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Project deliverables

Deliverable #D5.1

Local MAR agreements

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AGREEMAR

Adaptive agreements on benefits sharing for managed aquifer recharge in the Mediterranean region

Deliverable #D5.1

Local MAR agreements

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Executive summary

This deliverable presents the methodology and insights gained from developing adaptive Local MAR Agreements (LMA) to strengthen MAR governance in Mediterranean countries, specifically Cyprus, Tunisia, Portugal and Spain. It addresses the challenges of MAR implementation, including regulatory complexities, public mistrust and stakeholder coordination, and proposes LMA — adaptive, participatory agreements tailored to local contexts — as a solution to promote equitable benefit sharing, transparency, and sustainability of MAR systems.

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Abstract

Water scarcity and the increasing demand for freshwater resources have heightened the importance of sustainable water management strategies. Managed Aquifer Recharge (MAR) emerges as a critical solution, offering benefits such as groundwater stabilization, improved water quality, and enhanced drought resilience.

However, the successful implementation of MAR faces challenges, including stakeholder coordination, regulatory complexities, and public mistrust. The AGREEMAR project addresses these issues by developing adaptive and participatory Local MAR Agreements (LMA) tailored to the Mediterranean region. These agreements aim to ensure fair benefit-sharing, transparency, and long-term sustainability by involving diverse stakeholders in the co-creation process.

This deliverable outlines the methodology for drafting LMA, incorporating lessons learned from the demonstration sites in Cyprus, Tunisia, Portugal, and Spain. It includes a step-by-step guide for evaluating MAR governance, identifying key measures for improvement, and formulating agreements that balance technical, legal, environmental, and socio-economic considerations. The four case studies illustrate the flexibility and effectiveness of LMA in addressing local challenges while fostering collaboration and trust among stakeholders. This document also serves as a practical toolkit for advancing MAR governance, promoting sustainable water management, and supporting the broader adoption of MAR practices across the Mediterranean region.

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Abbreviations

ACUAMED	Aguas de las Cuencas Mediterráneas (Spain)
AdP	Águas de Portugal
AGREEMAR	Adaptive agreements on benefits sharing for managed aquifer recharge in the Mediterranean region
AgdA	Agda-AdP, Portugal (specific water sector partnership)
APA	Portuguese Environment Agency (Agência Portuguesa do Ambiente)
BPEH	Bureau for Environmental Health
CA	Constellation Analysis
CHJ	Confederación Hidrográfica del Júcar (Júcar River Basin Agency, Spain)
CRDA	Regional Commissariat for Agricultural Development (Tunisia)
DS partner	Demonstration Site partner
GW	Groundwater
INAT	National Institute of Agronomy of Tunisia (Institut National Agronomique de Tunisie)
LMA	Local MAR Agreements
LNEC	National Laboratory for Civil Engineering (Laboratório Nacional de Engenharia Civil, Portugal)
MAR	Managed Aquifer Recharge
NGO	Non-Governmental Organization
PES	Payments for Ecosystem Services
UTAP	Tunisian Union of Agriculture and Fishery (Union Tunisienne de l'Agriculture et de la Pêche)
WDD	Water Development Department (Cyprus)
WP	Work Package
WWTP	Wastewater Treatment Plant

Local MAR Agreements (LMA)

1 Introduction

1.1 Motivation and purpose of developing LMA

Water scarcity and rising demand for freshwater have made sustainable water management an urgent priority. **Managed Aquifer Recharge (MAR)**—the intentional replenishment of aquifers for future use or environmental benefits—offers a promising solution. Globally, MAR is recognized as a crucial tool for sustainable water management, helping to stabilize groundwater levels, improve water quality, reduce evaporation, and enhance drought resilience by storing surplus water for periods of high demand.

However, despite these benefits, unlocking the full potential of MAR remains challenging, particularly in ensuring fair access and distribution of the benefits to all stakeholders. One of the main complexities stems from the nature of groundwater as a **multi-use, open-access resource**. Groundwater flows across administrative boundaries involving a wide range of stakeholders—agricultural, municipal, and industrial—often with competing interests. Recharge activities, thereby, can affect groundwater levels and quality in adjacent areas, potentially impacting neighbouring users and ecosystems, requiring coordination among multiple users to ensure long-term sustainability. Additionally, MAR must be carefully managed to avoid environmental harm, particularly contamination of sensitive aquifers. Balancing recharge volumes with water quality and ecosystem health is therefore critical. Moreover, the **subsurface complexity** and the **invisible nature** of aquifer recharge operations often lead to public mistrust and uncertainty about outcomes. Concerns about contamination risks, unpredictable recharge rates, and other uncertainties can undermine support for MAR projects. The **regulatory landscape** for MAR is similarly **complex**, often lacking clear legislation or guidelines. **Overlapping jurisdictions** and fragmented regulations further complicate project approvals and enforcement.

To address these challenges, reliable governance mechanisms of guaranteeing benefits are required for a good functioning of a MAR system and for proper exploitation of its potential. This deliverable introduces the concept of adaptive agreements—hereafter mentioned as **Local MAR Agreements (LMA)**—developed for fostering the wider implementation of MAR in the Mediterranean countries. The format and scope of the agreements are flexible and responsive to changing hydrological, environmental, and socio-economic conditions. By involving all relevant stakeholders—water users, regulatory bodies, environmental groups, and more—such agreements can promote transparency, trust, and cooperation, tailoring MAR to local conditions for more effective water management and resilience. They empower stakeholders to collaboratively initiate and manage MAR projects, while having one or more of the below specific objectives:

- ✓ **Define** consensus-based terms, conditions, roles, and responsibilities for effective, efficient, and inclusive MAR governance
- ✓ **Reduce** the risks for future conflicts
- ✓ **Balance** the interests and needs of all relevant stakeholder groups
- ✓ **Ensure** efficient benefits sharing / create new benefits
- ✓ **Create** an enabling environment for MAR
- ✓ **Level** power and costs asymmetries (including ecosystem services)

Drawing on four case studies from the Mediterranean region, the authors showcase the diverse mechanisms and strategies used to establish, adapt, and manage agreements.

1.2 Purpose and structure of this deliverable

This document presents a collection of LMAs developed collaboratively with stakeholders of four demonstration regions of the AGREEMAR project. Due to the diverse contexts and levels of development of the different project demonstration sites, the LMAs vary in their maturity and scope. Some are already finalized, signed and ready for potential endorsement by the relevant stakeholders, while others consist of a compilation of recommendations and ideas that will be further developed and finalized beyond the project's conclusion. The presented agreement examples demonstrate how adaptive agreements can be crafted to address specific challenges, opportunities, and stakeholder needs at various MAR sites in the Mediterranean region.

A secondary focus of the document is to provide a detailed, step-by-step guide to the methodology used in creating these agreements. This guide serves as a practical resource, equipping stakeholders with the tools and processes required to establish effective and context-specific MAR agreements. It also includes a section on the lessons learned from the AGREEMAR civil assemblies, rounding out the methodology presented.

In combining real-world examples with a structured methodological approach, this document serves as both a guide and a toolkit for developing robust MAR agreements, promoting effective MAR governance and management ensuring fair benefit-sharing among diverse stakeholders across the Mediterranean region.

1.3 Examples for MAR agreements in literature

1.3.1 Example 1: Cross-municipal agreement incentivizing groundwater recharge through payments for ecosystem services in Japan, Kumamoto City

The **Kumamoto groundwater recharge agreements** in Japan were driven by the need to address groundwater depletion due to urban expansion, industrialization, and reduced natural recharge and associated need for cross-sector and -municipal cooperation. This initiative aimed to ensure water security for Kumamoto's residents, industry, and agriculture, all of which depend heavily on groundwater (Shivakothi et al. 2018).

The agreements, implemented through a **Payments for Ecosystem Services (PES)** scheme, incentivize local farmers to flood rice fields seasonally, enhancing groundwater recharge. The scheme is based on direct payments for water recharge services, with rates calculated per flooded area and duration. Private sector stakeholders (such as industries and Kumamoto City) fund these payments, providing farmers with compensation while supporting the region's groundwater resources. This PES approach was supplemented by the sale of "eco-products," such as rice and vegetables, labelled as contributing to groundwater recharge, further incentivizing farmer participation. A simplified visualisation of the system is presented in Figure 1 (Shivakothi et al. 2018).

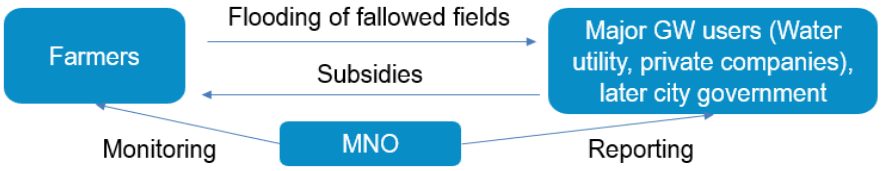

Figure 1. Simplified visualisation of the PES scheme as part of the Kumamoto groundwater recharge agreements

The PES scheme succeeded and won the Water for Life UN-Water Best Practices Award in 2013, due to a few critical factors (Shivakothi et al. 2018):

- **Win-win situation**: The payment scheme offered a mutually beneficial arrangement where farmers received direct compensation, and groundwater users (like Kumamoto City and local industries) could offset their water extraction, contributing to long-term water security for all parties.
- **Scientific foundation**: Groundwater research and modelling by local universities were essential in establishing a reliable basis for the PES rates and understanding recharge dynamics, which helped secure stakeholder confidence.
- **Flexible implementation:** Farmers had the flexibility to flood rice fields only during specific times, such as the wet season, which allowed them to cultivate other crops outside flooding periods, thereby supporting both recharge efforts and agricultural productivity.

- **Central, independent coordinator and NGO involvement**: The agricultural cooperative Midori Network Ookiku (MNO) served as a central, independent coordinator, managing contracts, verifying compliance, and facilitating smooth communication between stakeholders. Local NGOs also played a vital role in promoting the initiative and engaging the community.
- **Policy coherence**: Effective collaboration across agriculture, urban development, and water management policies facilitated the program's integration and helped address potential conflicts between groundwater recharge needs and other policy areas.
- **Integration into groundwater management policies**: Recognizing groundwater recharge as a priority within the city's water management policies ensured that recharge goals were aligned with broader water conservation strategies.

The Kumamoto PES scheme highlights the importance of (1) combining scientific evidence with practical incentives to secure ecosystem services, (2) engaging local stakeholders as integral participants, and (3) structuring contracts with adaptable terms (Shivakothi et al. 2018).

Figure 2. Farmers field qualified for PES payment (Shivakothi et al. 2018)

1.3.2 Example 2: Aquifer contracts to solve GW overexploitation in Morocco, Souss

Morocco introduced aquifer contracts to address the critical issue of groundwater over-exploitation, which has been driven by increasing water demand from agricultural expansion, recurrent droughts, and the prevalence of unlicensed wells. These contracts aimed to engage local stakeholders—including farmers, regional councils, and others—in a cooperative framework to manage and conserve groundwater resources, particularly in vulnerable areas like the Souss Massa-Draa Basin, where agricultural demands have significantly depleted groundwater levels (Closas et al. 2016).

The first aquifer contract was signed in 2006 as a non-binding technical and financial agreement between River Basin Agencies (RBAs) and various water users. These agreements set collaborative objectives to regulate groundwater extraction, implement efficient irrigation technologies, and enforce limits on water abstraction. For example, the Souss aquifer contract included measures such as promoting drip irrigation, increasing water fees for larger landholders, and planning for surface water supplementation. Overall, the contracts were designed to promote accountability and align local resource use with sustainable goals within a decentralized management framework (Closas et al. 2016).

Factors leading to contract challenges (Closas et al. 2016):

- **Insufficient scientific evidence of the issue**: Divergent views on the extent of resource overuse and conflicting priorities in resource allocation hindered a unified commitment to sustainable practices.
- **Lack of consensus on water fee increases**: The absence of agreement among ministries on raising water fees has kept payment voluntary.
- **Distrust toward public authorities**: Large landowners, particularly those benefiting from export-oriented agriculture, held more negotiating power in contract discussions than smaller farmers. This imbalance led to perceived inequities and mistrust regarding contract fairness.

- **Absence of regulatory enforcement mechanisms**: The voluntary nature of aquifer management contracts, along with limited enforcement capacity of under-resourced River Basin Authorities (RBAs), resulted in low participation and compliance.
- **Policy misalignment**: Inconsistent policies across relevant sectors hindered cohesive action.
- **Limited institutional capacity and role clarity**: Inadequate resources, insufficient institutional capacity, and unclear role definitions obstructed effective oversight and enforcement, with overlapping responsibilities across agencies adding to the challenges of contract enforcement.

The example of the Moroccan aquifer contracts proves the importance of strengthening institutional capacities, creating enforceable measures, and fostering genuine local engagement to balance power dynamics among users. Enhanced data and monitoring tools, such as metering and satellite imagery, could improve transparency and accountability, while legal reforms are needed to provide a binding framework for more effective water resource governance (Closas et al. 2016).

1.4 Project context

The AGREEMAR project aims to assist decision-makers in the safe use, sustainable planning and management of MAR techniques MAR. One example of a functioning MAR system is shown in Figure 3. This will be achieved through *"adaptive agreements on benefits sharing for MAR in the Mediterranean region"* facilitated by MAR feasibility maps and numerical groundwater models. In this way, the contribution of MAR to ensure water security in the Mediterranean region shall be strengthened. Although MAR is a globally recognised method for the sustainable management of water resources, inadequate planning tools and lack of incentive systems hinder its widespread implementation. AGREEMAR seeks to address and overcome these barriers. The project results will be tested at four demonstration sites in the Mediterranean region, namely Cyprus, Spain, Portugal, and Tunisia.

Figure 3. Infiltration pond of the Akrotiri MAR scheme in Cyprus

1.5 Our definition and scope of LMA

Against this background and taking the lessons learned from the two literature examples presented above in chapter 1.2, this deliverable uses the definition for LMA below:

AGREEMAR definition of LMA: MAR agreements are written, binding/non-binding, consensus-based arrangements between relevant stakeholders that outline the terms, conditions, roles and responsibilities of effective, efficient, and inclusive MAR governance related to a gap, challenge, or opportunity identified for a specific MAR project. These agreements aim to ensure a fair distribution of benefits, including sustainable and equitable management of MAR-related water resources through coordinated efforts and compliance with regulatory and environmental standards.

Specific and adapted: Each MAR site is unique, and no two are exactly alike. This variability applies to stakeholder composition, technical conditions, provided benefits, the legal framework regulating the MAR facility and its use, decision-making structure, and more. Accordingly, it is advisable to craft MAR agreements as specifically and precisely as possible, tailored to the unique gaps, challenges, or opportunities at each site. Therefore, the format of LMA may vary and should be tailored to the specific needs of local stakeholders. A sample template for LMA, aligned with the AGREEMAR project's methodology for developing such agreements (see Section 2), can be found in Annex 1.

Binding/non-binding: Stakeholder interviews revealed a clear preference among most stakeholders at the project demonstration site for non-binding agreements. However, to enhance the likelihood of success associated with a binding arrangement, this option will remain available to the stakeholders during the AGREEMAR workshops and thus is reflected in our agreement definition.

Target audiences: LMA should incorporate the perspectives and interests of all relevant stakeholders, particularly those who rely on groundwater resources. Since the agreements are context-dependent and adaptable to the specific issues of the chosen MAR site, there is no fixed target audience. Agreements may be bilateral—for instance, between a water authority and a water utility, or between a water utility and farmers using the recovered groundwater—or involve multiple stakeholders.

However, in developing LMA, it is both useful and essential to involve all relevant, participating, and impacted stakeholders to clearly define the purpose and scope of the agreements (see methodology chapter). At the conclusion of this process, such as through civil assemblies or stakeholder workshops, multiple agreements with distinct objectives and varying stakeholder groups may emerge.

1.6 Outlook

Looking ahead, the LMA developed within the AGREEMAR project set a foundation for sustainable and inclusive MAR practices across the four project demonstration sites. By employing an adaptive and participatory strategic approach, an ongoing implementation beyond the project's conclusion is fostered.

Additionally, the provided methodology and templates offer a replicable model for similar initiatives in the same and other regions, helping MAR stakeholders to continuously optimise their MAR governance and promoting a wider adoption of MAR practices globally.

2 Adaptive and participatory method for developing LMA

2.1 Strategic approach used in AGREEMAR – a step-by-step guide

The strategic approach for developing MAR agreements is designed as a flexible, voluntary assessment tool to evaluate both the performance and governance of MAR systems. It supports decision-makers in pinpointing necessary improvements and provides tools for the effective planning, implementation, and operation of MAR systems.

This approach is adaptable to various MAR types and site conditions, addressing a wide range of aspects—technical, social, legal, policy-related, economic, and environmental. The LMA development process is organized into three key steps: (1) Evaluate the current state of MAR governance; (2) Understand good MAR governance and identify 2-3 key measures to address identified gaps, challenges, and opportunities; (3) Elaborate agreements on implementing identified measures.

These three steps aim to create adapted LMAs through preparation, verification and refinement, and finalization stages. The entire process emphasizes the involvement and collaboration of local stakeholders, which includes:

- Preparatory meetings: Engaging DS partners and key stakeholders in the initial phase.
- Civil assemblies: Conducted in the verification and refinement phase to gather and review feedback.
- Concluding meetings: Held with key stakeholders to finalize the LMA.

This methodology builds upon the insights and outcomes of the AGREEMAR project, incorporating prior project outcomes such as constellation analysis and groundwater models. The application of these tools is detailed in the description of each step below. The selection of the tools may be adjusted based on local conditions and needs.

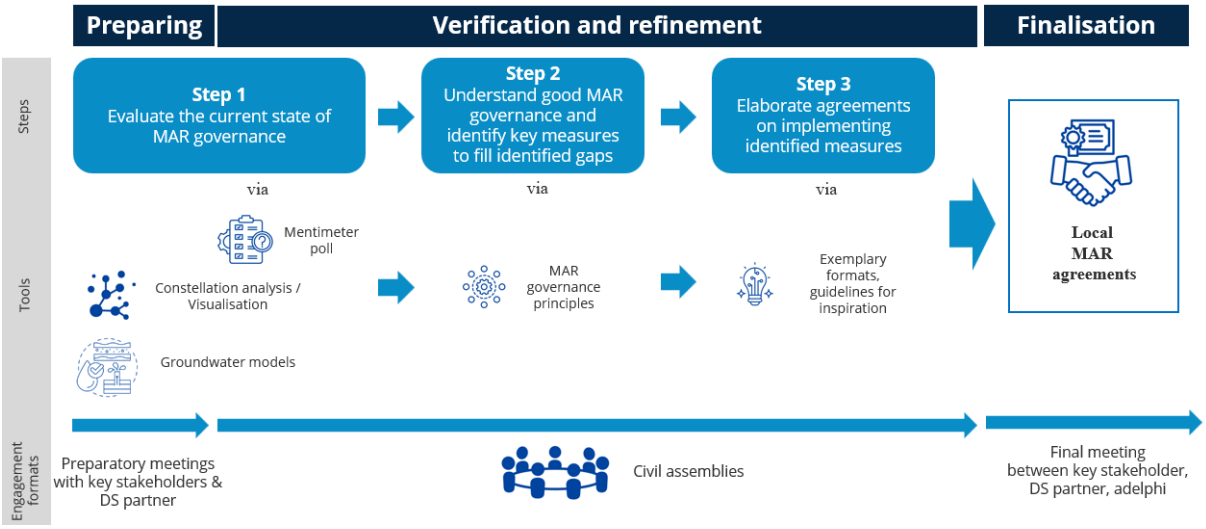

Figure 4. Three step approach towards LMA

Step 1. Evaluate the current state of MAR governance

This initial step spans both the preparation and verification phases, utilizing various tools to evaluate both environmental and technical characteristics (e.g., hydrogeology and aquifer properties, recharge infrastructure, water quality parameters) as well as governance aspects of the MAR site (e.g., regulatory compliance and permitting, roles and responsibilities, stakeholder engagement). The tools listed in Figure 4 have proven highly beneficial in the AGREEMAR project; they are provided here as recommendations but can be substituted as needed with alternative tools.

Essential for this step is the collaboration with key stakeholders who possess relevant expertise and hold recognition within the local stakeholder landscape, such as water utilities, research institutes, etc. This collaboration allows for preliminary discussions of obtained results and initial ideas for the LMA. Their input is also crucial to ensure alignment with local knowledge and experience, fostering greater acceptance of the results and facilitating the subsequent development of LMAs.

In this phase, it is also essential to address organizational matters for conducting civil assemblies in collaboration with key stakeholders. It is recommended that neutral stakeholders are involved in the facilitation process and contribute to the presentations if possible (refer to the sample agenda in Section 1.3).

Another critical aspect is identifying and managing any potential conflicts among stakeholders that may not yet be visible to the project partners but may pose significant risks to the successful execution of the civil assemblies. Paralyzing conflicts between stakeholders could arise, for example, due to unresolved funding for the MAR site or unclear assignment of responsibilities. Key stakeholders may have the insights necessary to manage these effectively.

Evaluating groundwater system behaviour and MAR performance and impacts

Developing groundwater models offers a solid scientific basis for assessing the technical performance of MAR sites. Common outcomes of these models include water heads, GW flow paths and velocities, water budget, saltwater intrusion, contaminant transport and fate, etc. This foundation is a critical success factor for achieving effective and sustainable agreements, as demonstrated in Example 1, Section 1.3. Through these models, key elements—such as a better understanding of the MAR benefits, beneficiaries, and the quantitative (e.g., groundwater flow models) and qualitative (e.g., solute transport models) impacts on the surrounding area—can be identified.

Analysing system dynamics from holistic point of view considering technical, natural, and social aspects

Another useful tool is the constellation analysis, a qualitative research method that helps to understand the complex structure and dynamics of a system by identifying and visualizing connections among key elements. This approach is particularly valuable in contexts where understanding the interplay of various components is essential for informed decision-making and strategic development. By visualizing these relationships, stakeholders can gain insights that lead to more coordinated actions and improved outcomes. This interdisciplinary method offers several advantages, including:

- MAR system evaluation: Mapping out elements such as participants, beneficiaries, activities, and outcomes to assess the effectiveness of MAR systems.
- Awareness and understanding: Raising awareness and fostering mutual understanding across diverse stakeholder groups regarding the benefits and costs associated with MAR.
- Community engagement: Engaging participants actively in the process, which strengthens commitment and buy-in while facilitating the identification of stakeholders, resources, and potential areas for collaboration.
- Policy analysis: Evaluating the impacts of different policies on stakeholders to understand complexities, identify gaps, and recognize challenges and opportunities in current policy implementation.
- Conflict resolution: Identifying core issues and relationships underlying conflicts, thereby helping stakeholders to appreciate each other's perspectives.

In the MAR context, relevant elements may include external threats (e.g., climate change), stakeholder roles (e.g., water resource regulators, water providers, water users), regulatory frameworks, technical services (e.g., increased surface water baseflow, water storage, water purification, mitigation of saltwater intrusion), natural ecosystems (e.g., coastal aquifer, wetlands), and findings from the AGREEMAR project (e.g., GW models, MAR feasibility maps). Figure 5 provides an example of a constellation analysis.

Constellation analysis can be effectively conducted during civil assemblies in a participatory approach to develop a shared understanding of the MAR site. However, it is recommended to conduct a preliminary constellation analysis before the civil assembly and discuss it with key stakeholders. This approach enables facilitators or external project partners to gain a better understanding of the local context and saves time during the assembly itself. During the assembly, stakeholders can work directly on a prepared template, modifying elements and relationships as needed. However, be mindful that the facilitator's

perspective can introduce biases, and by presenting an initial example may influence participants' independent viewpoints.

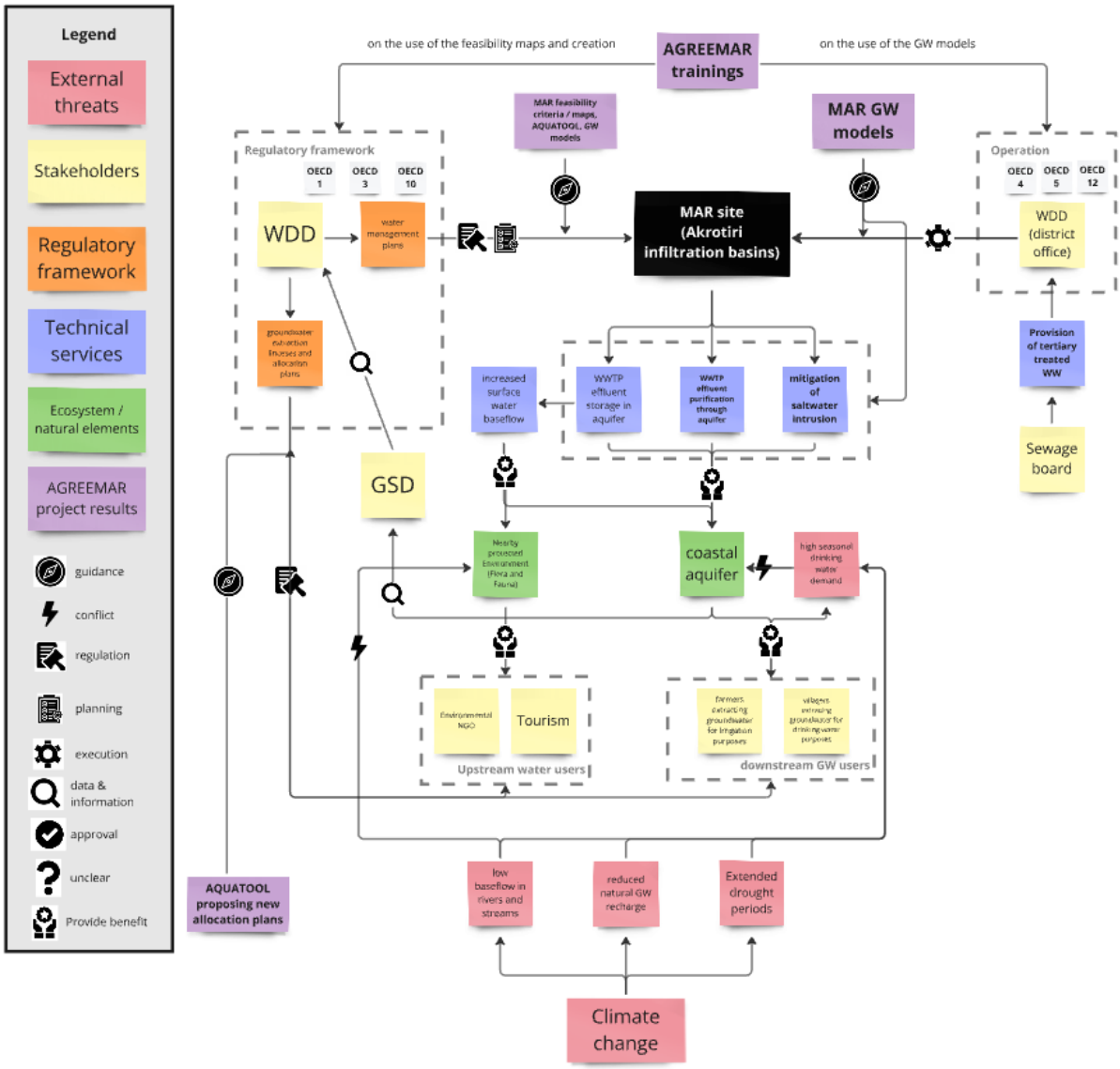

Figure 5. Sample constellation analysis

Gathering direct stakeholder feedback on challenges, gaps, and opportunities

Using tools like Mentimeter polls at the beginning of civil assemblies or beforehand as a survey can provide valuable insights. Suggested questions could include:

- What risks or optimisation needs do you see regarding this MAR facility?
- What are the possible external threats?
- Where do you see potential conflicts?

Additional tools for consideration

The tools outlined represent a selection of useful resources that can facilitate effective discussions during the next steps. Other potential tools include MAR feasibility maps—essential if identifying new MAR sites is part of the LMA—and cost-benefit analyses, among others.

Outcomes

- List of key areas for improvement of the MAR site: At the end of Step 1, a list of critical areas with potential for improvement at the MAR site is developed. These may include MAR legislation, technical setup and operation, financial arrangements, environmental impacts or water quality concerns. The first column of Table 5 in Annex 3 provides an overview of main key areas. It is recommended to review this list in advance with key stakeholders, identifying 2–3 relevant examples to draft preliminary LMA. This proactive approach can help ensure a smoother process in civil assemblies, where ideas can then be further refined or used as inspiration for additional stakeholder input.
- Potential areas of conflict between stakeholders: this includes preparing mitigation measures to address potential risks while ensuring that all perspectives from the various stakeholders are heard.
- Organizational details for conducting the civil assemblies have been decided: This includes decisions on venue selection, moderator choice, agenda design, and other logistical considerations.

Step 2. Understand good MAR governance and identify 2-3 key measures to address identified gaps, challenges, and opportunities

In this second step, a broad range of local, relevant stakeholders are engaged in a participatory approach—ideally through interactive sessions during civil assemblies. These stakeholders are encouraged to discuss and analyse prior-selected areas with improvement potential, as well as any specific LMA ideas brought forward. It is recommended to focus on 2-3 key areas. For guidance, an overview of selected MAR governance principles, organized by relevant areas, is available (see Annex 3). These principles, developed specifically for MAR within the project, are based on the OECD principles for water governance. Examples include clearly allocate and distinguish roles and responsibilities, conduct strategic site assessment and selection, advocate clear and enforceable regulatory frameworks, etc. By using targeted assessment questions (see column 4 of Table 5), stakeholders can systematically evaluate the status of the MAR site in selected areas, helping to identify and prioritize MAR principles (measures) that have not been fully implemented at the site.

Stakeholders should be encouraged to briefly describe the status of the implementation of selected principles at the MAR site, as well as specific gaps, challenges, and opportunities.

During these interactive sessions it is recommended to divide the participants into break-out groups if numbers require. Each group should be supported by a neutral, independent facilitator to guide the session and ensure that all stakeholders are heard.

Outcomes
List of prioritised MAR governance principles that have yet to be fully implemented with descriptions of shared goals and status considering gaps, challenges, and opportunities.

Step 3. Elaborate agreements on implementing identified measures

Within the same stakeholder groups, this third step focuses on elaborating agreements to implement the selected principles. These agreements should clearly define shared goals, roles, responsibilities, conditions, and collaborative efforts required to achieve these principles, ensuring optimized aquifer recharge while safeguarding environmental and community interests. A sample template for LMAs with a more detailed outline is provided in Annex 1.

If break-out sessions in civil assemblies are conducted, each group will select a representative to present and discuss their developed LMA ideas with the full assembly. This collaborative exchange will allow for refining the ideas, after which the best proposals will be chosen and merged into a final draft LMA.

The annexed "Overview of Good MAR Governance Principles" (Annex 3) offers formats, guidelines, and tools designed to support the implementation of MAR principles and provide concrete, actionable frameworks aligned with those introduced in the initial stages (Step 1).

Outcomes

(Preliminary) LMAs: Depending on the flow of the interactive sessions, these initial drafts may serve as recommendations or broad outlines, which can be refined in follow-up meetings. However, ideally, the agreements will be specific enough that stakeholders can commit to signing them at the conclusion of the civil assemblies (in case binding agreements are envisaged).

2.2 Lessons learned from the four AGREEMAR demonstration regions

The series of civil assemblies with stakeholders were conducted in Cyprus, Tunisia, Portugal and Spain, with the aim of discussing and refining the LMA, offered valuable insights into stakeholder engagement and the co-creation process.

One of the most significant lessons learned was the importance of adopting co-creative, dialogue-driven and participatory engagement formats. In Portugal and Cyprus, meetings were intentionally kept small, involving only one to two key stakeholders and up to eight participants. This approach ensured that discussions remained focused and intensive, as the invited stakeholders are the primary actors responsible for water management and planning at national and regional levels. Additionally, due to the close collaboration throughout the AGREEMAR project, these stakeholders were already well-informed about its progress and results. Consequently, general presentations on the project and its outcomes were unnecessary, allowing the meetings to concentrate fully on discussing and finalising the agreements.

The stakeholder meetings in Cyprus and Portugal were a resounding success, laying the foundation for the development of further MAR activities beyond the AGREEMAR project. The discussions demonstrated that the stakeholders involved are keen to explore the potential for MAR in other locations, a commitment that is also reflected in the signed agreements.

In contrast to the other two countries, the civil assemblies in Tunisia and Spain involved larger groups of 15 to 30 participants and followed a different structure. This approach was chosen to engage a broader range of stakeholders, present the main results of the AGREEMAR project, and provide updates on MAR developments at national and regional levels. Additionally, the concept of LMA was introduced. To ensure productive discussions about the LMA draft and its governance principles, participants were divided into smaller break-out groups, each focusing on specific aspects of the LMA and principles. These sessions concluded with short presentations and plenary discussions, which helped consolidate feedback and refine the outcomes effectively.

In Tunisia, the civil assembly reinforced that MAR implementation requires multidimensional collaboration – spanning legal, technical, environmental, and financial domains. By bringing together actors from these diverse fields, the assembly fostered a shared language, identified knowledge gaps, and established a foundation for long-term cooperation. Similarly, in Spain, the civil assembly brought together key stakeholders to strengthen consensus on MAR implementation, particularly in the Júcar River Basin District, setting the stage for future advancements.

Thorough preparation of the civil assemblies or stakeholder meetings was another key factor. Sharing LMA drafts with stakeholders in advance enabled more productive and focused discussions, as participants could familiarise themselves with the content beforehand. This preparation facilitated deeper engagement during the civil assemblies and stakeholder meetings, and resulted in a more efficient refinement, ultimately leading to stronger and more robust final LMA.

Tailoring the form, content and language of each LMA to its specific local context was equally important. While all countries aimed for non-binding agreements—later referred to as a *Letter of Intent* or *Charter* —the content was adapted to aligning with each region's legal framework, institutional roles, and policy environments. As stated earlier, stakeholder interviews conducted during the preparation phase revealed a clear preference for non-binding agreements.

For example, the Tunisian Charter includes detailed references to environmental and monitoring aspects, reflecting national priorities and challenges in terms of MAR. In contrast, the Spanish and Portuguese LMA emphasized regulatory alignment and technical feasibility, addressing their respective governance structures and operational needs.

These experiences provide a valuable blueprint for developing LMA in conjunction with stakeholder processes. Moving forward, it will be essential to maintain flexible and participatory engagement formats, align content with legal and institutional realities, and invest in early, inclusive dialogue to create robust and context-sensitive MAR agreements.

3 Developing LMA for each demonstration site

Building on the strategic approach outlined in Chapter 2.1, the LMA development process for each demonstration site was organized as follows: (1) assessment of the current state of MAR governance; (2) understanding of good MAR governance, including identification of key measures to address gaps, challenges and opportunities; and (3) drafting of the agreements.

As outlined in chapter 2.1, the initial ideas for the LMA were developed during the preparation and verification phase (see Figure 4). These ideas included key elements such as the objectives and scope of the LMA, issues to be addressed, relevant governance principles to incorporate, required AGREEMAR project outcomes (e.g. modelling results), and the identification of stakeholders to involve in the civil assemblies (see Boxes on preliminary ideas for LMA in each demonstration site chapter).

Bilateral exchange meetings with the DS partners provided an opportunity to collaboratively discuss and refine these preliminary ideas, gathering additional input and feedback. Based on these discussions, tailored drafts of the LMA were formulated for each of the four demonstration sites. Following consultation with the DS partners—and, in the case of Cyprus, with the main stakeholder—the terminology was revised, replacing the term "agreement" with *Letter of Intent (LoI)* in Cyprus and Portugal, or *Charter* in Tunisia and Spain. This change was made because the term "agreement" implied a binding commitment, which was not the case. The other two terms were deemed more appropriate as they better aligned with the expectations of both DS partners and stakeholders. It was also agreed to draft each agreement in the respective local language to facilitate easier discussions during the civil assemblies with the stakeholders.

Following the conducted civil assemblies, the proposed refinements were incorporated into the drafts and shared again with stakeholders for final adjustments. In the cases of Cyprus and Portugal, the agreements were signed by stakeholders, marking a significant milestone in the MAR governance process. The signing of these LMA reflects the stakeholders' commitment to the principles outlined in the documents and their shared dedication to MAR initiatives in their respective regions.

3.1 Akrotiri basin (Cyprus)

Preliminary ideas for drafting LMA

Box 1 summarises the initial ideas for the LMA for the demonstration site in the Akrotiri basin in Cyprus. These collected ideas served as the foundation for drafting the LMA, which was discussed and refined during the stakeholder meeting.

Issue to be addressed: Concerns about health impacts of recycled wastewater on nearby drinking water well field

- **Village:** benefit: ensure that the treated wastewater not negatively impact the groundwater quality // possible commitment: adjust the consumption rates according to the management plans
- **WDD:** benefit: mitigate possible conflicts with the local communities' reputation, provide scientific evidence that the existing MAR system does not have negative health or environmental impacts // possible commitment: recharge less during periods of water scarcity OR release larger amounts of water from Kouris dam into Kouris riverbed
- **Farmers**: benefit: allocation of larger amounts of water for irrigation purposes // commitment: to extract more water in case recharged water is flowing towards the drinking field (thus reduce the head gradients)

Relevant governance principles:

- 1.3 Employ an adaptive, sustainable and resilient MAR management & operation
- 1.4 Establish effective monitoring and evaluation strategies and plans
- 4.2 Evaluate and promote potential benefits on local ecosystems and mitigate potential negative impacts
- 6.2 Provide clear and accessible information

AGREEMAR results needed:

- Groundwater modelling objectives: provide scientific evidence (spatio-temporal evolution) under which conditions and MAR operation modes well fields are impacted (or not impacted) by the artificial recharge and provide recommendations to improve the MAR operation.
    - evaluate maximum recharge rates that can be implemented without negative impacts.
    - evaluate maximum extraction rates from the extraction wells for drinking uses.
    - investigate the impact of extracting more water from irrigation wells on the evolution of the recharged wastewater
    - quantify the influence of releasing water from the dam on the above-mentioned issues (minor scenario according to WDD since it is not expected to implement this action to save the drinking water well fields) in case recharged water is flowing towards the drinking field- (thus reduce the head gradients)

Box 1. Preliminary ideas for drafting LMA for the Akrotiri basin (Cyprus)

Civil assembly to refine LMA draft

The civil assembly in Cyprus, conducted as a stakeholder meeting with the primary stakeholder, the Water Development Department (WDD), focused on discussing and refining the draft LMA. In preparation for this meeting, it was agreed with ECoE that only WDD, as the main stakeholder, and a representative from the University of Cyprus would be invited. This choice was justified by the fact that WDD is the responsible Cypriot actor for the water management planning and the adaptation of the EU water policies on a national and regional level. With respect to the AGREEMAR project, the mission of the WDD involves the following tasks:

- The planning, study, construction and operation of waterworks such as dams, reservoirs, water conveyance projects, irrigation and water supply networks and water treatment plants.
- Managing and supplying water from Government Waterworks for various uses.

- Monitoring the water status, the water balance and the preparation and implementation of plans to manage the effects of droughts.
- The implementation of the national programme for the implementation of European Directive on the Treatment of Urban Waste Water with actions relating to the planning and construction of relevant waste water collection and treatment works.
- The implementation of actions for the protection of surface and ground water bodies.
- The monitoring and assessment of the qualitative and quantitative status of groundwater and surface waters.
- The collection and treatment of hydrological, hydrogeological, geotechnical and other data for the study, maintenance and safety of development works and the protection and management of water.
- The implementation of the provisions of the evaluation, management and handling of flood risks legislation.
- The development of a water conscience for the rational use and saving of water

During the discussion with the stakeholder, it was collectively decided to name the LMA Letter of Intent (LoI). This LoI will serve as a foundation for further discussions on MAR initiatives across the Republic of Cyprus and provides a blueprint for future agreements at the local level.

In additions, the outcomes of the AGREEMAR project related to the Cypriot case study were presented, including an overview of feasible regions for potential future MAR sites. Following the meeting, the initial draft of the LoI was modified with respect to the outcomes of the discussions. In particular, additional water legislation and relevant EU policies have been included, while the context has been adjusted to clearly reflect the agreement between the AGREEMAR consortium and the Cypriot water authorities. The final version of the LoI is signed by the General Director of the Water Authorities, which highlights the successful collaboration between the involved organizations, and provides a solid foundation for future MAR planning and implementation.

Figure 6. Stakeholder meeting in Cyprus discussing the LMA draft

The detailed protocol of the stakeholder meeting, including the agenda and minutes, is available in Annex 2.

The signed LoI for Cyprus is attached in Annex 4.

3.2 Korba (Tunisia)

Preliminary ideas for drafting LMA

Box 2 provides a summary of initial ideas for the LMA for the demonstration site in Korba, Tunisia. These ideas formed the basis for drafting the LMA, which was later discussed and refined during the stakeholder meeting.

Issue to be addressed: Deterioration of water quality and quantity, secured access to water for farmers (mitigation of sea water intrusion), sufficient water supply to the Korba wetland

- CDRA/WWTP needs financial support to manage MAR site
- Currently, reclaimed water is partly used to fill the wetland, however, reclaimed water has poor quality, better to use recovered water from MAR
- Since the MAR site is small, there is a possibility to install more MAR sites to also have an impact on seawater intrusion; who will operate these, who will benefit from them, how much water would they receive from the WWTP?

Relevant governance principles:

- Clearly allocate and distinguish roles and responsibilities for MAR financing / Ensure that the financial resources for MAR activities are secured (MAR GW models)
- Better adapt the allocation of the WWTP effluents to the needs of the beneficiaries and seasonal situation (develop adaptive allocation plan, linked to improved monitoring system?)
- Conduct strategic site assessment and selection for further MAR sites (MAR feasibility maps)

AGREEMAR results needed:

- GW modelling: Provide scientific evidence on
    - the impact of the Korba MAR site: currently and if the entire volume of reclaimed water is used. Which of the wells can be regenerated as a result?
    - How many MAR sites or what volume of recharge water is needed to have an impact on seawater intrusion?
    - Will a portion of the recharged water also reach the wetland and benefit it?
- MAR feasibility maps: Show feasible options for MAR

Box 2. Preliminary ideas for drafting LMA for Korba (Tunisia)

Civil assembly to refine LMA draft

The purpose of the civil assembly was to engage stakeholders in exploring the potential of MAR systems for improving groundwater availability, mitigating climate change impacts, and supporting sustainable water resource management in Tunisia. The event presented outcomes of the AGREEMAR project for the Tunisia case study in the Chiba basin (CapBon) and, more specifically, seeked to foster dialogue on the environmental, social, and economic benefits of MAR systems. The event also addressed critical issues related to groundwater restoration, sustainability, and saline intrusion prevention. This civil assembly fostered dialogue between scientists and decision-makers in Tunisia in order to promote sustainable solutions such as MAR, allowing to review the proposed AGREEMAR charter for Tunisia with the participants' contributions.

The charter for Tunisia can be used for further discussion on national level and as a blueprint for future agreements at local level. In the case of Korba, it will serve as a basis to develop a local agreement with the stakeholders involved at local level.

Figure 7. Civil assembly in Tunisia discussing the LMA draft

The detailed protocol of the civil assembly, including the agenda and minutes, is available in Annex 2. The final Charter for Tunisia is attached in Annex 4.

3.3 Alentejo region (Portugal)

Preliminary ideas for drafting LMA

Box 3 outlines the preliminary ideas for the LMA in the Alentejo region of Portugal. These served as the basis for the draft that was reviewed and adapted during the stakeholder meeting.

Issue to be addressed: Water scarcity // Provision of water through sustainable MAR systems using TWW

- Currently, the only MAR system licensed to use treated wastewater in Portugal is Comporta. The main objective of the MAR agreements would be to involve the two main stakeholders responsible for Comporta (APA and AgdA) in the idea of replicating new MAR sites similar to the Comporta site, under specific conditions (e.g. if water quality assessments at the Comporta MAR site demonstrate safety and effective performance), by licensing (in the case of APA) and promoting (in the case of AgdA) those systems.
- Adress water scarcity in Alentejo region.

Relevant governance principles:

- General permission to implement MAR issued by APA to AgdA.
- Obtain necessary permits and licenses for recharge and recovery operations and provide clear and appropriate approval processes.

AGREEMAR results needed:

- MAR feasibility maps: use maps for a first selection of suitable MAR sites for replication of the pilot after successful project completion.

Box 3. Preliminary ideas for drafting LMA for Alentejo region (Portugal)

Civil assembly to refine LMA draft

The civil assembly, conducted as a stakeholder meeting with the primary stakeholders namely APA and AgdA, was concluded with the successful finalization of the LoI for the implementation of MAR in Portugal. After a thorough and constructive review process, the two participating stakeholders reached consensus on the content and structure of the document. The finalized version reflects a shared understanding of the pressing water management challenges in regions such as Alentejo, and outlines a collaborative framework for advancing MAR as a strategic, sustainable response.

Significant improvements were made to the initial draft through the discussion, including the clarification of institutional responsibilities, the strengthening of legal and regulatory references, and the consolidation of technical, environmental, and financial aspects into a coherent and actionable structure. By integrating long-term monitoring, adaptive management strategies, and reference to potential national funding mechanisms, the final Letter of Intention lays a practical foundation for future MAR planning and implementation.

The meeting not only produced a finalized agreement but also strengthened trust and cooperation among the institutions involved. Following the session, all stakeholders received the refined version of the LoI and formally confirmed their support by signing it. The agreed-upon LoI is now positioned to guide the next steps in promoting MAR across Portugal may serve as a reference for the development of further agreements at regional or local levels. The final version signed by APA has undergone some changes in the last paragraphs, according to a last revision made by APA lawyers, nevertheless maintaining the whole spirit of the LoI.

Figure 8. Stakeholder meeting in Portugal discussing the LMA draft

The detailed protocol of the stakeholder meeting, including the agenda and minutes, is available in Annex 2. The signed LoIs for Portugal are attached in Annex 4.

3.4 Júcar River Basin District (Spain)

Preliminary ideas for LMA

Box 4 presents the initial ideas for the LMA in the Júcar River Basin District in Spain, serving as a basis for the draft that was examined and refined during the civil assembly.

Issue to be addressed: Recover the quantitative status of the aquifer

Relevant governance principles:

- Clearly allocate and distinguish roles and responsibilities
- Ensure that the financial resources for MAR activities are secured
- Employ adaptive management strategies
- Establish effective monitoring and evaluation strategies and plans

AGREEMAR results needed

- GW modelling / Aquatool objectives: assess the expected and sustainable quantities and volumes and improvement in reliability and vulnerability
- MAR feasibility maps: confirm the feasibility of MAR in the region

Box 4. Preliminary ideas for drafting LMA for Júcar River Basin District (Spain)

Civil assembly to refine LMA

The stakeholder meeting focused on presenting the outcomes of the AGREEMAR project related to the Spanish case study to the primary stakeholders: Water Commissary, the basin Hydrologic Planning Office, and the Irrigators Community of Vall d'Uixó. This included updates of the project, analysing the developments on the subject of artificial recharge that have taken place since then in different general aspects in Spain and in the DHJ, and discussing aspects related to the implementation and governance of MAR. A part of this meeting was dedicated to discussing and refining the principles of the draft MAR agreement, referred to as the MAR charter in this Spanish context.

The principles and bullet points outlined in the charter were thoroughly discussed, adjusted, and pre-finalized in the group discussions. It was agreed that the adjustments will be integrated into the draft and the reviewed version would be shared for a final round of feedback from the stakeholders. This charter for Spain serves as a foundation for further discussions on MAR initiatives across the country and the two aquifers in the country and provides a blueprint for future agreements at the local level.

Figure 9. Civil assembly in Spain discussing the LMA draft

The detailed protocol of the civil assembly, including the agenda and minutes, is available in Annex 2. The final Charter for Spain is attached in Annex 4.

4 References

Closas et al. (2016): Aquifer contracts: a means to solving groundwater over-exploitation in Morocco? With assistance of Alvar Closas and Karen G. Villholth. Edited by IWMI & GRIPP.

Shivakothi et al. (2018): (2018) Case for GRIPP site on Groundwater-based Natural Infrastructure Water-Storage Japan SWWW 2018. With assistance of Binaya Raj Shivakoti, Tsutomu Ichikawa and Karen G. Villholth. Edited by IGES.

Acknowledgement

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Annex 1 Sample LMA template

1 Context and Background

2 Expected Benefits of MAR Implementation

3 Objective

4 Principles (including concrete bullet points per principle)

- **2.1** Principle 1: Governance and Social Aspects
- **2.2** Principle 2: Legal Aspects
- **2.3** Principle 3: Technical Aspects
- **2.4** Principle 4: Environmental Aspects
- **2.5** Principle 5: Economic Aspects
- **2.6** Principle 6: Monitoring Aspects

5 Example of local MAR site (Box)

Please note that this is only a sample and the structure varies for each of the case studies. Some chapters may not be included for one country but for another.

Annex 2 Protocols of the civil assemblies

2.1 Akrotiri basin (Cyprus)

Agenda

Date: 21st March 2025

Moderation: adelphi, ECoE

Venue: Head Office Water Development Department (WDD), Nicosia (Cyprus)

Table 1. Agenda of the stakeholder workshop in Cyprus

Programme	Speaker / facilitator	Duration	Time-plan
Welcome, objectives and overview of results of the AGREEMAR project	ECoE (Dr. Panagiotou)	15 min	10:00
Introduction of adelphi	adelphi	10 min	10:15
Presentation 1: Identification of feasible regions for managed aquifer recharge in the Republic of Cyprus using a co-participative multi-criteria decision analysis	ECoE (Dr. Panagiotou)	30 min	10:25
Presentation 2: A game-theoretic framework for sustainable water allocation in agriculture: Enhancing economic and water efficiency in Akrotiri district (Cyprus)	University of Cyprus (Dr. Konstantinou)	20 min	10:55
Break		25 min	11:15
MAR Agreement: Introduction and purpose	adelphi	10 min	11:25
MAR Agreement: Discussion and refinement	adelphi	85 min	12:50
Wrap-up and closure	adelphi, ECoE	10 min	13:00

Figure 10. Participants of the stakeholder meeting in Cyprus

Participants of this meeting from left to right: Kyra Baumann (adelphi), Kostas Aristeidou (Coordinator of the Division of Hydrology & Hydrogeology, WDD), Raisa Ferreira Santos (adelphi), Panayiotis Sofronides (Hydrologist, WDD), Kyriaki Kyrmani (Hydrologist, WDD), Constantinos Panagiotou (ECoE), Antonis Thoma (Geologistt, Hydrogeologist, WDD) and Charalampos Konstantinou (not pictured).

Minutes

Constantinos Panagiotou (ECoE) commenced the meeting by welcoming the participants and outlining the event's objectives, including a detailed overview of the AGREEMAR project and its key findings. This introduction was followed by a presentation on the identification of feasible regions for MAR in the Republic of Cyprus. Charalampos Konstantinou from the University of Cyprus then delivered a presentation on a game-theoretic framework designed to optimize sustainable water allocation in agriculture, particularly enhancing economic and water efficiency in the Akrotiri district.

After a short break, adelphi presented the concept of MAR agreements and their significance as envisioned in the AGREEMAR project. A concise overview of the draft LoI for Cyprus was shared, which represents the agreement form selected by AGREEMAR partners. This non-binding agreement outlines the context, anticipated benefits of MAR implementation, objectives, principles, and guidelines to ensure WDD, the primary stakeholder, reaches a consensus to implement and expand MAR in Cyprus. During the plenary session, participants engaged in discussions on the draft, adapting and adding principles as necessary.

The meeting concluded with Constantinos Panagiotou expressing gratitude for the successful collaboration between the AGREEMAR project partners and WDD.

2.2 Korba (Tunisia)

Agenda

Date: 29th January 2025

Moderation: adelphi, INAT

Venue: Hotel Golden Tulip El Mechtel, Tunis (Tunisia)

Table 2. Agenda of the civil assembly in Tunisia

Programme	Intervenant / modérateur	Durée	Heure
Inscription		30 min	09:00
Ouverture & objectifs de l'atelier	Mrs. Elsa Semmling, adelphi, Alle-magne Dr. Anis Chekirbane, coordinateur du projet AGREEMAR, INAT	15 min	09:15
Background (*input sessions*)			
Présentation du projet AGREEMAR: objectifs, méthodes et princi-paux résultats	Dr. Anis Chekirbane, INAT	15 min	09:30
La recharge artificielle des nappes en Tunisie	Ing. Tiba Haggui, DGRE : Expérience Tuni-sienne dans la recharge artifici-elle des nappes Ing. Hanene Kraiem, CDRA de Nabeul : La recharge artificielle au gouvernorat de Na-beul	30 min	10:00
Concept des conventions de re-charge maîtri-sée des aquifères et exemples de bonne pra-tique	Mrs. Elsa Semmling, adelphi	15 min	10:15
Questions / réponses		15 min	10:30
Présentation du projet de la Charte nationale de RMA Objectif et déroulement des sessions de travail de groupe	Mrs. Elsa Semmling, adelphi Dr. Anis Chekirbane, INAT	20 min	10:50
Pause-café		20 min	11:10
Session de travail de groupes : revue du projet de la charte nationale de la recharge maîtrisée des aqui-fères et son adaptation à l'échelle locale			
Collecte des questions & commentaires sur le contenu de la charte de RMA proposée: Groupe 1: Gouvernance, aspects sociaux, jurid-iques et économiques Groupe 2: Aspects tech-niques et économiques Groupe 3: Aspects environ-nementaux et de contrôle Discussions: que doit-on considérer pour adapter cette charte à une échelle locale?	Groupe 1 animé par Mrs. Elsa Semmling, adel-phi & Dr. Jamel Ben Nasr, INAT Groupe 2 animé par Dr. Mohamed Fethi Ben Hamouda, INAT & Mme Tiba Haggui, DGRE Groupe 3 animé par Dr. Layla Ben Ayed, INAT & Dr. Khaoula Khemiri, INAT	50 min	12:00

Programme	Intervenant / modérateur	Durée	Heure
Présentation des résultats de chaque groupe, suivie par une discussion	1 à 2 représentants de chaque groupe Discussion animée par Mrs. Elsa Semmling & Dr. Anis Chekirbane	3 x 15 min présenta-tion 3 x 10 min discussion	13:15
Restitution	Mrs. Elsa Semmling & Dr. Anis Che-kirbane	15 min	13:30
Clôture	Pr. Hamadi Habaieb, Secrétaire d'Etat au-près du Ministre de l'Agriculture, des Res-sources Hydrauliques et de la Pêche Dr. Aissa Hlaimi, Directeur Général des Ressources en Eau, Ministère de l'Agri-culture, des Ressources Hydrauliques et de la Pêche	30 min	14:00
Déjeuner et networking		60 min	15:00

Figure 11. Participants of the civil assembly in Tunisia

All stakeholders related to the context of the AGREEMAR case study in Tunisia were invited to the event (DGRE, CRDA, UTAP (local representatives from the region), WWTP Korba, BPEH, ANPE, DGACTA, Environ-mental NGO (ATPNE Korba), research and academia (INAT, CERTE, CNSTN). A total number of 26 stakeholders took part in the civil assembly.

Minutes

After welcoming the participants and introducing to them the objectives of the event, the civil assembly began with an input session providing the participants with background information on the AGREEMAR project and its main results (INAT). This presentation was followed by inputs on Tunisia's experience with recharge approaches in general (DGRE) and on local level in the Nabeul governorate (CRDA de Nabeul). At the end of the input session, adelphi gave an overview of the concept of LMA as defined and foreseen in AGREEMAR, presenting examples from literature including their success factors and lessons learned. Discussion following this

input session allowed participants to reflect on different approaches/technologies of recharge (direct / indirect, artificial / natural) and to take stock of factors enabling or limiting recharge in Tunisia currently. Limitations included repeated droughts during the last years, insufficient quality of treated wastewater initially foreseen for recharge and in the case of nature-based approaches, the availability of areas. There was a consensus around the huge potential of MAR systems, provided that there functionality is guaranteed. The participants also highlighted the need to base any MAR project on thorough feasibility analysis including physical as well as non-physical criteria (e.g. socio-economic aspects).

The input session was followed by a presentation of the charter developed for the national context of Tunisia by the AGREEMAR project partners. The charter is the form of agreement that was chosen by the AGREEMAR partners in coordination with the local stakeholders as the most suitable form for a MAR agreement in the Tunisian context. This legally non-binding charter outlines the objective, principles and guidelines to ensure all stakeholders associated with MAR in Tunisia have a shared consensus to implement and scale-up MAR.

Participants were invited to split into groups in order to discuss principles that should be included in such a charter:

- Group 1 focussed on governance and social aspects, as well as legal aspects
- Group 2 focussed on technical and economic aspects
- Group 3 focussed on environmental and monitoring aspects

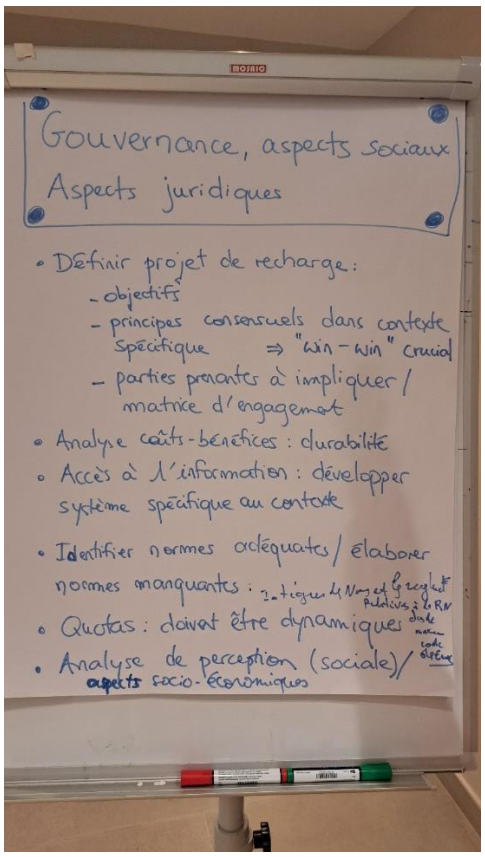
All groups brainstormed which principles should be included in the Charter for Tunisia under the aspects mentioned above, building on their expertise and sharing their experience on national, regional and local levels. Participants wrote down key outcomes of the group work on pinboards (see figures included in the section below) and presented them to the plenary. Key outcomes of the discussion are summarised below and will serve as a basis for finalisation of the Charter for Tunisia. Participants will be given the opportunity to read and contribute to the final version of the Charter.

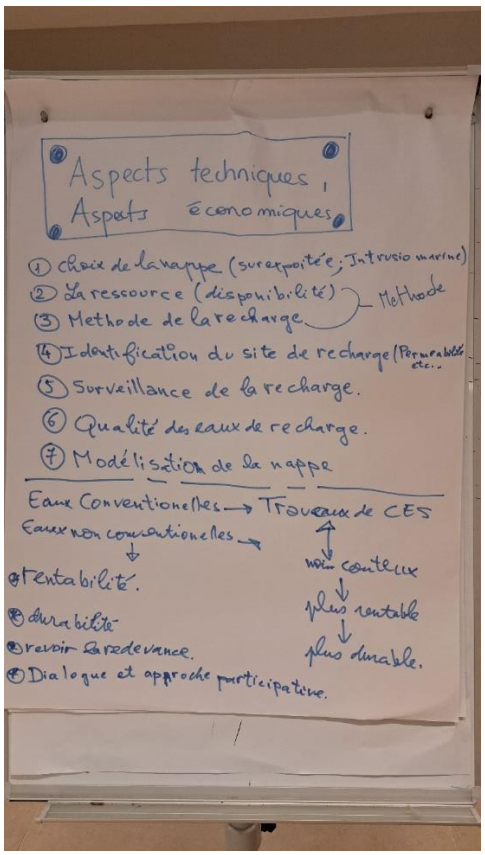
The civil assembly was closed by Prof. Hamadi Habaieb, State Secretary for the Minister of Agriculture, Water Resources and Fisheries, who underlined the importance of the AGREEMAR project in bringing together partners and case studies from diverse countries around the Mediterranean. The State Secretary also mentioned the measures Tunisia has undertaken over the last years to face water stress caused by many years of drought while water demand keeps rising. He emphasized the crucial importance of innovative approaches such as MAR and its potential to make use of non-conventional water resources, particularly treated wastewater.

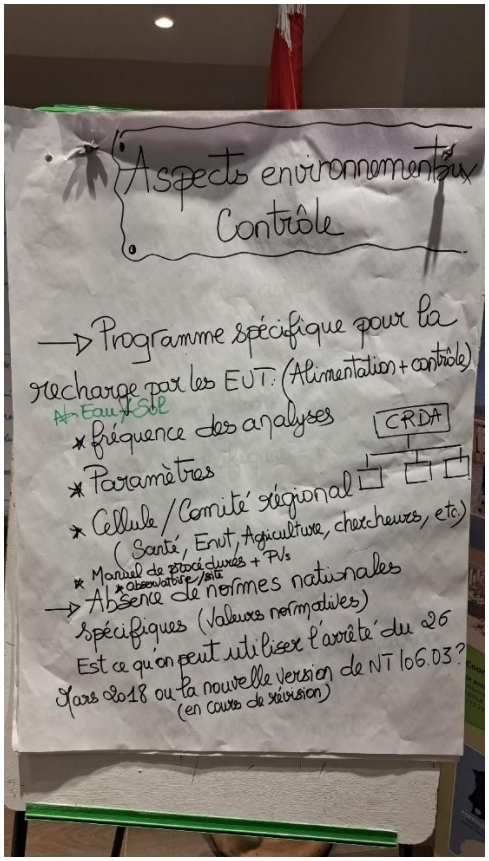
Key outcomes

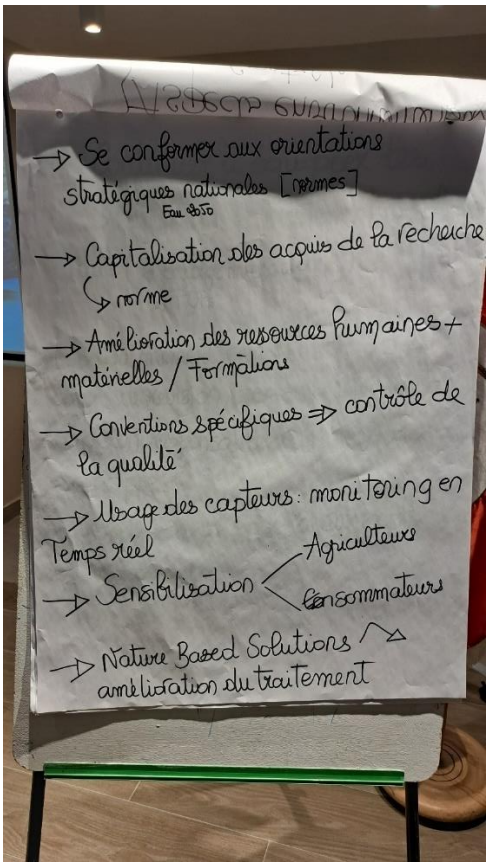
The main discussed aspects of the MAR charter with the participants could be summarized as follows:

- Stakeholder engagement: promote an inclusive approach with clear governance and regular consultations.
- Strengthening norms and legislation: adapt regulations and ensure compliance with water quality standards for recharge.
- Technical improvements: conduct hydrogeological assessments and use advanced modelling tools to optimize MAR projects.
- Environmental considerations: protect water quality and ecosystems while ensuring sustainable resource management.
- Economic viability: perform cost-benefit analyses and establish sustainable financial mechanisms.
- Collaboration and knowledge sharing: enhance interinstitutional cooperation and leverage international best practices.


Gouvernance, aspects sociaux
Aspects juridiques
• Définir projet de recharge :
- objectifs
- principes consensuels dans contexte spécifique ⇒ "win-win" crucial
- parties prenantes à impliquer / matrice d'engagement
• Analyse coûts-bénéfices : durabilité
• Accès à l'information : développer système spécifique au contexte
• Identifier normes adéquates / élaborer normes manquantes :
• Quotas : doivent être dynamiques
• Analyse de perception (sociale) / aspects socio-économiques


Aspects techniques, Aspects économiques
① choix de la nappe (surexploitée ; Intrusion marine)
② La ressource (disponibilité)
③ Methode de la recharge
Methode
④ Identification du site de recharge (Perméabilité etc..)
⑤ Surveillance de la recharge.
⑥ Qualité des eaux de recharge.
⑦ Modélisation de la nappe
Eaux Conventionelles → Travaux de CES
Eaux non conventionelles →
moins couteux
plus rentable
plus durable.
⑧ rentabilité.
⑨ durabilité
⑩ revoir la redevance.
⑪ Dialogue et approche participative.


Aspects environnementaux
Contrôle
→ Programme spécifique pour la recharge par les EUT. (Alimentation + contrôle)
Air Eau Sol
* fréquence des analyses
* Paramètres
* Cellule / Comité régional
(Santé, Envt, Agriculture, chercheurs, etc.)
CRDA
* Manuel de procédures + PVs
* observatoire / site
→ Absence de normes nationales spécifiques (Valeurs normatives)
Est ce qu'on peut utiliser l'arrêté du 26 Mars 2018 ou la nouvelle version de NT 106.03 ?
(en cours de révision)


→ Se conformer aux orientations stratégiques nationales [normes]
Eau Sol
→ Capitalisation des acquis de la recherche
norme
→ Amélioration des ressources humaines + matérielles / Formations
→ Conventions spécifiques ⇒ contrôle de la qualité
→ Usage des capteurs : monitoring en Temps réel
→ Sensibilisation
Agriculteurs
Consommateurs
→ Nature Based Solutions
amélioration du traitement

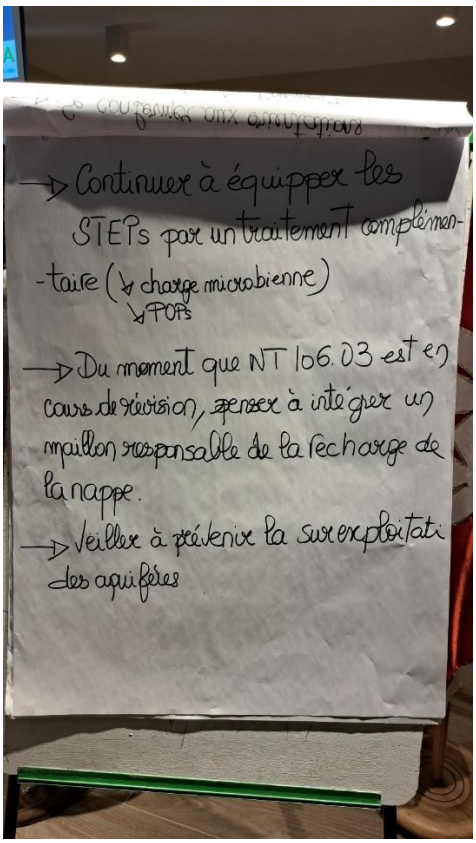


Figure 12. Results from the break-out groups

2.3 Alentejo region (Portugal)

Agenda

Date: 24th January 2025

Moderation: LNEC & adelphi

Venue: APA Alentejo, Av. Eng. Arantes e Oliveira 193, 7004-514 Évora, Portugal

Table 3. Agenda of the stakeholder meeting in Portugal

Programme	Speaker / facilitator	Duration	Time-plan
Welcome and objectives	LNEC and adelphi	15 min	14:00
Background (*input sessions*) Main outcomes of the last AGREEMAR workshop General concept of local MAR agreements Proposal for local MAR agreements	LNEC	15 min	14:15
Discussion: Finalising local MAR agreements Refining ideas presented using MAR governance principles and AGREEMAR results (e.g., GW models, feasibility maps, etc.). The discussion will be documented by the facilitator using Constellation Analysis.	LNEC and adelphi	2 hours	14:30
Final wrap up and closre	LNEC and adelphi	30 min	16:30

Minutes

The meeting began with a welcome from Teresa Leitão (LNEC), who provided a concise introduction to the AGREEMAR project, its objectives, and the relevance of Managed Aquifer Recharge (MAR) for addressing growing water stress in Portugal. She contextualized the importance of finalizing a joint LoI to guide future MAR initiatives, particularly in the Alentejo and Algarve regions.

Following the introduction, participants – representing key national and regional water institutions – gathered around a shared table to carry out a collaborative review of the draft LoI. There were no formal presentations; instead, the session took the form of an open, interactive dialogue, with all stakeholders having previously received and reviewed the draft document.

The group proceeded through the LoI section by section, carefully discussing the language, clarifying terms, and aligning expectations. The collaborative nature of the exchange allowed for immediate incorporation of feedback into a working version of the document. Key adjustments included:

- Clarification of stakeholder roles and responsibilities, particularly concerning coordination be-tween APA, AgdA, municipalities, and research institutions.
- Refinement of legal references, ensuring stronger alignment with Portuguese legislation (such as the Water Law and Decree-Law 382/99) as well as relevant EU directives, including the newly adopted Urban Wastewater Directive (2024/3019).
- Specification of the MAR licensing process, including clearer pathways and criteria to guide potential project proponents.
- Consolidation of technical and environmental aspects into a single principle, streamlining the document and emphasizing the integrated nature of MAR planning.
- Inclusion of long-term monitoring and adaptive management mechanisms to ensure environmental sustainability and continuous improvement.

- Strengthening of economic considerations, including references to national financing mechanisms such as the Environmental Fund and the integration of MAR into broader water planning instruments.

Throughout the meeting, stakeholders contributed constructively, and consensus was reached on each element. The final version of the LoI was reviewed in full at the end of the session, with all parties confirming their agreement and readiness to proceed with signing.

Figure 13. Participants of the stakeholder meeting in Portugal

All stakeholders related to the selected MAR site — including APA (national and regional offices) and AgdA-AdP — were invited and attended.

2.4 Júcar River Basin District (Spain)

Agenda

Date: 3rd April 2025

Moderation: UPV, adelphi

Venue: UPV

Table 4. Agenda of the civil assembly in Spain

Programme	Speaker / facilitator	Duration	Time-plan
Welcome and introduction	UPV (Joaquín Andreu)	15 min	09:00
Session 1: Update on the work carried out in the AGREEMAR project	UPV (Joaquín Andreu)	60 min	09:15
Session 2: Update on the vision on Managed Aquifer Recharge from stakeholder organisations	Water Commissary of the JRBD (Cristina Solá), Hydrologic Planning Office of the JRBD (Arancha Fi-dalgo), ACUAMED (Fernando Juan), Irrigators Community of Vall d'Uixó	15 min 15 min 15 min 15 min	10:15 10:30 10:45 11:00
Coffee break		15 min	11:15
Session 3: Round Table/Debate	UPV (Joaquín Andreu)	90 min	11:30
Session 4: MAR Agreement: Introduction, discussion and refinement	Group 1 facilitated by adelphi Group 2 facilitated by UPV	60 min	13:00
Final wrap up and closure	UPV	15 min	14:00
Lunch and networking			14:15

Figure 14. Participants of the civil assembly in Spain

Minutes

Joaquin Andreu commenced the meeting by welcoming the participants, outlining the objectives of the seminar, and providing a detailed overview of the status of the AGREEMAR project and the work carried out so far and from the last seminar.

This first session was followed by a presentation of each main stakeholder organisation present in the seminar. The presentations focused on what actions around MAR had been taken so far, or could be considered as such, developments around the topic and opportunities for the future implementation of MAR. After a short break Joaquin Andreu opened the round table discussion, were all the stakeholders contributed challenges, opportunities and potential solutions for the implementation of a MAR project.

In the next session adelphi presented two examples of MAR projects and the main governance principles and aspects included in the charter. This non-binding charter outlines the context, anticipated benefits of MAR implementation, objectives, principles, and guidelines to ensure a successful implementation and consensus to implement and expand MAR in Spain, particularly in the JRBD. During a group work session, two groups were formed, were each discussed three principles of the draft charter, adapting and adding further principles as necessary.

The meeting concluded with Joaquin Andreu expressing gratitude for the successful collaboration between the AGREEMAR project partners.

Annex 3 Good MAR governance principles

Table 5. Good MAR governance principles

Area	Principle ID	MAR principles	Questions to assess the status of a MAR system and identify gaps/risks	MAR phase	Adapted from the OECD Principle	Formats, guidelines, tools, methodologies helping to fill these gaps
Cross-cutting principles	0.1	**Clearly allocate and distinguish roles and responsibilities** for MAR planning, MAR policy making, implementation, operation, monitoring, conflict management, etc. and foster coordination between the responsible authorities and decision makers.	Are the roles and responsibilities for all MAR phases clearly defined (e.g. for enforcing and checking compliance with MAR regulations)?	MAR planning, MAR operation	OECD Principle 1	
			Are there mechanisms in place to review roles and responsibilities, identify gaps, and adjust when needed?			
			Are there gaps, overlaps, or conflicts related to the responsibilities and roles of the different stakeholders involved in MAR planning and management?			
			Are there dedicated bodies or capacities (e.g. within a ministry / agency) in charge of enforcement and compliance of MAR rules?			
	0.2	**Promote regular monitoring and evaluation** of compliance with the MAR agreement where appropriate	Do formal requirements exist for evaluation and monitoring?	MAR planning, MAR operation	OECD Principle 12	
	0.3	**Promote a strong science-policy interface** including the adoption and implementation of innovative MAR practices across relevant stakeholders	Have pilot tests been conducted?	MAR planning, MAR operation	OECD Principle 8	
			Have lessons learned from successes and failures be adopted?			
			Are there mechanisms for sharing knowledge and experience to bridge the gap between science, policy and practice?			
			Do platforms exist to draw lessons from failures in MAR systems/sites, and to catalyse and scale-up best practices and success stories?			
Technical	1.1	**Conduct strategic site assessment and selection** considering besides the	Do you use a standardized process for MAR site selection?	MAR planning		A methodology for feasibility mapping including all these

		intrinsic site suitability also feasibility criteria related to water demand, water availability and non-physical conditions such as legal and socio-economic aspects.	Was a feasibility map created for MAR site selection?			aspects are provided by the AGREEMAR project [Link].
			For MAR site selection, were criteria on the water demand, water availability and non-physical criteria considered?			
			Has a risk assessment been conducted?			
			Ensure that the MAR activities and design are in line with the water allocation plan of the region.			Developing a water allocation plan: Aquatool
	1.2	**Ensure that the MAR activities and set-up are appropriate for the hydrogeological characteristics** of the aquifer, and water balance.	Is there a good understanding of the hydrogeological characteristics of the aquifer recharged?	MAR planning / MAR operation		GW models à INOWAS Platform providing GW models and assessment features simplified for decision makers, helpful for adapting MAR operation/infiltration pattern, and in cases of big changes: MAR design, type, or location
			Is there a regular evaluation of the water balance / budget of the aquifer conducted?			
	1.3	**Employ an adaptive, sustainable and resilient MAR management & operation**	What long-term plans are in place to ensure the sustainability of the MAR system?	MAR operation		
			Does the current management approach / operation plan allow for adjustments based on monitoring results and changing conditions (e.g., climate change, land use, water demand)?			
			Is the site's operation regularly aligned to regional plans (considering e.g., allocation and adaptation plans)?			
			Are your management/operation practices regularly reviewed and updated to incorporate innovative approaches and new knowledge?			
	1.4	**Establish effective monitoring and evaluation strategies and plans** considering key indicators such as groundwater levels, recharge and recovered water quality, recharge rates, and aquifer storage changes on	Is there a regularly updated, timely shared, consistent and comparable online MAR information system in place providing data on XXX that is harmonised, co-ordinated and accessible across key stakeholders?	MAR operation	OECD Principle 5	INOWAS platform for data collection, processing, and visualization of real-time data + real-time update of MAR GW model
			Does a data collection, monitoring and evaluation plan exist?			

		a regular basis to ensure stable MAR system performance, reduce risks, and make informed management decisions.	Are real-time data collected and processed to inform decision making?			
			Are key data on MAR system performance publicly available and communicated to end users?			
	1.5	**Establish effective maintenance strategies and plans** to ensure a good MAR performance.	Are there clear procedures and protocols for performing maintenance tasks?	MAR operation		
			Are there contingency plans in place for dealing with unexpected maintenance issues or system failures?			
Regulatory	2.1	**Advocate clear and enforceable regulatory frameworks** governing MAR projects that are in line with sector specific processes.	Are comprehensive legal, institutional and regulatory frameworks in place that sets rules, standards and guidelines for MAR projects?	MAR operation		
			Are those frameworks for MAR projects well-coordinated, transparent and implemented?			
	2.2	**Ensure the effective implementation and enforcement** of the legal framework for MAR systems in the public interest.	Are regulatory tools to promote compliance and foster the quality of regulatory processes in place? (including M&E processes, e.g., regular inspections, audits, and enforcement actions, e.g., rewards and penalties)	MAR operation	OECD Principle 7	
			Are clear, transparent and proportionate enforcement rules, procedures defined?			
			Are relevant regulatory and inspection authorities embedded with resources in line with their mandate? In case of dedicated regulatory agency(ies), are they financially independent?			
	2.3	**Obtain necessary permits and licenses** for recharge and recovery operations and **provide clear and appropriate approval processes**.	Is the current approval process clear and transparent?	MAR operation		
			How many different authorities are involved in the approval process?			
			Is it possible to obtain a permit within a reasonable time frame?			

Policy	3.1	**Existence of a dedicated MAR policy** that defines goals, objectives, tasks and resources for MAR systems.	To what extent does a specific (national) MAR policy or similar guideline exist that defines and sets out objectives and tasks to achieve a sustainable water management?	MAR operation		
			Have applicable international/supranational MAR guidelines and/or frameworks and regulations been implemented at the national/subnational level?			
	3.2	**Encourage policy coherence** through effective cross-sectoral coordination, especially between policies for water and the environment, health, energy, agriculture, industry and land use.	To what extent are coordinated mechanisms in place to facilitate coherent policies across different ministries, agencies and different levels of government, including cross-sectoral plans?	MAR operation	OECD Principle 3	
			How are the MAR activities coordinated with other water management activities such as surface water management, wastewater treatment, and stormwater management?			
			Are incentives and regulations already in place to mitigate conflicts between sectoral strategies?			
	3.3	**Incorporate MAR into broader water resource management plans.**	Are there specific goals and objectives within regional water management plans that address MAR?	MAR planning, MAR operation		
Environmental	4.1	**Consideration of long-term environmental aspects during MAR planning and design**, including protection and conservation of its surrounding nature and biodiversity.	To what extent does the MAR site meet long-term environmental objectives?	MAR planning		
	4.2	**Evaluate and promote potential benefits on local ecosystems and mitigate potential negative impacts**, including surface	How frequently are environmental impact assessments conducted, and what methods are used?	MAR planning, MAR operation		
			What potential negative impacts on local ecosystems have been identified, and how are they being mitigated?			

		water bodies and dependent flora and fauna.	How are the identified potential benefits to local ecosystems being actively promoted and enhanced through MAR operations?			
Economical/ Financial	5.1	**Ensure that the financial resources for MAR activities are secured.**	How is the funding of the MAR site secured? Are there sufficient financial revenues, such as taxes, tariffs or transfers, to cover operating costs and to renew long-term assets?		OECD Principle 6	
			Is there a clear and consensus-based distribution of MAR-associated costs among stakeholders?			
			Is there a strategic financial planning in place to assess short-, medium- and long-term investments and operational needs?			
			Is MAR integrated int long-term investment plans?			
			Are there measures to ensure the availability and sustainability of funding?			
			In case of water-related disasters, are there flexible and solidarity mechanisms?			
Stakeholder Engagement, community involvement and awareness	6.1	**Ensure diverse representation and engagement** of all relevant stakeholder groups, including local communities, water users, environmental organizations, government agencies, and industry stakeholders and encourage participation from marginalized or underrepresented groups to ensure all voices are heard and considered to conduct an inclusive decision-making process, soliciting input, needs, and perspectives from diverse stakeholders	Who are the key stakeholders of the specific MAR site?	MAR planning / MAR operation		
			How are stakeholders, interested in or affected by the outcomes of MAR, identified?			
			To what extent are the different needs and expectations of stakeholders from different sectors considered?			
			Is there a national/international multi-stakeholder coordination platform for MAR, including representatives from public, private and non-profit sectors and different categories of users?			
			What regulations and/or mechanisms are in place for cooperation with neighbouring regions to coordinate and regulate transboundary water abstraction from MAR-impacting sites?			

			Are there horizontal coordination mechanisms at different levels, such as regular cross-sectoral meetings or joint actions of different ministries/agencies at the sub-national level?			
	6.2	**Mainstream and promote integrity and transparency practices** in MAR projects to increase accountability and trust in decision making among various stakeholders.	Are relevant stakeholders regularly informed about important processes in MAR design and governance and are effective mechanisms in place to access project documents, data and reports, and provide opportunities for feedback and input?	MAR planning / MAR operation	OECD Principle 9	
			Which tools are used for that (e.g. newsletter, social media, website, press releases)?			
			Do norms, codes of conduct or charters on integrity and transparency exist in the local/national MAR context? And is their implementation being monitored?			
			Are mechanisms in place to identify potential corruption drivers and risks across all relevant institutions, as well as other integrity and transparency gaps?			
	6.3	**Use participatory approaches** to gather local knowledge, preferences, and feedback, ensuring that community voices are heard and respected.	How were community members involved in the planning and decision-making processes of the MAR project?	MAR planning / MAR operation		
			How frequently was community feedback solicited, and what channels were used (e.g., surveys, public meetings, focus groups)?			
			How was local knowledge gathered and incorporated into the design and implementation of the MAR project?			
	6.4	**Ensure early and continuous stakeholder engagement**	Are stakeholders early in the planning and decision-making process engaged to identify concerns, preferences, and values?	MAR planning / MAR operation		

			What measures are in place to ensure ongoing community engagement and participation throughout the lifecycle of the MAR project?			
			Is there an ongoing communication maintained throughout all stages of the MAR project, from planning and implementation to monitoring and evaluation?			
	6.5	**Empower stakeholders** by providing opportunities for meaningful participation, decision-making roles, and leadership development as well as **offering trainings** on MAR concepts, processes, etc.	Are there guidelines or standards for capacity building across different stakeholders/authorities at all levels?	MAR planning / MAR operation		
			Is the capacity level of responsible stakeholders adapted to the complexity of MAR challenges?			
			What mechanisms exist to identify and address capacity gaps?			
			Where are capacity gaps in terms of MAR, notably for planning, management, finance/budgeting, monitoring and evaluation?			
			Do online platforms/tools/agreements exist for capacity building, experience learning and knowledge sharing?			
	6.6	**Foster an environment of mutual respect, trust, and collaboration** among stakeholders, project proponents, and decision-makers	Are diverse perspectives, interests, and concerns acknowledged and addressed with openness and empathy in stakeholder meetings?			
			How were conflicting preferences and concerns among different community groups managed?			

Annex 4 Final MAR agreements

Letter of Intent
Managed Aquifer Recharge

A letter of intention by the Water Development Department (WDD) to consider the outcomes of the AGREEMAR project with respect to the implementation and scale-up of future Managed Aquifer Recharge (MAR) projects in Cyprus

Context and Background

Located in the south-eastern part of the Mediterranean basin, the island of Cyprus faces significant water management challenges, with one of the highest water exploitation indices in the European Union, mainly due to prolonged droughts and excessive water use to meet growing demand. With limited freshwater resources, the island is promoting the use of non-conventional water sources, such as desalinisation and treated wastewater, as viable alternatives. The national water authorities aim to use treated wastewater to fulfil at least 40% of agricultural needs, which account for the majority of water consumption (64%), followed by domestic (28%) and tourism (5%) sectors. Currently, the agricultural sector utilises over 70% of the treated wastewater produced, with a significant portion allocated for artificial recharge at the two Managed Aquifer Recharge (MAR) sites of Ezousa and Akrotiri, addressing the imbalance between water demand and supply (See Box: SAT-MAR sites in Cyprus: Akrotiri and Ezousa).

MAR[1] has emerged as a crucial strategy, offering a proactive and scientifically guided approach to enhancing groundwater replenishment. By prioritizing MAR, water systems become more resilient, ensuring the sustainable availability of this essential and finite resource for future generations. The overall objective of the PRIMA AGREEMAR project[2] in Cyprus is to promote the use of SAT-MAR (Soil-Aquifer Treatment Managed Aquifer Recharge) as an environmentally sustainable technology to increase the groundwater availability, while mitigating and preventing seawater intrusion.

Expected Benefits of MAR Implementation

The implementation of MAR is expected to yield multiple benefits, including:

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[1] Managed Aquifer Recharge (MAR) is the practice of deliberately recharging aquifers to recover the water at some point in the future and/or for environmental or water quality reasons. It is considered as a multi-purpose water management tool, which incorporates a variety of water sources, recharge techniques and storage management practices (Dillon et al. 2009).

[2] The "Adaptive Agreements on Benefits Sharing for Managed Aquifer Recharge in the Mediterranean Region" (AGREEMAR) project, funded by National Funding Agencies from Tunisia, Germany, Cyprus, Portugal, and Spain under the PRIMA program, aims to achieve sustainable water resource management through Managed Aquifer Recharge (MAR) solutions designed for climate change adaptation.

- **Aquifer Recovery**: MAR will help replenish groundwater levels, ensuring a more sustainable water balance in the basin.
- **Improved Water Supply Security**: By integrating MAR with existing water management strategies, the reliability of water supply for agricultural, industrial, and urban uses will be enhanced.
- **Mitigation of Seawater Intrusion**: MAR can serve as a protective barrier against saltwater intrusion, preserving the quality of coastal groundwater resources.
- **Energy and Cost Savings**: Reducing the need for deep groundwater pumping decreases energy consumption and operational costs.
- **Environmental and Ecosystem Benefits**: MAR can contribute to maintaining river-aquifer connectivity and supporting ecological functions.

Objective

The **objective** of this Letter of Intent (LoI) is to establish a comprehensive framework which will be considered, **without the obligation to be adopted by the responsible authorities**, during the implementation and replication of MAR initiatives in Cyprus. This framework aims to address the critical challenges of water scarcity and groundwater management by enhancing water security through sustainable practices.

This LoI aligns with the General Governance Framework established under the PRIMA AGREEMAR project, further elaborated in this LoI with MAR principles encompassing governance, social, legal, technical, environmental, economic, and regulatory aspects. These principles apply to the context of scaling-up MAR in Cyprus. The LoI outlines principles and guidelines agreed among stakeholders for an effective initiation, implementation, operation and maintenance of MAR solutions in Cyprus. It ensures alignment with national legal frameworks and fosters sustainable practices, operational efficiency and environmental safety to address the challenges of water scarcity and groundwater management. The LoI embraces the key elements of stakeholder processes to ensure MAR activities to be transparent, participatory, where stakeholders are informed and consulted during any MAR initiation and implementation process within Cyprus. The LoI highlights the importance of stakeholder collaboration and adherence to best practices to maintain the integrity and effectiveness of MAR systems.

Principles

Principle 1: Governance and Social Aspects

- Engage relevant stakeholders, including MAR beneficiaries, and establish their roles and relationships to ensure collaborative efforts.

- Agree upon adaptations and conditions required to implement the MAR project effectively based on stakeholder consultation.
- Clearly define the duration of the MAR project implementation, outlining key milestones and timelines to ensure structured progress and accountability throughout the project's lifecycle.
- Define clear short-and long-term objectives to guide the MAR project, considering both immediate and future goals.
- Develop and define strategies, assigning specific roles and responsibilities to ensure accountability.
- Prioritize consulting with representatives of local communities to inform them of actions being considered, address their concerns and inform them of potential risks and benefits, while maintaining open communication to foster inclusivity and support.
- Ensure that communication and dissemination of intentions and results are accessible and easily understood, taking into account the ethical and cultural backgrounds of communities.

Principle 2: Legal Aspects

- Ensure compliance with relevant standards and regulations to maintain legal and environmental integrity. The management of water resources in Cyprus is regulated mainly from the following laws, which should also be considered in the implementation of MAR:
    - Managed Aquifer Recharge (MAR). Common Implementation Strategy for the Water Framework Directive and the Floods Directive. Guidance Document No. 39. European Commission. Directorate-General for Environment. Brussels.
    - Regulation (EU) 2020/741 on Requirements for Water Reuse: water quality and monitoring requirements and risk management provisions, for the safe use of reclaimed water in the context of integrated water management.
    - The Quality of Water for Human Consumption Law (46(I)/2023) / Directive (EU) 2020/2184 on the Quality of Water Intended for Human Consumption: requirements to improve access to safe drinking water, addressing contaminants, and promoting transparency, sustainability and equitable access, in alignment with public health and environmental goals.
    - The Integrated Water Management Law (N. 79/2010): all responsibilities/jurisdictions regarding the water resources management are assigned to the Water Development Department.

- The Water Protection and Management Law (N. 13/2004): harmonization legislation of the European Guideline Framework for Water Protection and Management of the Water Bodies and Resources within the EU.
- Law regarding Control of Water Pollution/Contamination (N. 106/2002): Harmonization with the European guidelines for urban sewage treatment (91/271/EOK)
- Law regarding Evaluation, Management, and Treatment of Flood Hazards (N. 70/2010): Harmonization with the European guidelines for floods (2007/60/EC)

- Develop water quality standards and regulations tailored for MAR in Cyprus.

Principle 3: Technical Aspects

- Advance the use of Soil-Aquifer Treatment in Managed Aquifer Recharge (SAT-MAR) as an innovative approach to enhance groundwater availability, supporting sustainable water management including flood management.
- Conduct a preliminary assessment to understand the feasibility and scope of the MAR project.
- Select suitable locations for MAR based on geological and hydrological criteria.
- Conduct comprehensive feasibility mapping to identify areas where MAR can be most effectively implemented, considering environmental, social, and economic factors.
- Perform detailed technical evaluations using modelling to predict outcomes and optimize design.
- Utilize advanced Decision Support Systems to enhance water management strategies, ensuring that MAR operations are optimized for efficiency and sustainability.
- Employ sophisticated groundwater modelling techniques to simulate and predict aquifer responses, aiding in the design and management of MAR systems for optimal performance.

Principle 4: Environmental Aspects

- Ensure that salinization and overuse of the aquifer are prevented, thereby maintaining or improving water availability for agriculture and local communities.
- To minimize environmental risks, the wastewater used for MAR is rigorously analysed in addition to secondary/tertiary treatment and tested for biological contamination and emerging pollutants.

- The MAR system maintains favourable hydrological conditions as per the defined standards for the surrounding ecosystem.

Principle 5: Economic aspects

- Conduct a thorough cost-benefit analysis to evaluate the economic viability and potential returns of the MAR project, ensuring that investments are justified by anticipated benefits.
- Distribute construction and maintenance costs among citizens of the Republic of Cyprus, as they benefit directly or indirectly from MAR (e.g. through mitigation of seawater intrusion).
- Capital costs (infrastructure such as pipelines) and costs associated with the transfer and treatment of wastewater used for MAR are funded by the government.
- New consumers/customers will be identified near the existing MAR infrastructure to sell groundwater extracted near the MAR site.

Principle 6: Monitoring aspects

- Integrate risk management plans to identify, assess, and mitigate potential challenges.
- Establish compliance and enforcement mechanisms to ensure adherence to the agreed-upon guidelines and maintain project integrity.
- Implement a monitoring and evaluation system to continuously assess progress and outcomes, facilitating adaptive management and improvement.
- Systematic water quality monitoring is carried out, with regular assessments of treated wastewater for pollutants, including emerging contaminants and pathogens.
- Comprehensive monitoring of groundwater quantity and quality is carried out.
- Monitoring the impact of climate change and crisis projections on recharge water availability and water demand patterns is incorporated into planning for the design and dimensioning of MAR sites.

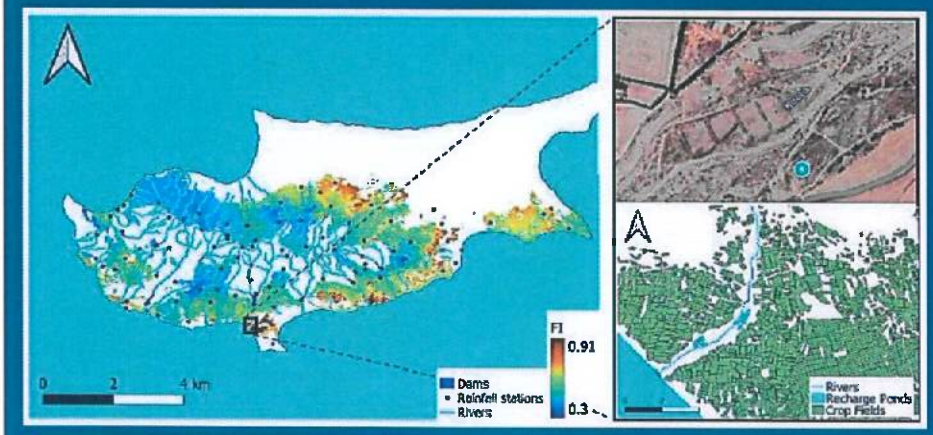
SAT-MAR sites in Cyprus: Akrotiri and Ezousa

At present, two SAT-MAR sites operating in the non-occupied part of Cyprus, both utilising tertiary treated wastewater as a source and employing infiltration ponds as a recharge technique. These systems aim to mitigate the intrusion of seawater into the coastal aquifer while storing water amounts for future use, primarily for agricultural purposes.

The Akrotiri MAR site is located in the southern part of the island, near the Limassol urban area. It consists of seventeen infiltration ponds, which are recharged based on the tertiary-treated wastewater from the urban Wastewater Treatment Plant during the winter period (1-4 Mm^3 in annual basis). Any surplus treated wastewater is discharged into the sea.

The second MAR site is installed close to Paphos urban area, located in the southwestern part of Cyprus, recharging the Ezousa aquifer in an annual basis. This choice is recommended by the water authorities as the only MAR technique suitable for recharging the groundwater systems with treated wastewater due to quality considerations (e.g. additional microbial and chemical purification processes via water-rock interactions).

Further details can be found in the technical case study briefs.



Cypriot demo region and Akrotiri MAR site.

Example of MAR in Cyprus, implemented under the AGREEMAR project

ΓΕΩΡΓΙΟΣ ΚΑΖΑΝΤΖΗΣ
Αν. Διευθυντής

Charte sur la Recharge Maîtrisée des Aquifères (RMA) en Tunisie

Un engagement entre parties prenantes à mettre en œuvre et à développer la recharge maîtrisée des aquifères en Tunisie

La pénurie d'eau constituant un défi de plus en plus critique, le besoin de solutions durables et à long terme est devenu plus pressant. En Tunisie, les aquifères côtiers sont soumis à diverses pressions résultant de la surexploitation des ressources en eau souterraine, principalement pour l'agriculture. Ces pressions ont exacerbé des risques tels que la pollution, la baisse du niveau des eaux souterraines, la salinisation et l'intrusion de l'eau de mer. La recharge artificielle des nappes phréatiques a débuté dans les années 1970 sous la forme de projets pilotes et est devenue une méthode efficace de gestion de l'eau dans les années 1990. Cette approche a donné des résultats prometteurs en matière de restauration du niveau des eaux souterraines. Par exemple, dans l'aquifère côtier de Teboulba, une augmentation significative de 30 m du niveau des eaux souterraines a été observée. De même, dans l'aquifère de Kairouan, au centre de la Tunisie, les niveaux d'eau ont augmenté de manière significative de 0,2 à 5,25 m en cinq mois de recharge artificielle. La recharge a également eu un effet positif dans un rayon de 8 km autour des puits d'injection, en augmentant les niveaux d'eau. Certaines études ont confirmé des augmentations similaires des niveaux d'eau dans des aquifères tels que le sous-écoulement d'El Khairat à la suite d'opération de recharge entre 2002 et 2005. La Tunisie reconnaît la nécessité d'adapter les méthodes de recharge artificielle des nappes phréatiques en utilisant les eaux usées traitées comme alternative aux ressources en eau conventionnelles, en particulier lorsque le changement climatique a un impact sur la disponibilité de l'eau dans les régions arides du pays.

La Recharge Maîtrisée des Aquifères (RMA)[1]s'est imposée comme une stratégie cruciale, offrant une approche proactive et scientifiquement guidée pour améliorer la recharge des nappes phréatiques. En donnant la priorité à la RMA, les systèmes aquifères deviennent plus résilients, garantissant la disponibilité durable de cette ressource essentielle et limitée pour les générations futures. Dans le cadre du projet PRIMA AGREEMAR[2] , un site de recharge artificielle de la nappe a été créé à Korba pour remédier au déséquilibre entre la demande et l'offre d'eau dans le bassin de Chiba et pour atténuer l'effet de l'intrusion marine sur les eaux de l'aquifère (**tel que le site de**

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[1] La recharge maîtriséedes aquifères (Managed Aquifer Recharge : MAR) est la pratique qui consiste à recharger délibérément les aquifèresafin de récupérer l'eau et l'utiliser ultérieurement pour des fins d'approvisionnement,environnementales ou d'amélioration de la qualité de l'eau souterraine(Dillon et al. (2009).

[2] Le projet "Adaptive Agreements on Benefits Sharing for Managed Aquifer Recharge in the Mediterranean Region" (AGREEMAR), financé par les agences nationales de financement de Tunisie, d'Allemagne, de Chypre, du Portugal et d'Espagne dans le cadre du programme PRIMA, vise à assurer une gestion durable des ressources en eau grâce à des solutions de recharge maîtrisée des aquifères (RMA) conçues pour l'adaptation au changement climatique.

recharge artificielle de Korba). C'est en exécutant ce projet pilote qu'a surgit l'idée de l'établissement d'une Charte de recharge maîtrisée des aquifères pour la Tunisie, en tant que complément aux efforts nationaux déjà menés dans le domaine de la recharge maîtrisée. À ce titre, les études et expérimentations pilotées par la **Direction Générale des Ressources en Eau (DGRE)** constituent un socle important à intégrer. Depuis les années 1960, plusieurs techniques ont été adoptées pour infiltrer les eaux de surface dans les aquifères, telles que **l'infiltration des excès d'eau d'irrigation** pour la nappe de Soukra (1965) ; **l'injection directe des eaux conventionnelle dans les puits** captant la nappe de Teboulba à Monastir (1970 – 1977) ; **l'infiltration-percolation des EUTs** pour la nappe de Nabeul-Hammamet (1985) ; les **lâcher de barrages** et les **seuils de retenue** dans les gouvernorats de Siliana, Kairouan, Kasserine, Nabeul et Zaghouan (1972-1992) ; **les barrages souterrains** de la nappe d'Oum Lagsab, Sidi Aich à Gafsa (1995) et **l'injection des eaux du Nord dans les carrières et les puits** des nappes de Ras Djebal, Morneg et Guennich (1992 – 1998). Selon les estimations, les volumes de recharge atteints entre 1992 et 2023 est de **1142 Mm^3 soit une moyenne d'environ 36,8 Mm^3/an**. Ces résultats traduisent l'importance de capitaliser sur l'expérience acquise à l'échelle nationale.

La **vision** globale vise à atteindre un impact durable et significatif à long terme, notamment en renforçant la sécurité hydrique par l'optimisation de la gestion technique des sites RMA et en favorisant l'évolution du cadre législatif lié à ces systèmes, basé sur les principes de bonne gouvernance. Cette approche ambitionne de proposer des solutions concrètes aux crises liées à la pénurie d'eau et aux sécheresses aggravées par le changement climatique. Cette charte, bien que juridiquement non contraignante, établit les **objectifs, principes et lignes directrices** nécessaires pour garantir une compréhension commune et une collaboration efficace entre toutes les parties prenantes impliquées dans la recharge maîtrisée des aquifères en Tunisie. Elle fixe les bases pour une mise en œuvre harmonieuse et une extension structurée de ces systèmes.

L'objectif principal de la charte RMA est de fournir un cadre global qui oriente la mise en œuvre et l'extension des initiatives de recharge maîtrisée des aquifères en Tunisie. Ce cadre vise également à établir une synergie avec la **Stratégie nationale de l'eau à l'horizon 2050**, qui identifie la recharge des aquifères comme un levier majeur de résilience hydrique. En ce sens, la charte s'inscrit dans une dynamique d'alignement avec les priorités institutionnelles nationales en matière de gestion durable de l'eau.

La Charte s'appuie sur le Cadre Général de Gouvernance établi dans le cadre du projet PRIMA AGREEMAR et intègre les principes fondamentaux de durabilité appliqués à la recharge maîtrisée des aquifères (RMA). Ces principes couvrent les dimensions de gouvernance, ainsi que les aspects légaux, techniques, environnementaux, économiques, sociaux et réglementaires, adaptés au contexte spécifique de la Tunisie. La Charte décrit les principes et les lignes directrices convenus entre les différentes parties prenantes pour un lancement, une mise en œuvre, une exploitation et une maintenance efficaces des projets de recharge maîtrisée des aquifères en Tunisie. Elle

garantit l'alignement avec les cadres juridiques nationaux et encourage les pratiques durables, l'efficacité opérationnelle et la sécurité environnementale pour relever les défis de la pénurie d'eau et de la gestion des eaux souterraines. En outre, la Charte établit des éléments clés pour s'assurer que les activités liées aux projets RMA soient transparentes et participatives. Elle garantit que les parties prenantes concernées sont informées, consultées et impliquées à chaque étape, depuis l'initiation jusqu'à la mise en œuvre. Enfin, la Charte met en avant l'importance de la collaboration interinstitutionnelle et de l'adhésion aux meilleures pratiques internationales, afin de préserver l'intégrité et l'efficacité des systèmes RMA tout en répondant aux enjeux hydriques actuels et futurs.

Principes de la charte RMA

Principe 1 : Gouvernance et aspects sociaux

- Associer activement toutes les parties prenantes concernées, y compris les bénéficiaires des systèmes RMA, en définissant clairement leurs rôles et leurs interactions pour garantir une collaboration efficace.
- Établir des objectifs précis, à court et à long terme, qui orienteront le projet RMA tout en prenant en compte les besoins immédiats et les perspectives futures.
- Fixer une durée définie pour la mise en œuvre du projet, accompagnée de jalons et d'échéances clairs, afin d'assurer une progression structurée et une responsabilisation continue tout au long du cycle de vie du projet.
- Identifier et mettre en place les ajustements nécessaires pour une mise en œuvre optimale, sur la base d'une consultation étroite avec les parties prenantes.
- Élaborer des stratégies bien définies en assignant des rôles et responsabilités spécifiques, afin de garantir une gestion transparente et une obligation de rendre des comptes.
- Mettre l'accent sur l'engagement communautaire en informant régulièrement les bénéficiaires des actions prévues, tout en maintenant une communication ouverte pour promouvoir leur inclusion et leur soutien.
- Assurer une communication continue et active entre les groupes d'intérêt locaux, les autorités chargées de la gestion de l'eau et les organisations environnementales, un élément clé pour la réussite des projets RMA.

Principe 2 : Aspects juridiques

- Veiller au respect des normes et réglementations pertinentes afin de préserver l'intégrité juridique et environnementale.

- Le système RMA fonctionne en totale conformité avec le Code de l'eau tunisien (établi en 1975) et toutes les mises à jour légales ultérieures.
- Toutes les activités respectent les normes nationales établies, notamment celles relatives à la qualité des eaux usées définies par l'Office National de l'Assainissement (ONAS).
- Élaborer des normes de qualité de l'eau et des réglementations spécifiques adaptées aux systèmes RMA en Tunisie.

Principe 3 : Aspects techniques

- Promouvoir l'utilisation des systèmes d'infiltration-percolation dans la recharge maîtrisée des aquifères (SAT-MAR) en tant qu'approche innovante pour améliorer la disponibilité des eaux souterraines et soutenir une gestion durable de l'eau en Tunisie.
- Sélectionner les sites appropriés pour les projets RMA en se basant sur une cartographie de faisabilité de la RMA qui tient en compte à la fois les critères physiques tels que les caractéristiques intrinsèques des sites, la disponibilité en eau de recharge et la demande pour les projets de RMA et les critères non physiques tels que les aspects socio-économiques
- Employer des techniques avancées de modélisation des eaux souterraines pour simuler et prédire les réactions des aquifères, facilitant ainsi la conception et la gestion des systèmes RMA pour des performances optimales.
- Adopter des systèmes avancés d'aide à la décision pour affiner les stratégies de gestion de l'eau, garantissant que les opérations RMA restent optimisées pour une efficacité et une durabilité maximales.
- Établir un inventaire national des méthodes de recharge artificielle des aquifères, en intégrant les techniques existantes et en évaluant leur applicabilité selon les contextes régionaux. **Une attention particulière sera portée aux régions du Centre et du Sud (Médenine, Gabès, Kébili, Kairouan),** afin d'identifier des solutions adaptées aux enjeux locaux et de favoriser l'émergence de nouveaux projets pilotes.

Principe 4 : Aspects environnementaux

- Veiller à prévenir la salinisation et la surexploitation de l'aquifère, afin de préserver ou d'améliorer la disponibilité de l'eau pour l'agriculture et les communautés locales.
- Pour minimiser les risques environnementaux, les eaux usées utilisées pour la recharge maîtrisée des aquifères (RMA) doivent être rigoureusement analysées après un traitement secondaire et testées pour détecter toute contamination biologique et la présence de polluants émergents.

- Assurer que le système RMA maintienne des conditions hydrologiques favorables, conformes aux normes établies pour préserver l'équilibre de l'écosystème environnant.

Principe 5 : Aspects économiques

- Réaliser une analyse coûts-avantages approfondie pour évaluer la viabilité économique et la rentabilité potentielle du projet RMA, en garantissant que les investissements sont justifiés par les bénéfices attendus.
- Évaluer la durabilité financière du projet et structurer les mécanismes de financement pour assurer un soutien à long terme.
- Mettre en place un cadre transparent de répartition des coûts afin d'assurer un partage équitable des responsabilités financières entre les parties prenantes, garantissant une contribution plus efficace de toutes les parties à la viabilité économique du projet.

Principe 6 : Aspects liés au contrôle

- Intégrer des plans de gestion des risques pour identifier, évaluer et atténuer les difficultés potentielles liées aux projets RMA.
- Mettre en place des mécanismes de conformité et d'application pour garantir le respect des lignes directrices convenues et maintenir l'intégrité des initiatives.
- Mettre en œuvre un système de suivi et d'évaluation continue basé sur des indicateurs qui facilitent la gestion adaptative et les améliorations continues du système RMA.
- Assurer un contrôle systématique de la qualité de l'eau avec des évaluations régulières des eaux usées traitées, en détectant les polluants, y compris les contaminants émergents et les agents pathogènes.
- Optimiser la performance des systèmes RMA en évaluant l'efficacité des bassins d'infiltration, en identifiant les colmatages, et en intégrant des technologies IoT pour la surveillance environnementale.
- Intégrer la surveillance des effets du changement climatique sur la disponibilité de l'eau de recharge et les schémas de demande dans la planification, la conception et le dimensionnement des sites RMA.

Carta de Intenções *para implementar a Gestão da Recarga de Aquíferos (MAR) em Portugal*

Contexto e Enquadramento

A escassez de água em Portugal é um desafio cada vez mais crítico, especialmente nas regiões do Alentejo e do Algarve, onde as alterações climáticas, o aumento da procura de água e a utilização mais intensiva de recursos hídricos, incluindo águas subterrâneas, têm levado à diminuição dos recursos e a preocupações ambientais. As bacias hidrográficas do Guadiana e do Sado e Mira são particularmente afetadas, com a agricultura a utilizar uma parte significativa da água disponível, recorrendo frequentemente à captação de águas subterrâneas para rega. Esta situação é agravada pelo aumento sazonal da população em zonas turísticas, exercendo uma pressão adicional sobre os recursos hídricos imposta não apenas pelo setor agrícola, mas também pelo setor urbano.

A Gestão da Recarga de Aquíferos (do acrónimo em inglês *Managed Aquifer Recharge* – MAR)[1] surgiu como uma estratégia essencial para enfrentar estes desafios, promovendo a recarga das águas subterrâneas através de métodos cientificamente orientados.

A Assembleia da República, nos termos do n.º 5 do artigo 166.º da Constituição, recomenda que o «governo incentive o desenvolvimento de projetos e iniciativas que contribuam para a operacionalização de MAR enquanto solução complementar de gestão de recursos hídricos em face do agravamento dos cenários de seca avaliando e acautelando devidamente todos os impactos ambientais» (Resolução 86/2022 de 26 de dezembro de 2022). Mais recentemente, uma das medidas propostas no Programa do XXIV Governo Constitucional para promover a eficiência hídrica, em particular no Algarve e Alentejo (ponto 8.1. do Programa), passa pela implementação de um projeto piloto de MAR.

O projeto PRIMA AGREEMAR[2] está a acompanhar a implementação de MAR em Portugal, com um local-piloto na área da Estação de Tratamento de Águas Residuais (ETAR) da Comporta, contribuindo para aumentar a oferta de água. Este projeto contribuiu com uma cartografia de zonas com potencial de implementação de MAR das

[1] A Gestão da Recarga de Aquíferos (MAR) é a prática de recarregar aquíferos de forma intencional para recuperar a água num momento futuro e/ou por razões ambientais ou de qualidade da água. É considerada uma ferramenta multifuncional de gestão da água, que integra uma variedade de fontes hídricas, técnicas de recarga e práticas de gestão de armazenamento (Dillon et al., 2009).

[2] O projeto "Acordos Adaptativos sobre Partilha de Benefícios para a Gestão da Recarga de Aquíferos na Região do Mediterrâneo" (AGREEMAR), financiado por Agências Nacionais de Financiamento da Tunísia, Alemanha, Chipre, Portugal e Espanha, no âmbito do programa PRIMA, tem como objetivo alcançar uma gestão sustentável dos recursos hídricos através de soluções de Gestão da Recarga de Aquíferos (MAR) concebidas para a adaptação às alterações climáticas.

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regiões hidrográficas do Guadiana e Sado e Mira. Dado o crescente défice hídrico, o aproveitamento de potenciais excedentes hídricos não convencionais como as águas de cheias e as águas residuais tratadas, podem contribuir para garantir a segurança hídrica a longo prazo. Em situações de escassez extrema, em que o armazenamento de água à superfície pode estar comprometido, o armazenamento subterrâneo em conjugação de técnicas MAR apresenta-se como uma solução viável, sobretudo em regiões com características hidrogeológicas adequadas das Massas de Água do Alentejo e do Algarve.

O projeto AGREEMAR pretende promover a aplicação das técnicas da Gestão da Recarga de Aquíferos com Tratamento do Solo-Aquífero (SAT-MAR) como uma solução estrutural para pequenas ETAR, melhorando a qualidade da água durante a própria infiltração, potenciando disponibilidade de águas subterrâneas, reduzindo o desequilíbrio entre a oferta e a procura e, por isso, mitigando os impactos das alterações climáticas. Através da cocriação de acordos, nomeadamente através da assinatura de uma Carta de Intenções, que promovam a implementação de MAR, o projeto procura reforçar a colaboração entre investigadores, entidades gestoras da água e utilizadores, assegurando o cumprimento da legislação, a garantia da qualidade da água e uma maior aceitação social e política desta abordagem sustentável devidamente enquadrada nas estratégias atuais e para uma melhor gestão dos recursos hídricos.

Desafios para a Gestão dos Recursos Hídricos nas Bacias do Guadiana e do Sado e Mira

Foram identificados vários desafios nestas bacias hidrográficas:

- **Sobreexploração de águas subterrâneas:** O uso intensivo de águas subterrâneas, tem evidenciado a tendência de descida dos níveis piezométricos, refletindo-se num aumento da pressão sobre os aquíferos. Alguns estudos recentes indicam uma variação anual do nível das águas subterrâneas entre 0,5 e 1 metro, nalgumas áreas.

- **Intrusão marinha:** Os sistemas aquíferos costeiros, incluindo o sistema aquífero da Bacia do Tejo-Sado – Margem Esquerda, que suporta o ecossistema estuarino do Sado, enfrentam o risco de intrusão marinha, podendo vir a afetar a qualidade da água doce e as atividades económicas.

- **Escassez de água e alterações climáticas:** A variabilidade dos padrões de precipitação e as secas prolongadas e recorrentes agravam os problemas de disponibilidade de água. Algumas projeções climáticas indicam uma redução de 10 a 15% na precipitação anual em certas áreas, até 2050.

- **Dificuldade em assegurar o abastecimento de água:** A região enfrenta incertezas na disponibilidade de água a longo prazo, dificultando a garantia de

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um fornecimento estável para alguns usos, especialmente durante períodos de seca.

- **Falta de infraestruturas e lacunas regulamentares:** Embora as técnicas MAR tenham sido testadas em projetos piloto, ainda falta um quadro regulatório e legal abrangente para a sua implementação no país, bem como a nível da União Europeia.

O Papel da Gestão da Recarga de Aquíferos (MAR) na Resolução Destes Desafios

A Gestão da Recarga de Aquíferos (MAR) é reconhecida como uma estratégia viável para mitigar estes desafios hídricos. A MAR envolve a recarga intencional dos aquíferos através de métodos tais como bacias de infiltração ou furos de recarga, com a utilização de fontes de água não convencionais tais como águas de excedentes hídricos (e.g., cheias) ou águas residuais tratadas.

Para as bacias hidrográficas do Guadiana e do Sado e Mira, alguns locais de demonstração de MAR incluem:

- **Estação de Tratamento de Águas Residuais (ETAR) da Comporta:** Utiliza técnicas de Gestão da Recarga de Aquíferos com Tratamento do Solo-Aquífero (SAT-MAR) para promover a infiltração das águas tratadas, ao mesmo tempo que melhora a qualidade das águas residuais tratadas antes da sua infiltração no sistema aquífero. Taxas atuais de infiltração: 110-581 m^3/dia, com uma média de 137 m^3/dia.

- **Locais com potencial de implementação:** O mapeamento da viabilidade de MAR, baseado em Sistemas de Informação Geográfica, identificou várias áreas da ARH do Alentejo com condições favoráveis para a implementação de MAR. A implementação futura requer estudos hidrogeológicos de detalhe para determinar a sua adequação a projetos da Gestão da Recarga de Aquíferos.

Benefícios Esperados da Implementação de MAR

A implementação da Gestão da Recarga de Aquíferos (MAR) nestas regiões deverá proporcionar múltiplos benefícios, incluindo:

- **Aumento da disponibilidade de água nos aquíferos:** MAR tem o potencial de aumentar o armazenamento de águas subterrâneas e a recuperação dos níveis piezométricos, mas os volumes específicos devem ser determinados com base em estudos hidrogeológicos específicos de cada local e em avaliações de viabilidade.

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- **Melhoria da segurança no abastecimento de água:** Ao integrar MAR com as estratégias existentes de gestão da água, a fiabilidade do abastecimento para a agricultura, a indústria e os usos urbanos será reforçada.

- **Mitigação da intrusão marinha:** MAR pode funcionar como uma barreira de proteção contra a intrusão marinha, preservando a qualidade dos recursos hídricos subterrâneos nas zonas costeiras.

- **Poupança energética e redução de custos:** Ao diminuir a necessidade de bombear água subterrânea de maiores profundidades, MAR pode contribuir para a redução do consumo energético, contribuir para a descarbonização e dos custos operacionais, promovendo simultaneamente a sustentabilidade dos aquíferos e a minimização dos impactes ambientais.

- **Benefícios ambientais e dos ecossistemas:** MAR pode ajudar a manter a conectividade entre rios e aquíferos e assegurar o bom estado dos Ecossistemas Dependentes de Águas Subterrâneas (EDAS), apoiando as funções ecológicas.

Objetivo desta Carta de Intenções

O objetivo desta Carta de Intenções é estabelecer um quadro abrangente para a promoção, implementação e expansão das iniciativas de Gestão da Recarga de Aquíferos (MAR) em Portugal. Este documento fornece princípios orientadores e diretrizes para futuras partes interessadas.

Esta Carta de Intenções está alinhada com o Quadro Geral de Governação estabelecido no âmbito do projeto PRIMA AGREEMAR, que procurou integrar aspetos de governança, legais, técnicos, ambientais, económicos e sociais relevantes para a expansão de MAR. Assegura também a coerência com os quadros legais nacionais, promovendo simultaneamente a eficiência operacional, a segurança ambiental e a sustentabilidade a longo prazo.

Um dos principais focos da Carta de Intenções é a colaboração, transparência e participação dos Atores (*stakeholders)*. O documento define processos para garantir que todos os atores relevantes sejam informados e consultados ao longo das fases de iniciação e implementação de MAR. Ao promover as melhores práticas e uma governança inclusiva, esta Carta de Intenções reforça a integridade e a eficácia dos sistemas de MAR na resposta aos desafios da segurança hídrica em Portugal.

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Princípio 1: Governança e Aspetos Sociais

- Se os *stakeholders* relevantes, incluindo os potenciais beneficiários de MAR, forem envolvidos (ou seja, se os seus papéis e relações puderem ser estabelecidos para garantir esforços colaborativos).
- Se for estabelecido um quadro para a Carta de Intenções (ou seja, se as responsabilidades e direitos dos principais atores ficarem devidamente estabelecidas).
- Se for reforçada a coordenação entre a Agência Portuguesa do Ambiente (APA), a os gestores e distribuidores de água como a AgdA, os municípios e as instituições de investigação (ou seja, se MAR puder ser mais bem integrada nas políticas nacionais de gestão da água).
- Se forem asseguradas consultas públicas e o envolvimento dos atores através da plataforma PARTICIPA e de consultas regionais (ou seja, se a transparência e a participação pública puderem ser garantidas).

Princípio 2: Aspetos Legais

- Se for garantido o cumprimento da Lei da Água e legislação complementar que transpõe as Diretivas-Quadro da Água e das Águas Subterrâneas (ou seja, se os projetos de MAR cumprirem a legislação nacional e comunitária em vigor).
- Se os padrões de qualidade da água e as aprovações regulatórias para as operações de MAR forem definidos (ou seja, se os projetos puderem avançar com clareza em relação à avaliação de riscos).
- Se MAR não for implementada perto de aterros, locais contaminados ou dentro dos perímetros de captações de águas subterrâneas, conforme estabelecido pelo Decreto-Lei 382/99 (ou seja, se a segurança ambiental puder ser garantida).
- Se for assegurada a conformidade com os padrões nacionais de qualidade das águas subterrâneas ("Limiares"[3] definidos pela APA) e outra legislação ambiental.
- Se for estabelecido o processo de licenciamento para a implementação das técnicas MAR junto das autoridades competentes (ou seja, seja claro para o requerente todos os passos no sentido de solicitar a autorização de implementação, e.g., estudos necessários, parâmetros de devem estar devidamente caracterizados ou indicadores qualitativos e quantitativos que suportem o pedido de licenciamento).

[3] Quadro 8.1, p. 115-117. (PGRH_3_SistemasClassificacao.pdf)

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Princípio 3: Aspetos Técnicos e Ambientais

- Se o processo for alavancado por mapeamentos preliminares de viabilidade[4], estudos hidrogeológicos e avaliações de risco, nomeadamente com a implementação de testes-piloto (ou seja, se os projetos de MAR puderem ser devidamente avaliados quanto à sua viabilidade).
- Se forem utilizados Sistemas de Apoio à Decisão (DSS) para que o projeto MAR possa alcançar o sucesso técnico (ou seja, se o desenho e a operação de MAR puderem ser otimizados com recurso a ferramentas adequadas e informação atualizada).
- Se for garantido o cumprimento da Diretiva (UE) 2024/3019 (revisão da Diretiva de Águas Residuais Urbanas) para a descarga de águas residuais tratadas (ou seja, se forem cumpridos os padrões ambientais).
- Se forem desenvolvidos programas de monitorização de longo prazo para acompanhar a evolução da qualidade da água para recarga e a do meio recetor, bem como a saúde dos EDAS caso se justifique (ou seja, se a sustentabilidade de MAR puder ser assegurada).
- Se forem desenvolvidas estratégias de gestão adaptativa com base nos resultados da monitorização garantindo a manutenção do bom estado da massa de água (ou seja, se a eficiência de MAR puder ser melhorada ao longo do tempo se necessário).

Princípio 4: Aspetos Económicos

- Se forem definidas vantagens financeiras claras para os atores (ou seja, se a viabilidade a longo prazo de MAR puder ser facilitada).
- Se for desenvolvida uma estrutura de financiamento a nível nacional envolvendo atores públicos e privados através de mecanismos como o Fundo Ambiental ou potenciado pelas estratégias e medidas definidas nos instrumentos de planeamento (ou seja, se os projetos de MAR puderem ser financeiramente apoiados).

Assinado por: **PATRÍCIA ALEXANDRA DIAS BRITO PALMA**
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Patrícia Palma
Vogal Executiva do Conselho de Administração

[4] Foi produzido no contexto do projeto AGREEMAR um conjunto de mapas de viabilidade para o sul de Portugal. A descrição detalhada do processo de construção desses mapas encontra-se publicada em artigo científico (Proposal for a managed aquifer recharge feasibility index for southern Portugal using multi-criteria decision analysis - ScienceDirect) e nos Relatórios de Projeto 2.2 e 2.3 Deliverables – AGREEMAR), sendo que os mapas estão disponíveis para consulta no *webmap* DATAHUB do projeto (datahub.inowas.com).

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Carta de Intenções *para implementar a Gestão da Recarga de Aquíferos (MAR) em Portugal*

Contexto e Enquadramento

A escassez de água em Portugal é um desafio cada vez mais crítico, especialmente nas regiões do Alentejo e do Algarve, onde as alterações climáticas, o aumento da procura de água e a utilização mais intensiva de recursos hídricos, incluindo águas subterrâneas, têm levado à diminuição dos recursos e a preocupações ambientais. As bacias hidrográficas do Guadiana e do Sado e Mira são particularmente afetadas, com a agricultura a utilizar uma parte significativa da água disponível, recorrendo frequentemente à captação de águas subterrâneas para rega. Esta situação é agravada pelo aumento sazonal da população em zonas turísticas, exercendo uma pressão adicional sobre os recursos hídricos imposta não apenas pelo setor agrícola, mas também pelo setor urbano.

A Gestão da Recarga de Aquíferos (do acrónimo em inglês *Managed Aquifer Recharge* – MAR)[1] surgiu como uma estratégia essencial para enfrentar estes desafios, promovendo a recarga das águas subterrâneas através de métodos cientificamente orientados.

A Assembleia da República, nos termos do n.º 5 do artigo 166.º da Constituição, recomenda que o «governo incentive o desenvolvimento de projetos e iniciativas que contribuam para a operacionalização de MAR enquanto solução complementar de gestão de recursos hídricos em face do agravamento dos cenários de seca avaliando e acautelando devidamente todos os impactos ambientais» (Resolução 86/2022 de 26 de dezembro de 2022). Mais recentemente, uma das medidas propostas no Programa do XXIV Governo Constitucional para promover a eficiência hídrica, em particular no Algarve e Alentejo (ponto 8.1. do Programa), passa pela implementação de um projeto piloto de MAR.

O projeto PRIMA AGREEMAR[2] está a acompanhar a implementação de MAR em Portugal, com um local-piloto na área da Estação de Tratamento de Águas Residuais (ETAR) da Comporta, contribuindo para aumentar a oferta de água. Este projeto contribuiu com uma cartografia de zonas com potencial de implementação de MAR das regiões hidrográficas do Guadiana e Sado e Mira. Dado o crescente défice hídrico, o aproveitamento de potenciais excedentes hídricos não convencionais como as águas de cheias e as águas residuais tratadas, podem contribuir para garantir a segurança hídrica a longo prazo. Em situações de escassez extrema, em que o armazenamento de água à superfície pode estar comprometido, o armazenamento subterrâneo em conjugação de técnicas MAR apresenta-se como uma solução viável, sobretudo em regiões com características hidrogeológicas adequadas das Massas de Água do Alentejo e do Algarve.

[1] A Gestão da Recarga de Aquíferos (MAR) é a prática de recarregar aquíferos de forma intencional para recuperar a água num momento futuro e/ou por razões ambientais ou de qualidade da água. É considerada uma ferramenta multifuncional de gestão da água, que integra uma variedade de fontes hídricas, técnicas de recarga e práticas de gestão de armazenamento (Dillon et al., 2009).

[2] O projeto "Acordos Adaptativos sobre Partilha de Benefícios para a Gestão da Recarga de Aquíferos na Região do Mediterrâneo" (AGREEMAR), financiado por Agências Nacionais de Financiamento da Tunísia, Alemanha, Chipre, Portugal e Espanha, no âmbito do programa PRIMA, tem como objetivo alcançar uma gestão sustentável dos recursos hídricos através de soluções de Gestão da Recarga de Aquíferos (MAR) concebidas para a adaptação às alterações climáticas.

O projeto AGREEMAR pretende promover a aplicação das técnicas da Gestão da Recarga de Aquíferos com Tratamento do Solo-Aquífero (SAT-MAR) como uma solução estrutural para pequenas ETAR, melhorando a qualidade da água durante a própria infiltração, potenciando disponibilidade de águas subterrâneas, reduzindo o desequilíbrio entre a oferta e a procura e, por isso, mitigando os impactos das alterações climáticas. Através da cocriação de acordos, nomeadamente através da assinatura de uma Carta de Intenções, que promovam a implementação de MAR, o projeto procura reforçar a colaboração entre investigadores, entidades gestoras da água e utilizadores, assegurando o cumprimento da legislação, a garantia da qualidade da água e uma maior aceitação social e política desta abordagem sustentável devidamente enquadrada nas estratégias atuais e para uma melhor gestão dos recursos hídricos.

Desafios para a Gestão dos Recursos Hídricos nas Bacias do Guadiana e do Sado e Mira

Foram identificados vários desafios nestas bacias hidrográficas:

- **Sobreexploração de águas subterrâneas:** O uso intensivo de águas subterrâneas, tem evidenciado a tendência de descida dos níveis piezométricos, refletindo-se num aumento da pressão sobre os aquíferos. Alguns estudos recentes indicam uma variação anual do nível das águas subterrâneas entre 0,5 e 1 metro, nalgumas áreas.
- **Intrusão marinha:** Os sistemas aquíferos costeiros, incluindo o sistema aquífero da Bacia do Tejo-Sado – Margem Esquerda, que suporta o ecossistema estuarino do Sado, enfrentam o risco de intrusão marinha, podendo vir a afetar a qualidade da água doce e as atividades económicas.
- **Escassez de água e alterações climáticas:** A variabilidade dos padrões de precipitação e as secas prolongadas e recorrentes agravam os problemas de disponibilidade de água. Algumas projeções climáticas indicam uma redução de 10 a 15% na precipitação anual em certas áreas, até 2050.
- **Dificuldade em assegurar o abastecimento de água:** A região enfrenta incertezas na disponibilidade de água a longo prazo, dificultando a garantia de um fornecimento estável para alguns usos, especialmente durante períodos de seca.
- **Falta de infraestruturas e lacunas regulamentares:** Embora as técnicas MAR tenham sido testadas em projetos piloto, ainda falta um quadro regulatório e legal abrangente para a sua implementação no país, bem como a nível da União Europeia.

O Papel da Gestão da Recarga de Aquíferos (MAR) na Resolução Destes Desafios

A Gestão da Recarga de Aquíferos (MAR) é reconhecida como uma estratégia viável para mitigar estes desafios hídricos. A MAR envolve a recarga intencional dos aquíferos através de métodos tais como bacias de infiltração ou furos de recarga, com a utilização de fontes de água não convencionais tais como águas de excedentes hídricos (e.g., cheias) ou águas residuais tratadas.

Para as bacias hidrográficas do Guadiana e do Sado e Mira, alguns locais de demonstração de MAR incluem:

- **Estação de Tratamento de Águas Residuais (ETAR) da Comporta:** Utiliza técnicas de Gestão da Recarga de Aquíferos com Tratamento do Solo-Aquífero (SAT-MAR) para promover a infiltração das águas tratadas, ao mesmo tempo que melhora a qualidade das águas residuais tratadas antes da sua infiltração no sistema aquífero. Taxas atuais de infiltração: 110-581 m^3/dia, com uma média de 137 m^3/dia.

- **Locais com potencial de implementação:** O mapeamento da viabilidade de MAR, baseado em Sistemas de Informação Geográfica, identificou várias áreas da ARH do Alentejo com condições favoráveis para a implementação de MAR. A implementação futura requer estudos hidrogeológicos de detalhe para determinar a sua adequação a projetos da Gestão da Recarga de Aquíferos.

Benefícios Esperados da Implementação de MAR

A implementação da Gestão da Recarga de Aquíferos (MAR) nestas regiões deverá proporcionar múltiplos benefícios, incluindo:

- **Aumento da disponibilidade de água nos aquíferos:** MAR tem o potencial de aumentar o armazenamento de águas subterrâneas e a recuperação dos níveis piezométricos, mas os volumes específicos devem ser determinados com base em estudos hidrogeológicos específicos de cada local e em avaliações de viabilidade.

- **Melhoria da segurança no abastecimento de água:** Ao integrar MAR com as estratégias existentes de gestão da água, a fiabilidade do abastecimento para a agricultura, a indústria e os usos urbanos será reforçada.

- **Mitigação da intrusão marinha:** MAR pode funcionar como uma barreira de proteção contra a intrusão marinha, preservando a qualidade dos recursos hídricos subterrâneos nas zonas costeiras.

- **Poupança energética e redução de custos:** Ao diminuir a necessidade de bombear água subterrânea de maiores profundidades, MAR pode contribuir para a redução do consumo energético, contribuir para a descarbonização e dos custos operacionais, promovendo simultaneamente a sustentabilidade dos aquíferos e a minimização dos impactes ambientais.

- **Benefícios ambientais e dos ecossistemas:** MAR pode ajudar a manter a conectividade entre rios e aquíferos e assegurar o bom estado dos Ecossistemas Dependentes de Águas Subterrâneas (EDAS), apoiando as funções ecológicas.

Objetivo desta Carta de Intenções

O objetivo desta Carta de Intenções é estabelecer um quadro abrangente para a promoção, implementação e expansão das iniciativas de Gestão da Recarga de Aquíferos (MAR) em Portugal.

Esta Carta de Intenções está alinhada com o Quadro Geral de Governação estabelecido no âmbito do projeto PRIMA AGREEMAR, promovendo simultaneamente a eficiência operacional, a segurança ambiental e a sustentabilidade a longo prazo.

Um dos principais focos da Carta de Intenções é a colaboração, transparência e participação dos Atores (*stakeholders)*.

A Administração da Região Hidrográfica do Alentejo, Departamento Regional da APA I.P., representada pelo seu Administrador, Eng. Rui Sequeira**, reconhece o interesse e pertinência do projeto AGREEMAR** ao apresentar como objetivo a otimização do equilíbrio hidrológico nos países do Mediterrâneo por meio do desenvolvimento de modelos de governança, estratégias de gestão, análises de custos-benefícios, especificações técnicas e ferramentas de simulação para otimizar o armazenamento de água em aquíferos, permitindo maior resiliência às mudanças climáticas.

A ARH do Alentejo por considerar que os princípios, objetivos propostos e os resultados a obter, pelo presente projeto, serão relevantes para utilização dos potenciais excedentes hídricos nas Bacias do Guadiana e do Sado e Mira, permitindo o uso conjunto de recursos de águas subterrâneas, sendo portanto uma componente importante da Gestão Integrada dos Recursos Hídricos, **vem manifestar o seu compromisso de colaborar com as diversas entidades envolvidas no projeto AGREEMAR, enquadrando-se este compromisso no âmbito das competências da ARH do Alentejo, enquanto Departamento Regional da Agência Portuguesa do Ambiente, IP, Autoridade Nacional da Água**, nos termos e para os efeitos do disposto na Lei da Água, nomeadamente através da promoção e execução da política dos recursos hídricos, com vista à sua proteção e valorização.

Évora, de abril de 2025

O Administrador da Região Hidrográfica do Alentejo
(Nomeado pela Deliberação Nº 1559/2024 de 2 de dezembro 2024)

Assinado por: **RUI JORGE PEREIRA SEQUEIRA**
Num. de Identificação: 08042095
Data: 2025.04.07 16:20:26+01'00'
Certificado por: **Diário da República**
Atributos certificados: **Administrador da Região Hidrográfica do Alentejo (ARH Alentejo) - Agência Portuguesa do Ambiente, I. P.**
CARTÃO DE CIDADÃO

Rui Sequeira

Carta para la Recarga Gestionada de Acuíferos (MAR[1])

Una visión compartida por las partes interesadas para implementar y ampliar la Recarga Gestionada de Acuíferos (MAR) en España

Contexto

España enfrenta importantes desafíos en la gestión del agua, especialmente en la región mediterránea, donde el aumento de la demanda hídrica, el cambio climático y el uso intensivo de agua subterránea han llevado a la sobreexplotación de acuíferos y a problemas ambientales. La Demarcación Hidrográfica del Júcar (DHJ), que abarca partes de la Comunidad de Valencia, Castilla-La Mancha y otras regiones, se ve particularmente afectada por estas problemáticas. La agricultura es el principal sector en el consumo de agua, representando casi el 80% de la demanda total de agua, con aproximadamente 2.482 hm^3/año utilizados para riego.

La Recarga Gestionada de Acuíferos (MAR)[2] ha surgido como una estrategia crucial, ofreciendo un enfoque proactivo y científicamente guiado para mejorar la recarga de aguas subterráneas. Al integrar MAR en la planificación hidrológica, los sistemas hídricos se vuelven más resilientes, garantizando la disponibilidad sostenible de este recurso esencial y finito para las futuras generaciones. En el marco del proyecto PRIMA AGREEMAR[3], se han seleccionado dos sitios como casos de estudio en la DHJ para abordar el desequilibrio entre la oferta y la demanda de agua en las cuencas de los ríos Mijares y Palancia (ver recuadro: Sitios MAR, Demarcación Hidrográfica del Júcar).

Desafíos del Agua en España y la Demarcación Hidrográfica del Júcar

Se han identificado varios desafíos críticos en la cuenca:

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[1] Por sus siglas en inglés: Managed Aquifer Recharge

[2] La Recarga Gestionada de Acuíferos (MAR) es la práctica de recargar deliberadamente acuíferos para recuperar el agua en el futuro y/o por razones ambientales o de calidad del agua. Se considera una herramienta multifuncional de gestión del agua, que incorpora diversas fuentes de agua, técnicas de recarga y prácticas de gestión del almacenamiento (Dillon et al. (2009).

[3] El proyecto «Acuerdos Adaptativos sobre el Reparto de Beneficios para la Recarga Gestionada de Acuíferos en la Región Mediterránea» (AGREEMAR), financiado por las Agencias Nacionales de Financiación de Túnez, Alemania, Chipre, Portugal y España en el marco del programa PRIMA, tiene como objetivo lograr una gestión sostenible de los recursos hídricos a través de soluciones de Recarga Gestionada de Acuíferos (MAR) diseñadas para la adaptación al cambio climático.

- **Sobreexplotación de Aguas Subterráneas:** El uso intensivo de aguas subterráneas, especialmente para riego, ha provocado el descenso de los niveles freáticos y mayor presión en los acuíferos.
- **Intrusión de Agua de Mar:** Las zonas costeras, incluyendo la Plana de Castellón y Sagunto, experimentan intrusión de agua salada debido al bombeo excesivo de agua subterránea, lo que afecta a la calidad del agua dulce.
- **Escasez de Agua y Cambio Climático:** La variabilidad en los patrones de precipitación y las sequías prolongadas agravan los problemas de disponibilidad de agua, afectando tanto a la agricultura como al abastecimiento urbano.
- **Baja Fiabilidad del Suministro Hídrico:** La región se enfrenta a incertidumbres en la disponibilidad de agua, lo que dificulta garantizar un suministro estable para distintos usos, especialmente durante períodos de sequía.

El Rol de la Recarga Gestionada de Acuíferos (MAR) para Afrontar Estos Desafíos

La Recarga Gestionada de Acuíferos (MAR) es reconocida como una estrategia viable para mitigar estos desafíos del agua. MAR implica la recarga intencionada de acuíferos mediante métodos como cuencas de infiltración, pozos de inyección y el uso de fuentes de agua convencionales y no convencionales, como aguas residuales tratadas. **Las acciones de recarga artificial no constituyen vertidos según la legislación española**. En España, el marco legal ha evolucionado para facilitar la implementación de MAR, garantizando el cumplimiento de normas ambientales y de salud pública.

Para la Demarcación Hidrográfica del Júcar, se han identificado dos sitios clave de demostración de la recarga gestionada de acuíferos:

1. **Balsa del Belcaire (sistema de explotación del Mijares):** Este sitio se beneficia de infraestructura existente, incluyendo pozos de infiltración y una balsa de almacenamiento superficial, con el objetivo de combatir la sobreexplotación de aguas subterráneas y la intrusión salina.
2. **Embalse de Algar (cuenca del Palancia):** Aunque enfrenta una dinámica más compleja entre los actores involucrados, se explora su potencial para mejorar el almacenamiento de agua y reducir el estrés del acuífero.

Beneficios esperados de la implementación de MAR

Se espera que la implementación de MAR en estas regiones traiga múltiples beneficios, incluyendo:

- **Recuperación de Acuíferos**: MAR ayudará a reponer los niveles de agua subterránea, asegurando un balance hídrico más sostenible en la cuenca.
- **Mejora en la Seguridad del Abastecimiento de Agua**: Al integrar MAR con las estrategias de gestión de agua existentes, se mejorará la fiabilidad del suministro de agua para usos agrícolas, industriales y urbanos.
- **Mitigación de la Intrusión de Agua de Mar**: MAR puede funcionar como una barrera protectora contra la intrusión de agua salada, preservando la calidad de los recursos hídricos subterráneos costeros.
- **Ahorro de Energía y Costes**: La reducción de la necesidad de bombeo de aguas subterráneas profundas disminuye el consumo de energía y los costes de operación.
- **Beneficios Ambientales y Ecosistémicos:** MAR puede contribuir a mantener la conectividad río-acuífero y apoyar las funciones ecológicas.

Al afrontar estos desafíos y aprovechar los beneficios de MAR, España busca mejorar la resiliencia de sus sistemas de gestión de agua, particularmente en regiones que dependen en gran medida de las aguas subterráneas. La integración de MAR en los Planes Hidrológicos de Cuenca apoyará la sostenibilidad a largo plazo y los esfuerzos de adaptación al cambio climático.

Objetivo de la Carta MAR

El **objetivo** de esta Carta MAR es establecer un marco integral que guíe la implementación y ampliación de las iniciativas MAR en España. Este marco busca abordar los desafíos críticos de la gestión de las aguas subterráneas y la escasez de agua mediante la mejora de la seguridad hídrica a través de prácticas sostenibles.

La Carta se alinea con el Marco General de Gobernanza establecido en el proyecto PRIMA AGREEMAR, que abarcan aspectos de gobernanza, legales, técnicos, ambientales, económicos, sociales y regulatorios. Estos principios se aplican al contexto de la ampliación de MAR en España. La Carta define principios y directrices acordados entre diversas partes interesadas para el inicio, la implementación, operación y mantenimiento efectivos de soluciones MAR en España. Asegura la alineación con los marcos legales nacionales y fomenta prácticas sostenibles, eficiencia operativa y seguridad ambiental para abordar los desafíos de escasez de agua y de gestión de aguas subterráneas. La Carta abarca los elementos clave de los procesos de las partes interesadas para garantizar que las actividades MAR sean transparentes y participativas, donde las partes interesadas sean informadas y consultadas durante cualquier proceso de inicio e implementación

de MAR en España. La Carta resalta la importancia de la colaboración entre actores y la adhesión a mejores prácticas para mantener la integridad y efectividad de los sistemas MAR.

Principios de la Carta MAR

Principio 1: Gobernanza y Aspectos Sociales

- Involucrar a las partes interesadas relevantes, incluidos los beneficiarios de MAR y las partes interesadas afectadas, y establecer sus roles y relaciones para garantizar esfuerzos colaborativos.
- Plantear y acordar con las partes interesadas los objetivos realistas del proyecto antes de iniciar el proyecto, incluyendo claridad en las implicaciones de llevarlo a cabo, compromisos y consecuencias; y asegurar la participación y acuerdo de todas las partes interesadas antes del inicio del proyecto.
- Definir objetivos claros a corto y largo plazo para guiar el proyecto MAR, teniendo en cuenta tanto las metas inmediatas como las futuras.
- Definir claramente la duración de la implementación del proyecto MAR, estableciendo hitos y plazos clave para garantizar un progreso estructurado y la rendición de cuentas a lo largo del ciclo de vida del proyecto.
- Acordar las adaptaciones y condiciones necesarias para implementar el proyecto MAR de manera efectiva, basándose en la consulta con las partes interesadas.
- Desarrollar y definir estrategias, asignando roles y responsabilidades específicas para garantizar la rendición de cuentas.
- Priorizar la participación de la comunidad y de agrupaciones de usuarios, incluyendo los beneficiarios de MAR, informándoles sobre las acciones consideradas, ampliando la divulgación de las ventajas y beneficios del proyecto, y manteniendo una comunicación abierta para fomentar la inclusión y el apoyo.
- Aportar herramientas a la comunidad y/o usuarios que faciliten la agrupación y sensibilización.
- Mantener una comunicación continua a través de consultas y publicaciones a nivel regional y local entre los grupos de interés locales, las autoridades del agua, las organizaciones ambientales y otras partes interesadas, para garantizar la implementación y la transparencia del proyecto MAR.

- Llevar a cabo comités de seguimiento periódicos con las partes interesadas pertinentes para asegurar la sostenibilidad a largo plazo de la Carta. Los comités serán guiados por directrices establecidas.
- Establecer un reglamento/guía consensuado y aceptado por todas las partes interesadas incluyendo usuarios, comunidad afectada y beneficiarios, asegurando el cumplimiento de los principios aquí establecidos y las particularidades de la implementación del proyecto MAR.

Principio 2: Aspectos Legales

- Garantizar el cumplimiento de las normativas y regulaciones pertinentes para mantener la integridad legal y ambiental.
- Asegurar la alineación con el Boletín Oficial del Estado (Reglamento del Dominio Público Hidráulico).
- Desarrollar estándares que especifiquen los niveles de calidad del agua y los orígenes viables de los recursos hídricos mediante modelos de gestión del agua. Enfatizar la ausencia de impactos en la fiabilidad del suministro de agua a otros usuarios en la cuenca.
- Promover el desarrollo de legislación y/o estándares que correspondan con la realidad del contexto, considerando la normativa existente:
    - Legislación/estándares que sean razonables y adaptables.
    - Legislación/estándares que aseguren la factibilidad de su cumplimiento.
    - Legislación/estándares compatibles con la normatividad existente.
- Garantizar que las solicitudes MAR sean procesadas y aprobadas en un tiempo razonable para fomentar la cooperación de las partes interesadas.
- Enfatizar el recurso agua como un recurso estratégico, implicando la problemática ambiental, demostrando los beneficios ambientales y su relación con los beneficios potenciales obtenidos por las partes implicadas, particularmente los usuarios del recurso.

Principio 3: Aspectos Técnicos

- Fomentar el uso de la Recarga Gestionada de Acuíferos (MAR), cuando sea viable, como un enfoque innovador para mejorar la disponibilidad y la calidad de las aguas subterráneas y apoyar la gestión sostenible del agua en España.

- Realizar estudios preliminares, con la participación activa de todas las partes interesadas y la supervisión de la Confederación Hidrográfica del Júcar, incluidas pruebas piloto, para comprender la viabilidad y el alcance del proyecto MAR.
- Llevar a cabo cartografía exhaustiva de la viabilidad para identificar áreas en las que MAR pueda implementarse con mayor efectividad, considerando criterios geológicos, hidrológicos, ambientales, sociales y económicos, entre otros. Seleccionar ubicaciones adecuadas para MAR basándose en dichos criterios. Por ejemplo, priorizar áreas con alto potencial de recarga, como las regiones de la balsa del Belcaire y el embalse de Algar, basándose en análisis de decisión multicriterio.
- Realizar evaluaciones técnicas detalladas utilizando modelos para predecir resultados y optimizar el diseño, incluyendo evaluaciones de viabilidad del acuífero, informes de compatibilidad e infraestructura de recarga, etc.
- Utilizar sistemas avanzados de apoyo a la toma de decisiones para mejorar las estrategias de gestión del agua a escala de cuenca, garantizando que las operaciones MAR sean optimizadas para la eficiencia y la sostenibilidad.
- Aplicar técnicas sofisticadas de modelación de cantidad y calidad de las aguas subterráneas para simular y predecir las respuestas del acuífero, ayudando en el diseño y gestión de los sistemas MAR para un desempeño óptimo.
- Promover estrategias conjuntas de uso del agua, combinando técnicas MAR con fuentes de agua superficiales, subterráneas y no convencionales, como aguas residuales tratadas y desalinizadas, para minimizar el estrés del acuífero, potenciar la restauración natural y mejorar la fiabilidad y resiliencia de la demanda hídrica.
- Incorporar el análisis de los efectos del cambio climático en la disponibilidad de agua de recarga y en los patrones de demanda en la planificación para el diseño y dimensionamiento de los sitios MAR.

Principio 4: Aspectos Ambientales

- Garantizar que las actividades MAR sean autorizadas en base a evaluaciones técnicas, contribuyendo a la sostenibilidad del acuífero, específicamente para:
    - Mitigar la contaminación de las aguas subterráneas.
    - Mitigar la sobreexplotación.
    - Mitigar la intrusión de agua de mar.

    - Mitigar los efectos sobre las masas de agua superficiales y los ecosistemas dependientes.

- Realizar estudios ambientales para evaluar riesgos potenciales como contaminación, cambios hidrológicos involuntarios y subsidencia del terreno, empeoramiento de la calidad del agua, efectos sobre los ecosistemas, etc.
- Para minimizar los riesgos ambientales cuando se utilizan aguas residuales en MAR, además de llevar a cabo tratamiento terciario, se debe realizar un riguroso análisis incluyendo pruebas de contaminación biológica y contaminantes emergentes.
- El sistema MAR mantiene condiciones hidrológicas favorables según estándares definidos para el ecosistema circundante.

Principio 5: Aspectos Económicos

- Realizar un análisis coste-beneficio exhaustivo para evaluar la viabilidad económica y el rendimiento potencial del proyecto MAR, asegurando que las inversiones estén justificadas por los beneficios previstos.
- Evaluar la viabilidad financiera y estructurar los acuerdos financieros para apoyar el proyecto de forma sostenible.
- Definir un marco transparente de asignación de costes para distribuir las responsabilidades financieras entre las partes interesadas de forma equitativa, asegurando que todas las partes contribuyan de forma justa a la sostenibilidad financiera del proyecto. Incluir un sistema tarifario que refleje los beneficios directos e indirectos.

Principio 6: Aspectos de Monitorización

- Implementar un sistema de monitorización y evaluación para analizar continuamente el progreso y los resultados, facilitando la gestión adaptativa y la mejora continua. Para la vigilancia y mantenimiento, se especificarán protocolos de instalación, operación y vigilancia del sistema, incluyendo el control de calidad de las aguas subterráneas.
- Llevar a cabo una monitorización sistemática de la calidad del agua de recarga, con evaluaciones periódicas de aguas residuales tratadas para detectar contaminantes, incluyendo contaminantes emergentes y patógenos.
- Integrar planes de gestión de riesgos para identificar, evaluar y mitigar posibles afecciones a la calidad del agua y a los ecosistemas.

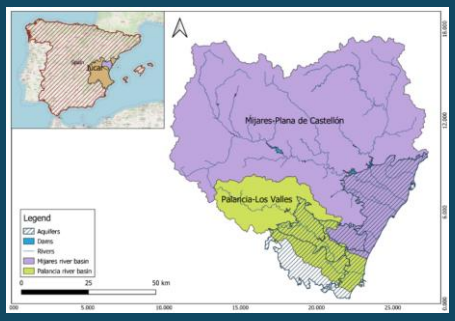
- Realizar informes de seguimiento y posibles mejoras, que estén parcialmente basados en todos los datos y herramientas disponibles.

Sitio MAR, Demarcación Hidrográfica del Júcar (DHJ)

Las cuencas de los ríos Mijares y Palancia en la DHJ, situadas en el este de España, enfrentan importantes desafíos de gestión del agua. Estos se deben principalmente a la demanda agrícola, el suministro urbano y los impactos del cambio climático. La cuenca del río Mijares abarca 4.818 km^2, nace en la Sierra de Gúdar y desemboca en el mar Mediterráneo, y la Cuenca del río Palancia abarca 1.086 km^2, nace en el Sierra del Toro y desemboca en el municipio de Sagunto. Estas cuencas son vitales para cubrir las necesidades de agua, sin embargo, los niveles de las aguas subterráneas están disminuyendo y el agua marina se está infiltrando debido a la sobreexplotación y a la reducción de la recarga natural.

Se han seleccionado dos sitios MAR en la DHJ para abordar el desequilibrio entre la oferta y la demanda de agua en las cuencas de los ríos Mijares y Palancia. Estos sitios MAR tienen como objetivo mejorar la disponibilidad de aguas subterráneas, mejorar los servicios ambientales relacionados con el agua y prevenir la intrusión de agua marina. Las estrategias de gestión integran MAR en el uso conjunto de recursos hídricos superficiales, subterráneos y no convencionales, como aguas residuales tratadas y aguas desalinizadas. Estas estrategias mejoran significativamente la fiabilidad de la demanda de agua, reducen el bombeo de los acuíferos y aumentan su recarga, mejorando así la sostenibilidad de los acuíferos y el estado cuantitativo y cualitativo de los mismos.

Más detalles sobre los sitios MAR de la DHJ se encuentran en los informes técnicos de los casos de estudio.



Sitios MAR en la Demarcación Hidrográfica del Júcar, España, seleccionados como casos de estudio en el marco del proyecto AGREEMAR.