POLICY BRIEF 2

MAR2PROTECT

Paving the way for Managed Aquifer Recharge in Europe

Recommendations for policy makers at the national level in EU Member States

Key message

- In order to address challenges related to water scarcity and water quality, Managed Aquifer Recharge (MAR) schemes are common in EU Member States.
- MAR interventions operate at the intersection of diverse European directives and regulations, as there is no explicit regulatory framework for MAR in the European Union.
- Transposing EU directives to the national level in EU Member States is complex and lengthy. In combination with the absence of a clear regulatory framework for MAR, this adds further uncertainty for MAR interventions.
- To ensure that the potential of MAR is realised, concrete steps are required by national policy makers to help MAR practitioners navigate and comply with this complex policy landscape.

Executive summary

Population growth, rapid urbanisation, and consequent increasing demand for water resources, with the worsening of climate change risks and water-related crises worldwide, have resulted in a global trend of depletion of groundwater resources (Alam et al., 2021; Dahlke et al., 2018)[1]. Global insufficiency in water resources requires alternatives to increase water supply (Page et al., 2020)[2]. One sustainable groundwater management strategy to protect and enhance groundwater quantity and quality is to design and implement Manage Aquifer Recharge (MAR).

Although MAR has been implemented in European countries since the 1970s and is increasingly relevant to increase groundwater availability and prevent groundwater pollution (i.e., salination), **this is done on a project basis rather than a strategic level, *as there is no explicit regulatory framework for MAR in the European Union***. MAR is, therefore, currently operating at the intersection of a range of (overlapping) policy domains. Based on a policy analysis undertaken by MAR2PROTECT (Vallejo et al. (2024), this policy brief presents **seven concrete recommendations for policy makers at the national level in EU Member States.**

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Introduction

Climate change and environmental exploitation related to a growing population have increased global concerns about preserving and managing water resources. These impacts also affect groundwater quality and quantity, bringing urgency to the discussion about sustainable groundwater management in the water resources community (Levintal et al., 2023; Stoksad, 2020). Traditionally, in Europe, groundwater has been an important source of drinking water. In addition, groundwater accounts for about 95% of freshwater,[3] providing about 50% of water for irrigation worldwide. Due to climate change and industrial overexploitation, about 26% of European aquifers are overexploited and contaminated.[4]

Groundwater has become not only scarce, but it is also vulnerable to contamination from natural and anthropogenic sources (Mays & Scheibe, 2018). Global insufficiency in water resources for irrigation and agriculture and the intense extraction of surface and groundwater resources require alternatives to increase water supply (Page et al., 2020). A natural way to increase the natural yield of groundwater is to store water in underground aquifers.[5]

MAR is an approach implemented locally to address decreasing groundwater availability. MAR not only helps to increase groundwater quantity but can also be used to prevent contamination and, increasingly, to reuse and re-enter treated wastewater into the water cycle, contributing to the EU's clean and sustainable water goal for 2027.

Since the mid-1970s, European countries have implemented different types of MAR, increasing groundwater quantity and preventing groundwater pollution. Currently, MAR is implemented on a project basis, since ***there is no explicit regulatory framework for MAR in the European Union***. MAR is currently operating at the intersection of a range of (overlapping) *policy* domains:

(1) groundwater management,

(2) use of reclaimed water sources,

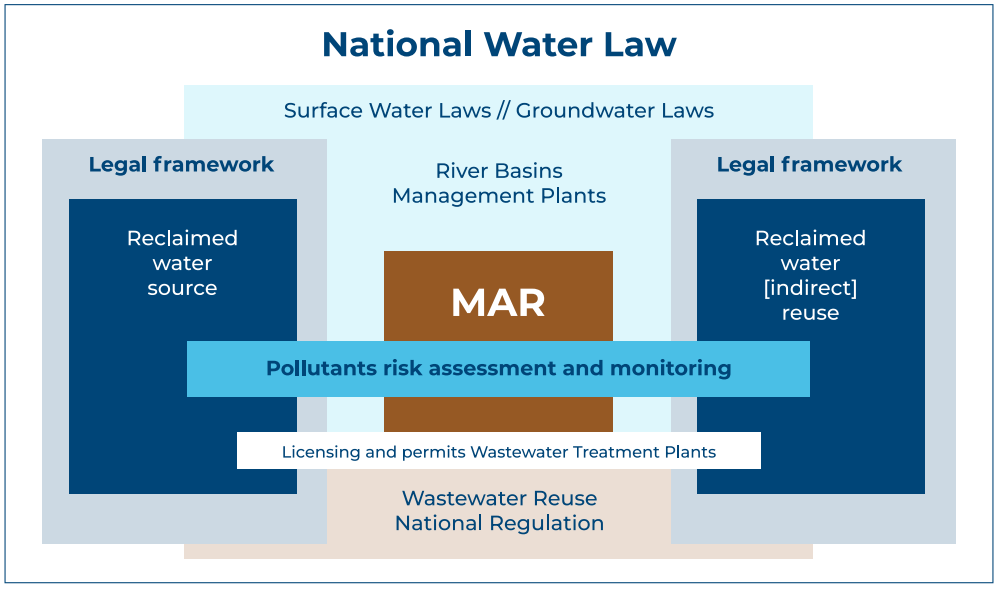
(3) reuse of recovered water, and

(4) reuse of treated wastewater,

all of which require monitoring and controlling of pollutants.

Relevant regulatory instruments are related to both the source of water (e.g., wastewater) and the [indirect] reuse (e.g., drinking water, irrigation) of reclaimed water. MAR cuts across both of these two domains. Moreover, the pollutants regulations (including their measurements and monitoring) are transversally related to reclaimed water sources and reuse policies.

Conceptual framing of legislation in EU Member States regulating MAR



The Member States need to take appropriate legislative actions to transpose EU directives to the national level and implement them regionally or locally through the corresponding legal framework, either regarding MAR inputs (reclaimed water source (mostly treated wastewater) or MAR outputs ([indirect] reuse of the reclaimed water [indirect] reuse).

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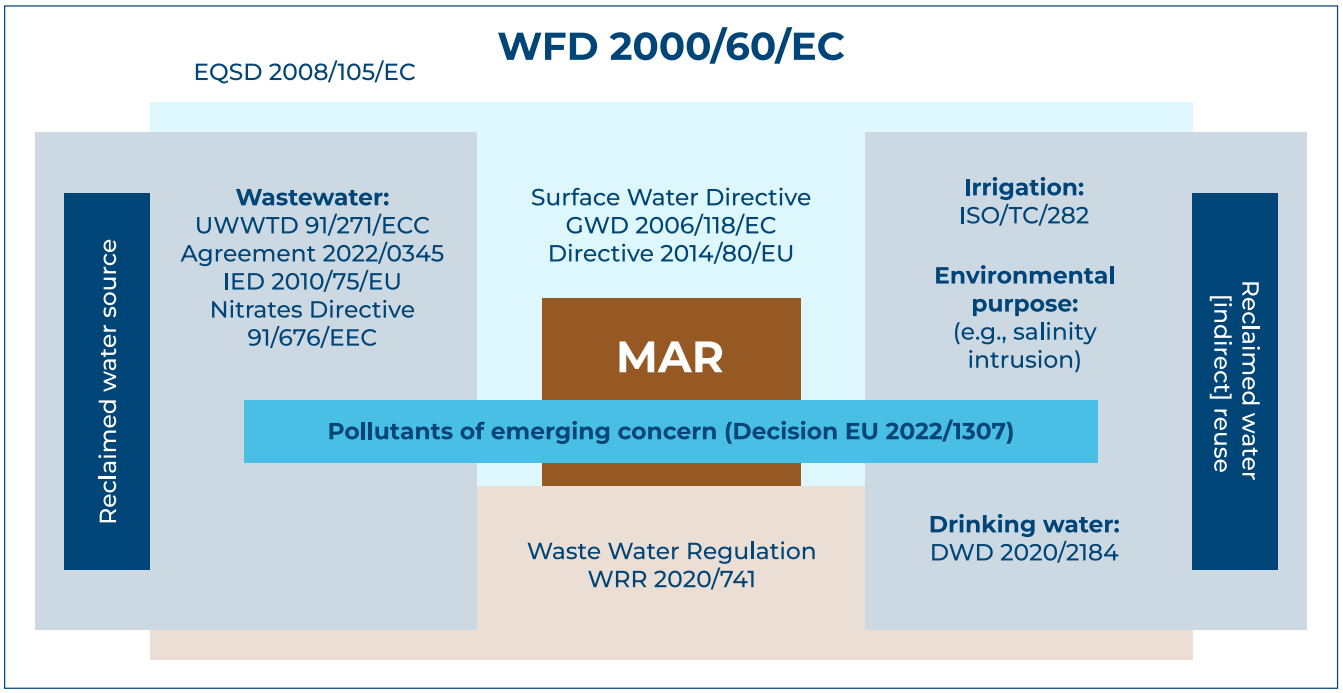
Challenges

Transposing policy directives from the European to the national levels of its Member States is a complex and lengthy task, requiring gradual national policy amendments and new pieces of national legislation. **In combination with the absence of a clear regulatory framework for MAR, this lengthy transposition process adds further uncertainty for MAR interventions.**

River Basin Management Plans (RBMPs) define country-specific parametric pollution values to identify water pollution and establish measures to reverse and monitor these trends, and they are evaluated every five and ten years by the Member States.[6] Following the WFD 2000/60/EC, the GWD 2006/118/EC, and the SWD guidelines, the Member States started to design and readapt their RBMPs to reach the water environmental targets settled by the European Commission. Nevertheless, there are no clear requirements for regulating and protecting groundwater in most RBMPs, and the complexity of the RBMPs varies across regions.

European water management legal framework for EU Member States



A particular challenge regarding the regulation of MAR is the case-by-case basis required, as not only do aquifers have different characteristics calling for a site-by-site approach but there are distinctly different types of MAR. National policies are (re)formulated to create legal instruments that regional governments adopt to implement MAR according to the source of reclaimed water and the intended [indirect] reuse.

Regional risk management and strategic river basin plans are highly relevant since they guide water-related instruments such as MAR operationalisation. The complexity of the regulation increases as these requirements are translated to the public and private wastewater treatment plants (WWTPs) in the implementation process.

In practice, many national/regional WWTPs cannot fulfil the EU UWWD mandate and EU Watch List to remove pollutants and *Pollutants of Emerging Concern* **or new lists of pollutants and value parameters are constantly being added to the EU regulation, as the implementation of these regulations requires reinvestment to update regional/local WWTPs.**

At the national level, regulations state lists of pollutants to be monitored and controlled. These lists are also present at the regional level in the RBMPs. However, there are discrepancies in the sort of pollutants listed in the regional regulation and their value parameters.

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The EU watch list of Pollutants of Emerging Concern is not completely aligned with those included in national policies. The difference between the list of pollutants and the list of pollutants of emerging concern from the EU is not easily transposed to the national level due to the restrictive [national] rules already in place, mechanisms to implement measures as national regulations are not yet fully adopted, the lack of monitoring [and technological] mechanisms at the local level and the increase in costs that would be involved in addressing them. Currently, the list of pollutants addressed in MAR projects is not aligned with the lists of pollutants listed in the European, national, or regional regulations.

Critical information on water systems is not collected or publicly available in countries like Spain and Italy.[7] Moreover, authorities have limited capacity to monitor for illegal intakes and discharges. Most countries have noticed the lack of monitoring and control data, and in the case of EU Member States, it has been the basis for non-compliance with this WFD requirement.

Licenses and permits are another legal instrument stated in the WFD 2000/60/EC to regulate MAR, and the EU Member States, through their RBMPS, are the implementers. However, the regional process of assigning these licenses and providing permits remains unclear.

Recommendations for policy makers at the national level in EU Member States:

Challenges with River Basin Management Plans

*Set up a special **Mutual Learning Exercise** (MLE)[8] on the RBMPs at the regional/local level within countries (and across countries) **to strengthen the capacity of river basin management actors to prepare and implement RBMPs considering the groundwater component**. This MLE should engage diverse stakeholders from different disciplines (e.g. water management, land use, social sciences), including MAR experts, to ensure that MAR interventions are explicitly included in river basin conservation plans.*

Navigating policy complexity and implementation

*Create regional and/or national **competence centres or contact points that provide a "one-stop shop" for MAR practitioners** to understand what specific policies, procedures, licenses, and obligations are applicable for their specific MAR intervention(s) and groundwater protection activities, taking into account the case-by-case requirements of MAR, with differing aquifers characteristics, source water, and intended (indirect) reuse of water. This will help ensure that MAR interventions are well-planned and compliant with obligations in specific locations and that they can contribute effectively to achieving groundwater sustainability.*

Local implementation of wastewater treatment obligations

*Undertake **regular national consultations (e.g. annually) with water service actors** on how to address infrastructural wastewater treatment requirements to align them with national regulations (that may be based on supra-national directives). The inclusion of MAR experts will provide technical expertise on the removal of pollutants prior to groundwater treatment and pollution prevention.*

Diverging lists of pollutants

*In order to harmonise the list of pollutants monitored, sub-national authorities could **use MAR projects as a way to monitor and prepare projections (through modelling) of groundwater pollution**. For this, harmonisation in the list of pollutants monitored (and modelled) under MAR is needed. Since most MAR projects are financed at national or supra-national levels, **calls for proposals should include an explicit requirement to address officially listed pollutants**, including those on the watch list of pollutants of emerging concern.*

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Challenges with monitoring and reporting

In order to comply with the monitoring and reporting requirements of the WFD 2000/60/EC and the UWWD, ***seize MAR as an opportunity for filling data gaps****, reporting obligations, and groundwater protection actions and make provisions to ensure that monitoring infrastructure and capacity are in place and sustainable over time.*

Policy complexity: multi-level, multi-actor

Opportunities for ***harmonising MAR-related requirements and processes*** *(availability and quality of source water, recharge techniques, guidelines for 'limiting' and 'preventing' pollutants in source water') should be seized when updating/revising relevant national policies, such as the RBMPs in 2027, and ensuring the participation of regional MAR experts.*

Way forward

The variety of legislative tools and the diversity of the actors and contexts they address reflect the complex nature of water management legislation in general and that related to MAR in particular. Distinct challenges need to be addressed, as identified by Vallejo et al. (2024), at one or more governance levels (see table). This policy brief has provided recommendations for national-level policy makers in EU Member States. A sister policy brief (Policy Brief 1, 10.5281/zenodo.14135794) details the recommendations for policy makers at the EU level.

Overview of challenges and recommendations at three governance levels in the EU

Challenge	Policy Recommendation (in brief)	Europe	National	Regional / local
Policy complexity: multi-level, multi-actor	Seize opportunities for harmonizing MAR-related requirements and processes	✓	✓	✓
Challenges with River Basin Management Plans	Set up a special Mutual Learning Exercise to include the MAR component in the RBMP at sub-national level within EU member states			✓
Local implementation of wastewater treatment obligations	Undertake regular national consultations (including MAR experts) with water service actors		✓	✓
Diverging lists of pollutants	Shape calls for proposals for MAR projects to address officially listed pollutants	✓	✓	✓
Increased water consumption due to wastewater reuse	(Re)emphasize agreed European objectives regarding the reuse of reclaimed water as a mechanism for water-saving and not as a local tool for increasing water use	✓	✓	✓
Challenges with monitoring and reporting	Seize MAR as an opportunity for filling data gaps, reporting obligations, and groundwater protection actions	✓	✓	✓
Navigating policy complexity and implementation	Create regional and/or national competence centres or contact points that provide a "one-stop shop" for MAR practitioners		✓	✓

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Acronyms

AI: Artificial Intelligence

DSS: Decision Support System

GWD: Groundwater Directive

MAR: Managed Aquifer Recharge

MEL: Mutual Learning Exercise

RBMP: River Basin Management Plans

SWD: Surface Water Directive

WFD : Water Framework Directive

WWTP: Wastewater Treatment Plant

UWWD: Urban Wastewater Directive

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Endnotes

1. https://environment.ec.europa.eu/topics/water/groundwater_en
2. https://europeanwaters.eu/#:~:text=Over%2015%25%20of%20the%20aquifers,%2C%20Belgium%2C%20and%20the%20Netherlands
3. https://environment.ec.europa.eu/topics/water/groundwater_en
4. https://europeanwaters.eu/#:~:text=Over%2015%25%20of%20the%20aquifers,%2C%20Belgium%2C%20and%20the%20Netherlands
5. Aquifers are 'natural underground strata of permeable rock, sand, or silt capable of storing and transmitting groundwater and are replenished naturally through infiltration from streams or rain soaking through rock and soil into the aquifer below (Dillon et al., 2009, p. 2; Mankad et al., 2015, pp. 214-215; Scheibe & Mays, 2018).
6. See Gourcy et al. (2019) for a summary of different (non)parametric analytical groundwater quality approaches in ten Member States. (Frollini et al., 2021).

   (Gourcy et al., 2019).
7. World Bank Group (2019)
8. Mutual Learning Exercises are policy support mechanisms provided by the European Commission that focus on research & innovation challenges of interest to several members states and associated countries. https://projects.research-and-innovation.ec.europa.eu/en/statistics/policy-support-facility/mutual-learning

Project summary

The MAR2PROTECT project aims to provide an innovative, holistic approach to prevent groundwater contamination from the impacts of global and climate change through developing a set of innovative technologies for Management Aquifer Recharge (MAR) and a new generation of MAR management tools. The core of this innovative MAR approach is the M-AI-R-DSS tool, an innovative Decision Support System (DSS) that aims to incorporate technological and societal engagement information using an Artificial Intelligence (AI)-based tool that will help monitor and enhance groundwater quantity and quality in real-time.

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