative hydrological calculation (QMNA5, and/or hydrobiological assessment if evidence based on university research work can be provided).
- The current groundwater monitoring network as proved not to be adapted to give a clear view on ground water bodies quantitative status in Kazakh sub-basin. This is needed for RBMP and to identify in which water table deteriorated conditions can be observed resulting from groundwater overuse. On top of it, the potential feeding of the adjacent Ararat valley areas from the deep-water flow through porous lava stone region would need to be further investigate.
- The improvement of knowledge on water balance and real-time assessment at nodal point should open the way to the improvement of water use permitting practices, including reform suggested at dedicated workshops for focusing more the efforts of the bigger users and better take into consideration of the cumulative effect of water use permit on a single properly monitored sub-basin or groundwater body.
- Moreover, for surface water, the pertinence of in-basin water storage versus water transfer through canals would need to be studied more deeply, including a multi-sectoral vision rather than limited to the agriculture sector only. Tentatively, the use of water in the Kazakh basin could be thought considering the touristic vocation of the basin. With more water passing through it and maintaining its ecological value generating potentially higher touristic attraction and related revenues from visitors. On the contrary less agriculture development in the sub-basin (so less water consumption) could be a way of resorbing water deficit in downstream region?
- Acting Hrazdan River Basin Management Plan, that covers Kazakh basin area, demand as well important effort to be properly run including developing resources for stakeholder engagement trough a basin committee to be run by an active RBO secretariat. National authorities could logically concentrate efforts in RBM Planning process consolidation and deepening during the present cycle, when local authorities could get prepared to progressively take in hand local thematic planning in order to work on the definition and the programming of the implementation of complex measures based on the use of quantitative management tool.

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Appendices

Appendix 1: Strategies of Quantitative Water Management Planning in Eastern Partnership Countries

Table 13 provides a non-exhaustive list of strategies on quantitative water management planning adopted by Eastern Partnership Countries.

The EaP countries have made significant progress in several areas of water policy reform. Since 2016, the European Union has assisted in the refinement or development of River Basin Management Plans for 11 pilot river basins. Regular multi-stakeholder National Policy Dialogues (NPDs) and peer-to-peer international exchanges have enabled the implementation of water sector reforms. Transboundary cooperation has been ongoing in the Kura and its sub-basins, including the Khrami-Debeda, Neman, Dniester/Nistru, Western Dvina/Daugava, and Danube River basins. The development of data management platforms in the six countries has led to increased transparency and access to water information. The EaP countries are working to align their water indicators with those set out by the EU and with best international practice. Furthermore, the ratification and implementation of Multilateral Environmental Agreements (MEAs) has progressed, and river basin management plans are coordinated in some transboundary basins.

Table 13 Strategies of quantitative water management in Eastern Partnership countries

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T. I. Adamenko, A. O. Demydenko, M. I. Romashchenko, A. M. Tsvietkova, A. M. Shevchenko, M. V. Yatsyuk	UA	Global Water Partnership	Rethinking of water security for Ukraine based on results of national policy dialogue	2016	https://www.gwp.org/globalassets/global/gwp-cee_files/regional/rethinking-water-security-ukraine-2016.pdf
Nataliia Kovshun1, Nataliia Savina, Mamadou Alouma Diallo, Nina Kushnir, Dong Zhiwei, and Vitalii Zoshchuk	UA		Principles of creating a system of sustainable water use in Ukraine	2021	https://www.e3s-conferences.org/articles/e3sconf/pdf/2021/56/e3sconf_icsf2021_10007.pdf
Dr Jai Clifford-Holmes	UA	Global Water Partnership	How water resources management can support climate-resilient development in Ukraine	2021	https://www.gwp.org/globalassets/global/about-gwp/publications/country-briefs/ukraine.pdf

AUTHORS	COUNTRY	ORGANISATION	TITLE	YEAR	LINK
	AZ	EUWI+	Updated terms of references for local contractor for preparation of a water allocation strategy with detailed assessment of existing and forecast resources and demands and options to meet any deficits in Ganikh (Alazan, Gabirri (Iouri) and Upper Kura pilot basins of Azerbaijan	2019	https://www.euwipluseast.eu/images/2019/TENDERS_DOC/D_Terms_of_reference_AZ09_YP_DEADLINE_EXTENSION.pdf
Winston Yu, Rita E. Cestti, and Ju Young Lee	AM	World bank Group	Toward integrated water resources management in Armenia	2015	https://documents1.worldbank.org/curated/en/433731468218409267/pdf/Toward-integrated-water-resources-management-in-Armenia.pdf
Mr Christoph Leitner, Ms Florence Pintus	AM	EUWI+	Guidance document for establishing and updating river basin management plans in Armenia	2017	https://www.euwipluseast.eu/images/2021/04/PDF/EUWI_AM_guidance_document_RBMP_2017_EN.pdf
	MD	OECD	An outlook of Moldova's water policy journey to 2030		https://www.oecd-ilibrary.org/sites/1c95e536-en/index.html?itemId=/content/component/1c95e536-en
Nihat Zal (EEA), Lidija Globevnik (ETC/ICM), Kari Austnes (ETC/ICM) and Gašper Šubelj	REG	European Environment Agency	Water availability, surface water quality and water use in the Eastern Partnership countries, an indicator-based assessment	2020	https://www.eea.europa.eu/publications/regional-water-report
	MD	UNDP	The Water Law, adjusted to European standards, is becoming an efficient instrument in managing water resources	2023	https://www.undp.org/moldova/news/water-law-adjusted-european-standards-becoming-efficient-instrument-managing-water-resources
	MD	The World Bank	Moldova: Water security and future outlook	2020	https://thedocs.worldbank.org/en/doc/7bf12b95f10a3daf7b570718b2100e15-0080012021/related/MEU-Water-Special-Note-May-2021-FINAL-eng-Copy.pdf
Smets, Susanna; Midgley, Amelia; Mao, Zhimin; Vladicescu, Veaceslav; Neumann, James E.; Strzepek, Ken; Pricop, Felicia	MD	The World Bank	Moldova: Water security diagnostic and future outlook	2020	https://hdl.handle.net/10986/34809

AUTHORS	COUNTRY	ORGANISATION	TITLE	YEAR	LINK
Daniela Burduja, Petru Bacal	MD		Regional aspects of water use and management in the Republic of Moldova	2023	https://cejgsd.org/CEJGSD_2023-05/02/article/04/62-84_fulltext.pdf
Daradur M., Cazac V., Josu V., Leah T., Lopotenco V., Rajendra P. Pandey, Shaker R., Talmac I., Caisin V., Isac A	MD	UNCCD Drought initiative	National Drought Plan of the Republic of Moldova	2019	https://www.unccd.int/sites/default/files/country_profile_documents/Drought%20Plan%20ENG%2020%20June%20%2C%202019.pdf
	GE	UNECE	Overview of implementation of the water-related directives implemented in Georgia in line with the EU-Georgia association agreement, scenarios for the water sector reform, and progress monitoring indicators in the water sector (as of January 2024)	2024	https://unece.org/sites/default/files/2024-03/GE%20water%20outlook_2021-24_fin.pdf
	GE	OECD	Developing a water policy outlook for Georgia		https://www.oecd-ilibrary.org/sites/4e4ec92d-en/index.html?itemId=/content/component/4e4ec92d-en#section-d1e2816
	GE	EUWI+	The law of Georgia on water resources management	2019	https://euwipluseast.eu/images/2021/07/PDF/Draft_Water_Law__ENG_2019_March_clean_with_cover_page.pdf
	GE	USAID	Governing for growth - Georgia	2017	https://www.hydroc.de/governing-for-growth-g4g/

Appendix 2: Stakeholder typology

IWRM actors in Eastern Partnership countries (source: EUWI+):

- Armenia
- Azerbaijan
- Georgia
- Moldova
- Ukraine

Stakeholder engagement processes (source: EU4ENV water and data):

- Armenia
- Azerbaijan
- Georgia
- Moldova
- Ukraine

The term "**stakeholder"** refers to all individuals or legal entities who have an influence on the quantities of water available or used, and who are affected by the availability of the resource.

Certain stakeholders in water management may be described by a country's laws and regulations. The analysis of legal texts will seek to establish an inventory of the competent structures and to specify the following elements:

- Structure designation
- Reference texts and work in progress
- Mission and nature of intervention
- Number and location
- Budget sources and resources

The legislative process that makes it possible to describe the bodies, specify how responsibilities are shared and interconnected, and size the resources allocated to these bodies, is long and complex. The resulting organisation is akin to the **governance of quantitative water management**. Governance is thus an instrument of water policy, characterised by its objectives, resources and performance.

Legislators

A brief description will be produced featuring the actors involved, the legislative process, and the stages leading to the preparation, presentation and validation of a law. This information can then be used to follow, understand and possibly interact with the construction of water policy and governance.

In order to provide a clear understanding of the progress and dynamics of water regulation, the key events in the history of water regulation will be described, along with a list and timetable of current legislative initiatives.

The state and its representations at sub-national levels

It is important to emphasise the importance of the state's role as planner, in order to promote the initiation of quantitative management approaches and encourage their emergence, in view of quantitative issues (territories with a quantitative deficit, under pressure, or subject to a water storage or transfer project), or to identify the need for dialogue between stakeholders.

The state must ensure that the information and studies gathered throughout the process are transparent, and encourage feedback from other regions. It must also ensure that actions are monitored during the implementation phase of the quantitative resource management approach.

Financers

The quantitative management of water resources can be financed by a variety of sources: direct and indirect users, local authorities, private financiers, basin agencies and international donors. The steering committee must be made aware of the criteria specific to each funder very early on in the process, to ensure that the actions envisaged are realistic.

Water users and their representatives by thematic and geographic sector

- The ecosystem – a silent but sensitive player in major environmental balances:
  - Streams, forests, wetlands, etc.
  - The tropical chains attached to them.
  - The characterisation of states and indicators.
  - The functions they perform for humans.
  - The need for water to maintain their equilibrium and their ability to perform their functions.
- Water and wastewater utilities and their users.
- Actors who use water as an input to perform various functions:
  - Agricultural or fish farming food production (at different scales).
  - Energy production.
  - Industrial production designed to satisfy different types of needs on different scales (possibility of distinguishing between a function designed to satisfy the needs of a territory and an economic production function).
- Actors who use water as a support for navigation.
- Actors who use water as a support for tourist activities.
- Citizen actors who live within the watershed perimeter.
- All citizens whose equilibrium and quality of life are closely linked to the balance and proper functioning of natural ecosystems.

Organisations producing information and data

Knowledge, data, indicators, thresholds, know-how, rules, etc.: we need to distinguish these terms to determine how information is used and how it is produced.

Depending on the nature of the information, more attention should be paid to the reference work (for knowledge relating to phenomena, mechanisms or techniques) or to the actor involved in a process (actor / tool / practice) who is responsible for producing the information (monitoring data).

The list below could represent a typology of information producers:

- Information systems architecture.
- Standards producers.
- Producers of reference systems and general data on resource identification and characterisation.
- Producers of periodic monitoring data on resource status.

- Producers of meteorological monitoring data (rainfall, ETP, temperatures, hygrometry, wind speed and direction, etc.).
- Producers of climate forecasts.
- Producers of forecasts of resource availability taking into account climate scenarios.
- Producer of reference systems and knowledge on the functioning, techniques and needs associated with the various uses of water.
- Producers of data for monitoring the water needs, withdrawals and consumption of different user categories (uses).

Appendix 3: Global open data sources

Table 14 provides a non-exhaustive list of global data sources available to the general public. Public data freely available online provide basic information for characterising basins and sub-basins. The proposed method consists in using homogeneous data available worldwide, and then refining them with better quality data (better spatial resolution, more relevant typologies, better-mastered data sources and production methods) produced at national or sub-national levels.

A level of precision is assigned to the data sources listed below, based on the following criteria:

- Resolution of spatial data
- Length of time ranges of climatological data
- Geographical coverage

Table 14 Non-exhaustive list of global data sources available to the general public

Data type	Source	Level of precision	Description
Topography	Shuttle Radar Topography Mission (SRTM)	+++	Altimetry data acquired by the Space Shuttle to generate a 90m resolution digital topographic database on a near-global scale.
	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	++	Near-global digital elevation model between latitudes 83N and 83S with 30-metre recordings.
Watersheds	Hydrosheds	+++	Series of vectorised polygons representing the contours of basins and sub-basins worldwide. Low resolution (500m).
	FAO	+++	Data and maps of the world's largest watersheds from HydroSheds and Hydro1K. Resolution of 15 arc seconds (500m) between latitudes 60N and 60S, and 30 arc seconds (1km) for higher latitudes.
	Catchment Characterisation and Modelling (CCM)	+++	Geographic database containing rivers and watersheds of Europe from the Atlantic ocean to the Ural mountains. The tool, developed by the Commission's Joint Research Centre, can be used to study cause-effect relationships of environmental processes where river networks or drainage basins (catchments) play an important role.
The rivers	Hydrosheds	+++	Worldwide hydrographic dataset. Low resolution (500m).
	Global surface water explorer	++	Data, maps and information on the spatial and temporal distribution of surface water resources over the last 38 years on a global scale.
Aquifers	Global Groundwater Information System (GGIS)	++	Interactive portal for sharing data and information on the world's groundwater resources. Access to map layers, documents, wells and piezometric monitoring. Also includes several thematic maps.

Data type	Source	Level of precision	Description
	World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP)	++	Gathers data, maps and information on groundwater resources.
Soil properties	FAO/UNESCO soil map of the world	++	Global and continental soil mapping (1:5,000,000).
	Harmonised World Soil Database (HWSD) v2.0	++	Comprehensive inventory of soil properties (morphology, physico-chemical characteristics) with a resolution of 1 km worldwide.
	Soil and Physicographic database for North and Central Eurasia	++	Database of physico-chemical properties of soils in Eurasia.
Rainfall	Climate Change Knowledge Portal - World Bank	+++	Historical climate data and future projections modeled at country and watershed scales over long time periods (>30 years).
	AQUASTAT - FAO	+	Estimation of annual precipitation with spatial distribution at 19km resolution for the period 1961-1990.
	USGS	++	Near real-time rainfall data available within 3 hours of satellite observation. Resolution between 1km and 15km. Worldwide scale.
	Global Precipitation Measurement (GPM)	+++	Precipitation data from the GPM and TRMM missions are made available free to the public in a variety of formats from several sources at NASA Goddard Space Flight Center.
Evapotranspiration	USGS	++	Modelled with satellite instruments on the basis of variables such as land cover, soil and air temperature, and solar radiation. Resolution between 30m and 500m.

Data type	Source	Level of precision	Description
Modelling the effects of climate change	Climate Change Knowledge Portal - World Bank	+++	Historical climate data and future projections modeled at country and watershed scales over long time periods (>30 years).
	MFI	+	Global climate change indicators from FAOSTAT. Data by country at annual scale for periods longer than 30 years.
Land use	ESA	+++	Land cover data and mapping for 2020 and 2021 at 10m resolution, based on Sentinel-1 and Sentinel-2 data, worldwide.
	USGS	++	A set of models derived from NASA observations, with resolutions ranging from 15m to 1km, on a global scale. Observation of land cover and vegetation (see "GLCC" under "Land Cover", or "MODIS Land Cover v6" under "NASA LPDACC Collections").
	Copernicus Global Land Service	++	Worldwide land cover data (forests, cultivated areas, grasslands, lakes, wetlands, etc.) at 100m resolution.
	FAO	++	Land use database with a spatial resolution of 30 arc seconds, worldwide. Data available in GeoTIFF format in the WGS84 coordinate system.
Water withdrawals	OECD	++	Data on surface and groundwater withdrawals for supply to distribution networks, irrigation, industrial production and power plant cooling worldwide. Data range from 1970-2021.

Appendix 4: Methods to analyse rainfall and runoff volumes

The characterisation of runoff volumes aims to provide indicators of water volume and flow at different points in the catchment and at different seasons, in order to understand the hydrological regime. It is essential to describe the situation during low-water periods, based on the flow volumes over different durations, the return frequencies and the duration of rainfalls. This low-water hydrology (characterised by flows such as QMNA5, VCN10, Q99) can then be compared with the minimum flows featuring in the regulations governing instream flows.

An equivalent analysis should be carried out for precipitation – which can vary significantly from one year to the next – and potential evapotranspiration. These characteristics should also be linked to the geological and hydrogeological information available.

The parameters to be studied are:

- The **modulus** (average flow over several years) at various points on the gauging stations in the basin
- **Low-water flows**: several characteristic values can be used:
  - **QMNA**: mean monthly low-water flow. This is used to statistically assess the lowest flow in a river over a given period. The most common QMNA is QMNA5.

    QMNA5 is the minimum monthly flow with a 1/5 probability of not being exceeded in a given year, i.e. the value of the QMNA such that it occurs, on average, only one year in five or twenty years per century.
  - **VCNx**: lowest average flow recorded over a consecutive period of x days. The probability of occurrence (return period) can be calculated by statistical analysis based on a statistical law. The value of the VCN provides information on the drying-up of rivers. The number next to it indicates the number of consecutive days for which it is expressed (VCN30, the lowest average flow for 30 consecutive days). Unlike the QMNA5, it is calculated over a period of any 30 consecutive days, and can therefore straddle 2 months (e.g. from September 9 to October 8).

    VCN10 is the minimum annual flow calculated over 10 consecutive days.
  - other indicators of low-water severity or seasonality or intermittence

    Q99, Q97.5, Q95 and Q90 are the values that are exceeded 99% (97.5 / 95 / 90) of the time over the entire measured flow chronicle.

  Hydrological methods establish threshold values curves (Q99, Q97.5, Q95 or Q9012), or on average flow values associated with durations (VCN7 with a ten-year return period), or on the percentage of a value characteristic of the hydrological regime (30 to 75% of average minimum monthly flows with a five-year return; 2.5 to 50% of the mean interannual flow).

  These values can be calculated for annual, bi-annual and five-year return periods.
- The **ratios between these characteristic low-flow values and the modulus** (to compare rivers in the watershed).
- The **average and variability of annual precipitation and evapotranspiration** (to draw up an initial table of hydrological balances).

The different expressions for flow are:

Q = flow (m^3/s) (or L/s when flows are very low)

D = Specific flow: flow Q (m^3/s) divided by the surface area of the drainage basin S (km^2) at the point where the flow is measured.

$$D\ (m^3/s/km^2) = Q / S$$

P' = Depth of runoff, an expression used to compare flow with rainfall over a period of duration T

$$P' = D \times T$$

On a yearly scale :

$$P'\ (mm) = Q / S \times (365\ d * 24\ h * 3600\ s) * 10^9 * 10^{-12} = Q / S \times 31536$$

Flow	Annual flow in the basin (mm/year)
Precipitation	
Evapotranspiration	

Flow	Hydrological station 1	2	3	4
Flow (converted into depth of runoff: mm/year)				
Flow/Precipitation (%)				
Low flow (number of days under a reference flow rate) *				
QMNA or other low-water flow				

*: *This number of days varies according to the reference flow chosen (QMNA5, VCN10, 10th of the modulus, etc.). The threshold flow must be the same for each station, the aim being to carry out an initial characterisation and comparison of the behaviour of the various catchment areas.*

The ratio of flow to precipitation is used to estimate the proportion of precipitation that feeds directly into river flow. The number of low-flow days enables an initial identification and comparison of the behaviour of the basins to which the hydrological stations are attached. This approach requires selecting a reference flow to characterise the low-water period (QMNA5, VCN10, 10th of the modulus, etc.).

Source: [67] Minimum Ecological Flow and quantitative water resource management (FR)

[68] Low water-flows, OFB (FR)

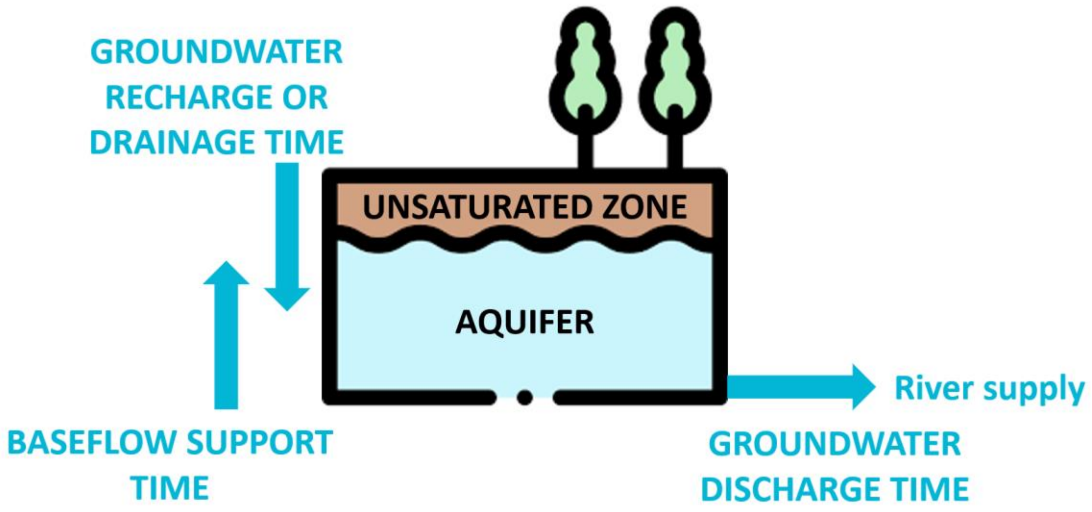
Appendix 5: Methods to assess the contribution of the aquifer

To characterise system dynamics, the contribution of the aquifer should be assessed. This approach requires estimating the time it takes for aquifers to discharge in order to support the watercourse(s), particularly during low-water periods. The general idea is therefore to determine the number of days during which an aquifer supports the base flow of a river, even without the addition of meteoric water (i.e. water from atmospheric precipitation that has not yet reached the earth's surface).

The flow of a river at the outlet of a watershed integrates the flows coming from the various storage areas in space and time. Aquifer systems generate the bulk of slow flows and baseflow support. Thus, in terms of water quantity, the contribution of aquifer systems, however slow, is highly significant.

The parameter to be studied is the **average number of days the water table supports the river**.

The method for extracting base flows and calculating **discharge time** is based on the analysis of flows. Discharge times can be analysed in relation to groundwater levels measured by piezometers, where available.



In practice, the following steps should be followed:

- Calculate effective daily precipitation as P (precipitation) – ETP (potential evapotranspiration).
- Select the set of periods during which P-ETP is negative or zero (period with no infiltration to the water table), in order to concentrate on periods when groundwater flows contribute to the river.
- Delete the first 10 days of each period, since the initial decrease in flow also includes residual contributions of surface runoff.
- For each selected period, draw the flow decrease as a function of time.
- For each selected period:
  - set a decreasing exponential model: $Q(t) = Ae^{\frac{-t}{\tau}}$
  - or use the linear form of the 1/τ slope model: $\ln Q(t) = \ln A - 1/\tau$

The discharge time τ, is of the order of several tens of days.

Then calculate the median/average emptying time for all selected periods. To obtain a good estimate of the discharge time, the following are required:

- sufficiently long series, the quality of the estimate depending on the length of the low-water periods analysed,
- a minimum of 10 low-water periods, as there is considerable variability between these periods.

The most relevant information is not so the value of the groundwater discharge time per se, but the comparison of groundwater discharge times between sub-basins, which will enable us to estimate, within the same basin, the areas where the underground structure limits the water supply to rivers.

Groundwater discharge time provides direct information on the capacity to support base flows. Thus, after a period without precipitation equivalent to the discharge time, the flow is greatly reduced compared to its starting point. After a period without precipitation, equivalent to three times the discharge time, flow can be considered negligible (flow divided by around 10). This discharge time, also known as "water diffusion time", is directly linked to the geometric (surface) and hydrodynamic characteristics of underground media (transmissivity and porosity). It is generally linked to the storage capacity of the aquifer system, and therefore to the total volume that can support the river's base flow. This discharge time is therefore directly linked to the physical and hydrodynamic characteristics of the underground environment. These interpretations of discharge time clearly show the importance of the phasing of aquifer recharge events in sustaining base flows after a certain number of rain-free days. Modelling may therefore be of interest at this stage in order to introduce temporal information to better quantify low-water flows.

Source: [67] Minimum Ecological Flow and quantitative water resource management (FR)

Appendix 6: Methods for hydrological modelling

Modeling the hydrosystem enables water practitioners to estimate the maximum volume that can be abstracted, while respecting characteristic flow thresholds. Taking into account the complexity of a hydrosystem is only possible with a numeric model, which can be either spatialised or global (the choice depends on the objectives of the model).

Analytical solutions: These can be used to calculate the flow subtracted from the watercourse at time t after the start of pumping, which is considered to be the damage caused to the river. The USGS STRMDEPL08 software package can be used to perform calculations based on a number of solutions. It can be downloaded from: http://mi.water.usgs.gov/software/groundwater/strmdepl08/index.html

Numerical models:

- Mesh models (spatialised): These models are based on physical equations that explicitly describe groundwater flow and, where applicable, also describe exchanges with watercourses. Among the software packages supporting spatial models and which have been used in studies of large basins are MARTHE (BRGM, see bibliographical references), MODCOU (École des Mines de Paris), MODFLOW (widely distributed), MIKE SHE (DHI), SIM.
- Global models: These models use a physical concept to represent the functioning of the hydrosystem, e.g. an assembly of reservoirs in hydraulic connection, via simplified laws. Examples of software include GARDENIA (BRGM) and its BICHE extension for simulating nitrate transfers, GR4J (CEMAGREF), and CREC (LNH-EDF).

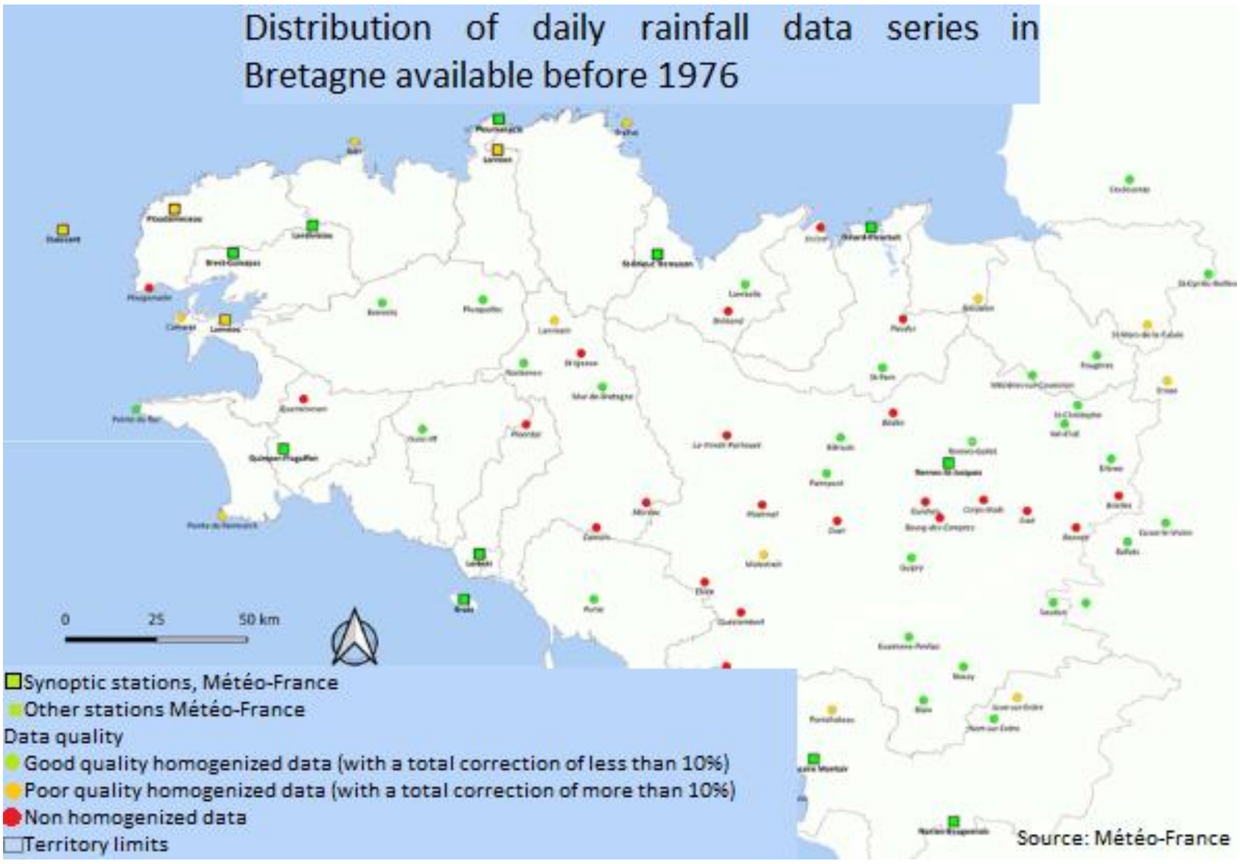
Source: [69] Contribution to the characterisation of interactions between groundwater, surface water and associated ecosystems in relation to the WFD, BRGM (FR)

Appendix 7: Climate assessment methods for water resources

In practice, the following steps should be followed:

- Data acquisition:
  - Select data series: Type of data (daily precipitation, minimum and maximum monthly temperature, monthly evapotranspiration, monthly global sunlight, etc.), Quality of data (series length, uninterrupted series, etc.).
  - Verify and prepare data: Check that data series are not interrupted, fill in missing data, and prepare data series over various time periods (daily, monthly, hydrological season, hydrological year, etc.).

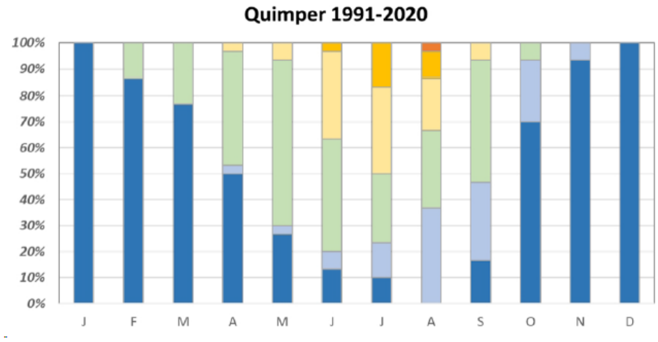
A good distribution of gauging stations across the territory is essential to obtain representative data, such as the rainfall stations shown on the map below (upstream/downstream distribution, coastal/inland distribution, relief).



- Assessment of past data:
  - Describe the current climate to better understand the local climate and define “at-risk” sectors on the territory: spatialisation of rainfall patterns in the region, distribution of rainy days, importance and distribution of heavy rains, indicators (average total, number of rainy days, etc.).
  - Define and quantify flood and drought risks in the territory and identify their evolution: implement a probabilistic approach to quantify extremes, a climatic approach to the risk

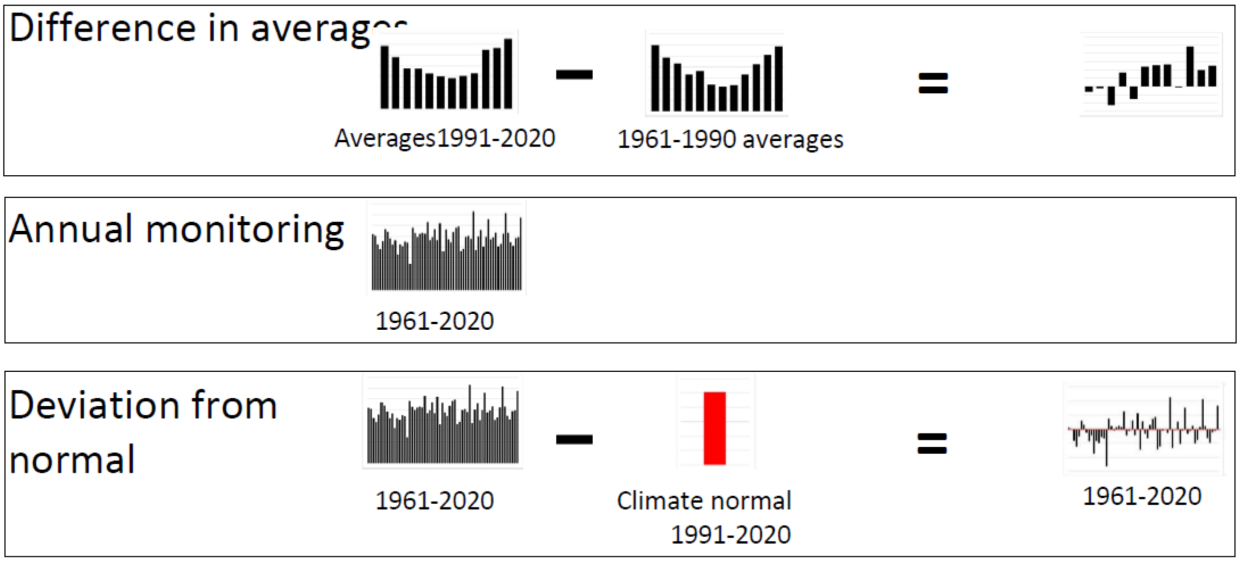
of flooding by exceeding rainfall thresholds, a climatic approach to drought risk based on the water balance.

Example of representation of the evapotranspiration deficit frequency over 30 years:

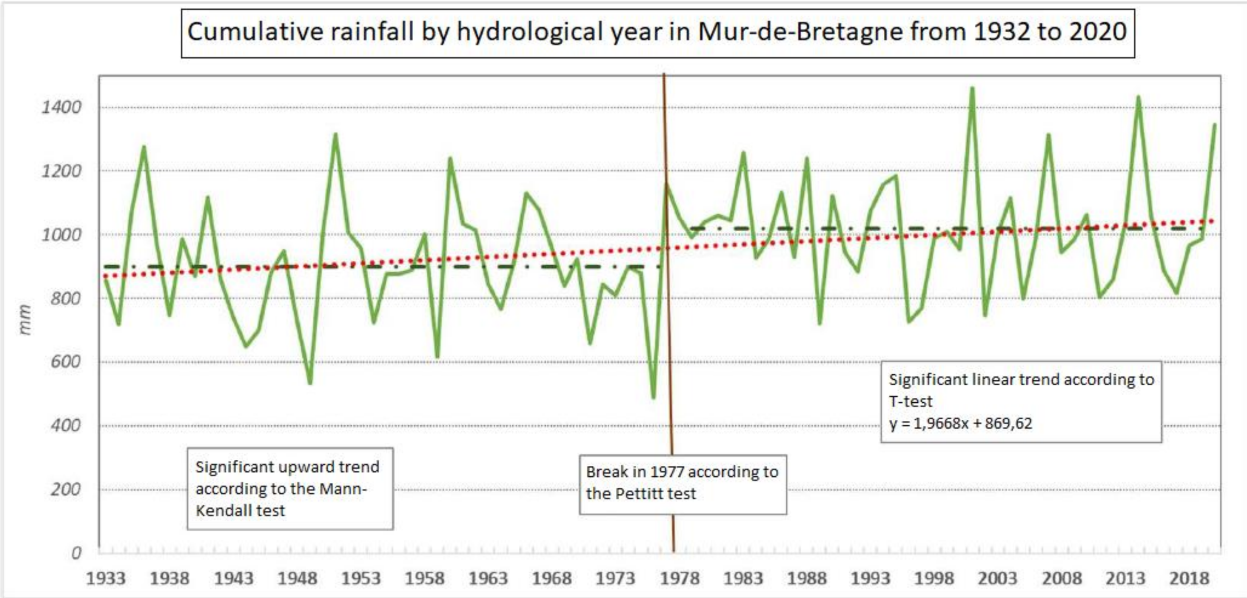


	ARID	P<ETP and DE>100
	DRY	P<ETP and 60<DE<=100
	SUB DRY	P<ETPand30<DE<=60
	LOW DEFFICIENCY	P<ETP and DE<=30
	HUMID	P>=ETP and RU <> RU0
	HYPER HUMID	P> ETP and S>0

- Describe climate trends over the historical period and identify annual, seasonal and monthly trends: evaluate rainfall trends (cumulative rainfall and number of days of rain), assess rainfall intensification.

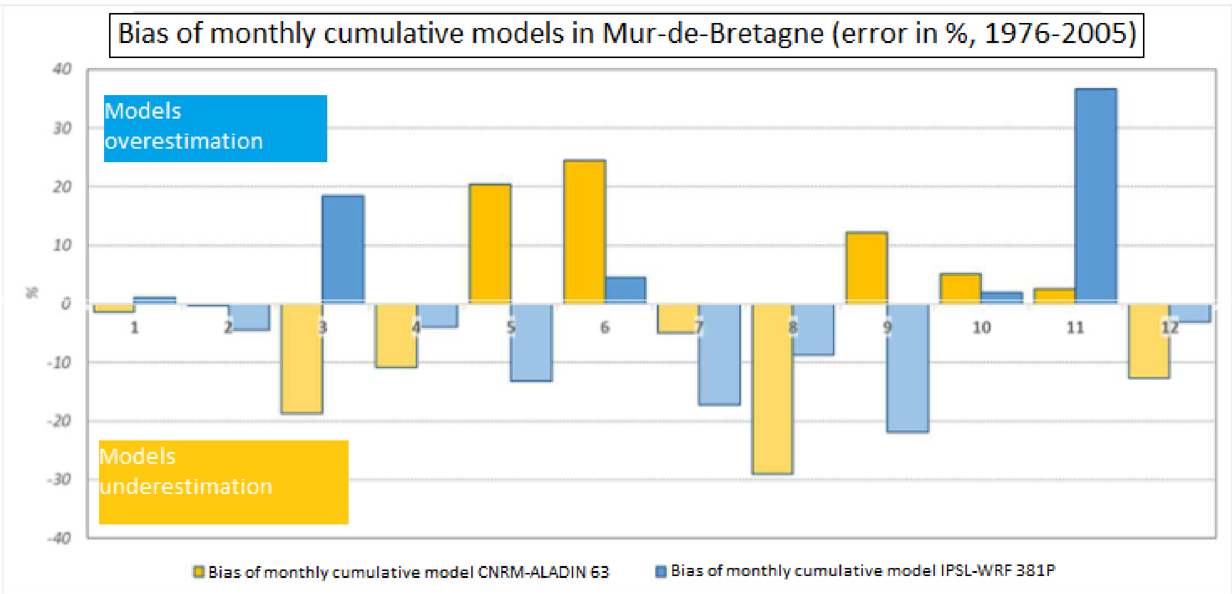


It is essential to test the significance of trends using statistical tests such as: T-test, Mann Kendall test, Pettitt test.



- Assessment of future data
  - Data extraction.
  - Bias correction: calculate and correct model biases.

Example of data correction based on average differences between modelled and observed data from 1976 to 2005:



  - Future trends (short-, medium- and long-term): Identify trends according to different scenarios and climate models, Identify convergences and divergences in trends according to models.
  - Future risks: drought, flooding.

Source: [70] A methodological approach to territorial climate diagnosis under the "water resource" dimension (2021) (FR)

Data: Global Precipitation Measurement

Appendix 8: Methods to determine minimum flow values

Several methods can be used to define ecological minimum flows. These methods differ mainly in terms of the way they integrate ecological aspects, scale, complexity and data requirements. Selection of the most appropriate method depends on the resources available and the severity of pressures. Purely hydrological methods may be a reasonable solution to cover the whole river basin; a more detailed approach will be required to take specific measures likely to have an impact on socio-economic aspects.

Table 15 Methods to help determine minimum flow values (source: Barran P., Larinier M., Courret D., ONEMA)

	Hydrological methods	Hydraulic methods	Habitat methods
Description	Analysis of the natural hydrological cycle and characteristic values for low-water conditions.	Study of variations in hydraulic parameters and water surface area as a function of flow rate.	Cross-referencing a given flow rate with preferences for one or more target species at different stages of development.
Method objective	Define threshold values to set a minimum flow rate proportional to the natural situation in order to guarantee a minimum level of disturbance.	Define a minimum flow value above which hydraulic characteristics (especially depths) and water surfaces decrease significantly.	Choose the flow value most favourable to the species in the watercourse.
Data	- Relatively long (more than 10 years) hydrological reference periods (little disturbed by withdrawals) in the basin concerned or in a basin with similar characteristics. - Average flow values associated with durations - Variability of low-water conditions (inter-annual variation values)	- Average speeds and water levels - Wetted widths - Wetted perimeter	- Knowledge of species and their development stages, as well as their preference for hydraulic conditions and substrate. - Measurements of flow, velocity and mean water level
Interest	- Quick, easy approach - Good description of low-flow situations, enabling a real comparison with the situation modified by an abstraction project.	- Takes into account the specific morphology of watercourses (slope, bottom roughness, bank shape) - Include elements of river sensitivity to flow reduction	- Integration with the hydrological cycle to define limiting habitat durations within the perimeter
Limits	- The guide values are not based on hydromorphological, hydraulic or ecological criteria. - Requires good knowledge of flow cycles with relatively long records and hydrological situations with few low-flow disturbances.	- Requires appropriate choice of measurement sites and representativeness of measurements - Elements based solely on physical characteristics (relationship between hydrological regime and bed geometry). No biological criteria are taken into account	Conditioned by the choice of measurement sites and their level of representativeness, the choice of target species, and the quality of hydraulic modelling.

	- Does not take into account river morphology, which can influence the sensitivity of ecological communities		

Appendix 9: Methods to determine of crop water needs

Crop water needs could be expressed by the following equation:

Crop Water need = [ETo (monthly) *Kc (month, date planted, type of crop)] – Pe (monthly)

Reference evapotranspiration ETo

The **reference evapotranspiration (ETo)** is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. Grass has been taken as the reference crop. ETo is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall that grows actively, completely shades the ground, and is not short of water.

The FAO Penman-Monteith method is maintained as the sole standard method for the computation of ETo from meteorological data. Many software packages already use the FAO Penman-Monteith equation to assess the reference evapotranspiration. As an example, the output of CROPWAT, the FAO software for irrigation scheduling, is recommended.

Penman-Monteith equation $ETo = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}U_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$

Where:

- ET_o is the reference evapotranspiration [mm day^{-1}]
- R_n is the net radiation at the crop surface [MJ m^{-2} day^{-1}]
- G is the soil heat flux density [MJ m^{-2} day^{-1}]
- T is the air temperature at 2 m height [°C]
- U_2 is the wind speed at 2 m height [m s^{-1}]
- e_s is the saturation vapour pressure [kPa]
- e_a is the actual vapour pressure [kPa]
- e_s - e_a is the saturation vapour pressure deficit [kPa]
- D is the slope vapour pressure curve [kPa $°C^{-1}$]
- g is the psychrometric constant [kPa $°C^{-1}$]

The calculation procedure consists of the following steps:

- Derivation of some climatic parameters from the daily maximum (T_{max}) and minimum (T_{min}) air temperature, altitude (z) and mean wind speed (U_2).
- Calculation of the vapour pressure deficit (e_s - e_a). The saturation vapour pressure (e_s) is derived from T_{max} and T_{min}, while the actual vapour pressure (e_a) can be derived from the dewpoint temperature (T_{dew}), the maximum (RH_{max}) and minimum (RH_{min}) relative humidity, the maximum relative humidity (RH_{max}), or the mean relative humidity (RH_{mean}).
- Determination of the net radiation (R_n) as the difference between the net shortwave radiation (R_{ns}) and the net longwave radiation (R_{nl}). In the calculation sheet, the effect of soil heat flux (G) is ignored for daily calculations as the magnitude of the flux in this case is relatively small. The

net radiation, expressed in MJ m^{-2} day^{-1}, is converted to mm/day (equivalent evaporation) in the FAO Penman-Monteith equation by using 0.408 as the conversion factor within the equation.

- ETo is obtained by combining the results of the previous steps.

Source: FAO

Effective rainfall or precipitation (Pe)

If the **effective rainfall or precipitation (Pe)** is sufficient to cover the water needs of the crop, irrigation is not required. The effective rainfall should be estimated, bearing in mind that part of the rainfall is not effective as it percolates below the root zone (deep percolation) or flows over the soil surface as run-off.

The effective precipitation is estimated on a monthly basis, using measured rainfall data and a formula or table to determine the effective precipitation. This formula takes into account factors like rainfall reliability, topography, and prevailing soil type etc. If such formulas or other local data are available, they should be used. The table below could be used to obtain a rough estimate of the effective rainfall.

P mm/month	Pe mm/month	P mm/month	Pe mm/month
0	0	130	79
10	0	140	87
20	2	150	95
30	8	160	103
40	14	170	111
50	20	180	119
60	26	190	127
70	32	200	135
80	39	210	143
90	47	220	151
100	55	230	159
110	63	240	167
120	71	250	175

Crop coefficient (Kc)

The **crop coefficient (Kc)** mainly depends on:

- **The climate** (month): for example, in sunny, hot climates, crops need more water per day than in a cloudy, cool climates.

The daily water needs of the standard grass crop are also called "reference crop evapotranspiration".

Table 16 Average daily water needs of standard grass during irrigation season (in mm) (source: FAO)

Climatic zone	Mean daily temperature		
	Low <15°C	Medium 15-25 °C	High >25°C
Desert/arid	4-6	7-8	9-10
Semi arid	4-5	6-7	8-9
Sub-humid	3-4	5-6	7-8
Humid	1-2	3-4	5-6

- **The crop type**: crops like rice and sugarcane need more water than crops like beans and wheat.

The crop type may influence water needs in two ways:

- Daily crop water needs

Table 17 Crop water needs in the peak period of various field crops as compared to standard grass (source: FAO)

-30%	-10%	Same as standard grass	+10%	+20%
Citrus	Cucumber	Carrots	Barley	Paddy rice
Olives	Radishes	Crucifers (cabbage, cauliflower, broccoli, etc.)	Beans	Sugarcane
Grapes	Squash	Lettuce	Maize	Banana
		Melon	Flax	Nuts and fruit trees with cover crops
		Onions	Small grains	
		Peanuts	Cotton	
		Pepper	Tomato	
		Spinach	Eggplant	
		Tea	Lentils	
		Cacao	Millet	
		Coffee	Oat	
		Clean cultivated nuts and fruit trees e.g. apples	Peas	
			Potatoes	
			Safflower	
			Sorghum	
			Soybeans	
			Sugarbeet	
			Sunflower	
			Tobacco	
			Wheat	

- Duration of the total growing season of the crop

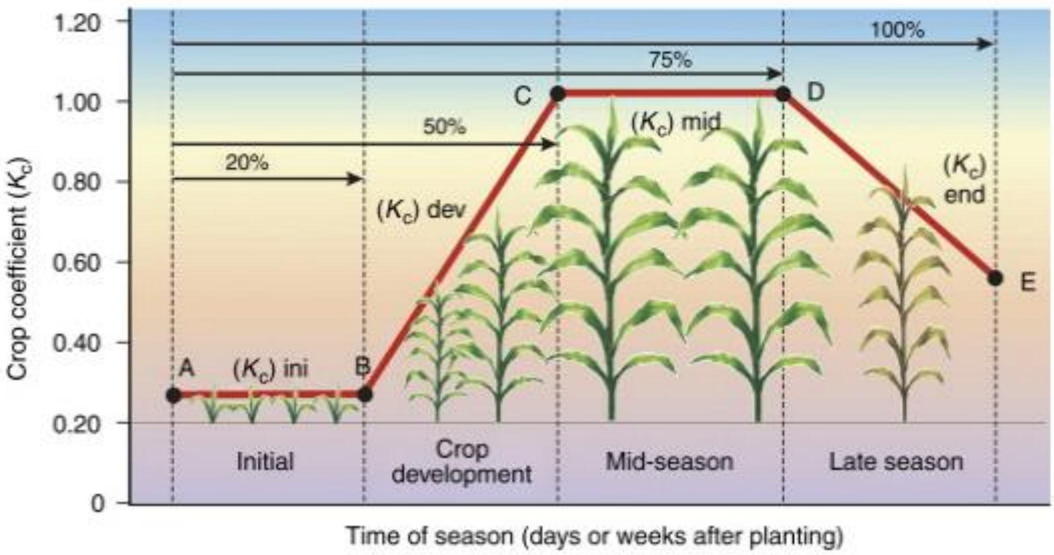
Table 18 Indicative values of the total growing period (source: FAO)

Crop	Total growing period (days)	Crop	Total growing period (days)
Alfalfa	100-365	Millet	105-140
Banana	300-365	Onion green	70-95
Barley/Oats/Wheat	120-150	Onion dry	150-210
Bean green	75-90	Peanut/Groundnut	130-140
Bean dry	95-110	Pea	90-100
Cabbage	120-140	Pepper	120-210
Carrot	100-150	Potato	105-145
Citrus	240-365	Radish	35-45
Cotton	180-195	Rice	90-150

Cucumber	105-130	Sorghum	120-130
Eggplant	130-140	Soybean	135-150
Flax	150-220	Spinach	60-100
Grain/Small	150-165	Squash	95-120
Lentil	150-170	Sugarbeet	160-230
Lettuce	75-140	Sugarcane	270-365
Maize sweet	80-110	Sunflower	125-130
Maize grain	125-180	Tobacco	130-160
Melon	120-160	Tomato	135-180

- **The growth stage** (date planted): grown crops need more water than crops that have just been planted.

Figure 22 Schematic representation of increase and decrease in crop coefficient based on different plant development stages (source: S. irmak, Encyclopedia of Ecology, 2008)



Other agricultural sectors such as livestock and fish farming are also major users of water resources. It has been estimated that the livestock sector uses an equivalent of 11,900 km³ of freshwater annually – or approximately 10 percent of the estimated annual global water flows (111,000 km³) (FAO).

Table 19 Example of water requirements for various classes of livestock (source: Agriculture and Food, Government of Western Australia)

Livestock type	Long-term average demand (l/day)	Maximum summer demand (l/day)
Alpaca (lactating)	8-10	16-25
Alpaca (dry, adult)	4	8-10
Alpaca (<12 months)	2-3	5-6
Cattle (lactating)	80	160
Cattle (adult, dry)	50	100
Cattle on saltbush (adult, dry)	70	140
Cattle (weaner)	25	50
Goats (lactating)	20	35-40
Goats (adult, dry)	10	20
Goats (weaner)	5	10
Horses (lactating)	90	150
Horses (adult, dry)	45	70
Horses (<12 months)	20	40
Sheep (lactating)	7	14
Sheep on improved pasture (adult, dry)	5	10
Sheep on saltbush (adult, dry)	8	12
Sheep (weaners)	2.5	5

Table 20 Example of water requirements depending on different types of fish production (source: FAO)

Management	Production		Fish population	Water requirements
	t/ha	Kg/m^3		m^3/kg
Natural water	0.03	0.003	Mixed	300
Cage	0.5	50	Single species	200
Fish pond (extensive)	1.0	0.1	Single-multispecies	15
Fish pond (intensive)	3.0	0.3	Multispecies	7
Industrial	100	10	Single species	150
Recirculation	200	20	Single species	10

Appendix 10: Methods to assess industrial needs

To assess the abstracted, used and restored volumes of the industrial sector may involve the following:

- Identify major industrial activities in the territory.
- Understand the main water uses by sector of activity.

  Main categories of industrial water uses :

  - Addition to product: unique, essential or important constituent of the finished product (bottled water, beverages and many food products; dialysis; injectable preparations).
  - Essential manufacturing agent (e.g. paper mills, textile and dyeing industries, pharmaceuticals, chemicals, etc.).
  - Washing of products and equipment (e.g. food industry), rinsing of finished products (e.g. electronics industry).
  - Thermal uses: cooling, boiler feed and heat transport.
  - Transport of materials or waste (e.g. steelmaking scrap, sugar beet, paper mill fibres or pulp), gas scrubbing and other uses where recycling is generally the rule.
  - Electrolytic surface treatment, requiring limpid, often softened water (nickel plating, chromium plating), or even demineralised water.
  - Air conditioning.
  - General services.
- Exploit available statistical data and estimate missing data.
- Characterise and estimate water uses by category of industry:
  - Type of water used (surface water, groundwater, etc.).
  - Large, medium and small users.
  - Type of industry.
  - Supply mode: autonomous, drinking water networks, wholesalers, etc.
  - Volumes used.

Table 21 Examples of types of water uses by category of industrial activity (source: OIEAU)

Category of industrial activity	Type of water uses
Dairy industry	Cleaning and disinfection Product washing Milk reconstitution Boiler feeding, cooling
Beverage industry	Beverage preparation Cleaning Cooling
Pharmaceutical industry	Water for cooling circuits

Car industry	Very different according to plant activity, including: cooling and feeding of machining and grinding plants, bath preparation, paint shops, final rinsing, etc.
Textile industry	Boilers (large top-ups) Manufacturing Air conditioning
Manufacture of pulp, paper, paperboard and paperboard products	Consumption of to 150 m3/tonne of product - frequent recycling Wood preparation, pulping, paper production and coating, fibre transport Steam production and supply to cooling circuits
Steelmaking and primary steel processing	High water consumption of up to 40 m3/tonne of coke Indirect and direct cooling Steam production, final product rinsing, bath preparation
Oil refining	High consumption - tendency to recycle Water for cooling circuits Steam generation
Electrical and electronic components industry	Water for cooling circuits
Electricity generation and distribution (thermal or nuclear power plants)	Water/steam circuit supply Condenser cooling

Table 22 Examples of orders of magnitude of water demand in industry (source: Gesteau)

Type of activity	Water demand (m^3/j/ha)
Logistics	1.5
Tertiary activities	4
Shops and crafts	4
Small and medium industries	8
Industries	10
Car industries	15
Agri-food industries	100-150

It should be noted that volumes listed in the table above are abstracted volumes. In most industrial sectors, a percentage of abstracted water is returned to natural environment.

Table 23 Examples of orders of magnitude of water demand in industrial areas (source: Gesteau)

Type of industrial area	Estimated number of people	Water demand (equivalent individual specific water demand)
Business park: shops and crafts	Average of 20 people/ha (not permanently in the area)	5/ha
Business park: industries and tertiary activities (offices)	Average of 60 people/ha (permanently in the area)	20/ha

Table 24 Examples of orders of magnitude of volumes of water needed to manufacture products (source: CNRS)

Type of manufactured product	Volume of water (l)
1 kg of rayon (viscose)	400-11,000 l
1 kg of steel	300-600 l

1 kg of sugar	300-400 l
1l of alcohol	100 l
1kg of cardboard	60-400 l
1 kg of cement	35 l
1kg of soap	1-35 l
1 kg of plastic material	1-2 l

Appendix 11: Dashboard: Example of indicators

Table 25 Example of indicators

Runoff and erosion	
Type of indicator	**Example of indicator**
Status – Runoff areas at risk	Identification of areas where runoff causes flooding or erosion; land use in these areas (SAGE Midouze)
Response – Priority areas for erosion control	Percentage of natural, wooded, grassed or planted land in risk zones (SAGE Est Lyonnais)
Response – Runoff control programme	Progress of programmes to combat agricultural runoff (SAGE Canche)
Drought, low-water levels and piezometric monitoring	
Type of indicator	**Example of indicator**
Status - Flow monitoring in low-water period	Quantity objectives exceeded at strategic river nodes for surface water (low-water target flow, alert threshold flow and crisis flow) (SAGE Nappe de Beauce and associated aquatic environments)
	Number of days crisis flow rate exceeded per strategic river node; or % of basin strategic nodes at which low-water target flows are exceeded during the year (SAGE Layon-Aubance/Vilaine)
	Number of days below DOE and deficit (SAGE Estuaire de la Gironde and associated environments)
	Low-water flows, temperatures, oxidizable matter discharges (SAGE Gironde Estuary and associated environments)
Status - Knowledge	Location of environmental monitoring stations (gauging stations, piezometers gauging stations, piezometers, limnimetric scales and flow stations) (SAGE Boutonne)
	Changes in piezometric indicator levels by management sector (SAGE Nappe de Beauce and associated aquatic environments)
	Number of days when the alert level of the groundwater management protocol is exceeded (SAGE Baie de Bourgneuf et marais breton)
Response - requirements	Number of prefectural decrees declaring a state of drought by management sector (SAGE Nappe de Beauce et milieux aquatiques)
Status - Monitoring	Quality monitoring of low-water reservoirs (SAGE Adour amont/Midouze)
Flooding	
Type of indicator	**Example of indicator**
Status – Knowledge of flood risk	Status of the atlas of flood-prone areas (SAGE Oudon)
	Length of watercourse affected by flooding phenomena and equipped with a measurement network (SAGE Sarthe amont)
	Number of people and properties affected by flooding (SAGE Arguenon - Baie de la Fresnaye)

Flooding	
Type of indicator	**Example of indicator**
Response - prevention and reduction of vulnerability	- % of areas covered by a vulnerability prevention and reduction plan - Number of vulnerability prevention and reduction plans approved or planned - Number of vulnerability prevention and reduction plans and flood zone atlases taken into account in town planning urban planning documents
Response – Awareness raising	- Number of awareness-raising campaigns and % of municipalities reached - Number of municipalities with DICRIM and PCS plans - Improved flood risk awareness in vulnerable municipalities. Inventory of flood markers (SAGE Estuaire de la Gironde et milieux associés)
Response – Crisis management	Equipped of reporting stations (SAGE Vilaine)
Response – Flood expansion zones	Number and surface area of flood expansion zones (SAGE Sambre)
	Status of operations to create, restore or preserve flood expansion zones (SAGE Sarthe amont)

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