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Project deliverables

Deliverable #D5.3

Toolbox with policy briefs and guidelines for follow-up committees

Funded by

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AGREEMAR

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

Deliverable #D5.3

Toolbox with policy briefs and guidelines for follow-up committees

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Executive summary

Deliverable D5.3 provides a toolbox with policy briefs and guidelines developed in the framework of the AGREEMAR project to support follow-up committees in the four demonstration sites.

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Deliverable author(s)	Syrine Ghannem (UPV), Rafael J. Bergillos (UPV), Joaquín Andreu (UPV), Javier Paredes-Arquiola (UPV), Abel Solera (UPV), F. Constantinos Panagiotou (ECoE), Anis Chkirbene (INAT), Khaoula Khemiri (INAT), Teresa E. Leitão (LNEC), Tiago N. Martins (LNEC)
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V1.7	16.05.2025	F. Constantinos Panagiotou (ECoE), Teresa E. Leitão (LNEC), Tiago N. Martins (LNEC), Anis Chkirbene (INAT), Khaoula Khemiri (INAT)	Partners' contributions and review
V1.8	26.05.2025	Syrine Ghannem (UPV)	Final version

Abstract

This document presents the outcomes of the AGREEMAR project related to the follow-up committees that must be established to secure the long-term sustainability of the agreements for the implementation of Managed Aquifer Recharge (MAR) at the four project demonstration sites. It provides a Toolbox with policy briefs and guidelines for the follow-up committees with concrete, site-specific recommendations that could also inspire other applications in Mediterranean regions. Those recommendations are based on the General Governance Framework proposed in WP3 and the resulting MAR charter principles (WP5), addressing legal, technical, environmental, economic, and monitoring aspects relevant to the demonstration sites.

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Abbreviations

AGREEMAR	Adaptive Agreements on Benefits Sharing for Managed Aquifer Recharge in the Mediterranean Region
AgdA	Agda-AdP, Portugal (specific water sector partnership)
ANPE	National Environmental Protection Agency
APA	Portuguese Environment Agency (Agência Portuguesa do Ambiente)
BPEH	Office of Planning and Hydraulic Balances
CEDEX	Centro de Estudios y Experimentación de Obras Públicas (Center for Public Works Studies and Experimentation)
CERTE	Center for Water Research and Technologies
CHJ	Confederación hidrográfica del Júcar (Júcar River Basin Agency)
CRDA	Regional Commissariat for Agricultural Development
DGRE	General Directorate of Water Resources
DGGREE	General Directorate of Rural Engineering and Water Exploitation
ECoE	ERATOSTHENES Centre of Excellence
EIA	Environmental Impact Assessment
INAT	Institut National Agronomique de Tunisie (National Agronomic Institute of Tunisia)
LNEC	Laboratório Nacional de Engenharia Civil (National Laboratory for Civil Engineering, Portugal)
MAR	Managed Aquifer Recharge
ONAS	National Sanitation Utility
SAT-MAR	Soil-Aquifer Treatment MAR
TUD	Technische Universität Dresden
UPV	Universitat Politècnica de València (Polytechnic University of Valencia)
UTAP	Tunisian Union of Agriculture and Fisheries
WDD	Water Development Department
WWTP	Wastewater Treatment Plant

Policy Briefs

1. Introduction

The AGREEMAR project addresses water scarcity challenges in Mediterranean countries by promoting the implementation of Managed Aquifer Recharge (MAR) as a strategic approach to enhance water availability and groundwater sustainability. The project emphasizes building the capacity of stakeholders to develop and implement MAR systems through integrated and adaptive frameworks.

Key contributions of AGREEMAR include:

- A stakeholder engagement strategy (WP1) that fostered local dialogue and participatory planning.
- The development of feasibility maps for MAR (WP2), assessing the recharge feasibility in the areas of the four selected demonstration sites.
- An adaptive governance framework (WP3) to support regional and local collaboration among different stakeholders.
- Numerical modeling tools (WP4), including groundwater (INOWAS) and water allocation (AQUATOOL) modelling, to simulate the impact of MAR and assess water availability under different scenarios.
- The creation of four MAR Charters (WP5) that integrate technical, legal, environmental, and socio-economic considerations for each demonstration site.

This document provides a structured toolbox of policy briefs and guidelines designed to support follow-up committees established at each site. It offers guidelines for monitoring, reporting, emergency planning, and stakeholder coordination to ensure long-term success and adaptability of MAR systems.

The follow-up committees in MAR projects should consist of a diverse group of stakeholders with defined responsibilities. The committee should aim for representation from all relevant sectors.

The committees should be composed of:

- River Basin Agency representatives: Responsible for coordination and official supervision of existing and new MAR schemes. The chairperson will be designated from among these representatives, and the secretary will be selected at the first committee meeting.
- Technical experts: engineers, hydrogeologists, and environmental scientists involved in MAR for monitoring and evaluation.
- Water user representatives: water users directly affected by groundwater availability and MAR implementation such as farmers.
- Environmental NGO representative: advocates for sustainability and ecological integrity.
- Public health representative: Ensures water quality and public safety concerns are addressed.
- Financial advisor: assists with budget reviews, cost-sharing models, and economic evaluations.

The committee is expected to hold regular meetings (at least one per year) to assess the performance of the MAR system. It will be responsible for validating monitoring results, ensuring compliance with regulatory standards, and reviewing stakeholder feedback to guide adjustments in operational strategy. In the case of system failure, drought, or water

quality issues, the committee will coordinate emergency responses. It will also prepare and submit annual reports and ensure that findings and decisions are accessible to the public.

The committee may, when deemed necessary, request updated assessments using the INOWAS and AQUATOOL tools to re-evaluate the role of the MAR system in the basin.

2. Policy briefs

Based on the work developed within the AGREEMAR project, a set of policy briefs is proposed focusing on guidelines for follow-up committees for MAR implementation. These are detailed in the annex for the four case studies.

3. References

Conrad, A.; Heim, R.; Helling, Leo. 2022. AGREEMAR Deliverable 1.1: Stakeholder engagement strategy and plan. Available online at https://www.agreemar.inowas.com/deliverables.

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Ghannem, S., Bergillos, R.J., Andreu, J., Solera, A., Leitão, T.E., Martins, T.N., Alpes K.G., Oliveira M.M., Horovitz M., Chkirbene A., Khemiri K., Panagiotou C.F. 2024. AGREEMAR D3.3: Set of Regional Draft Agreements tailored to the project case studies. Available online at https://www.agreemar.inowas.com/deliverables.

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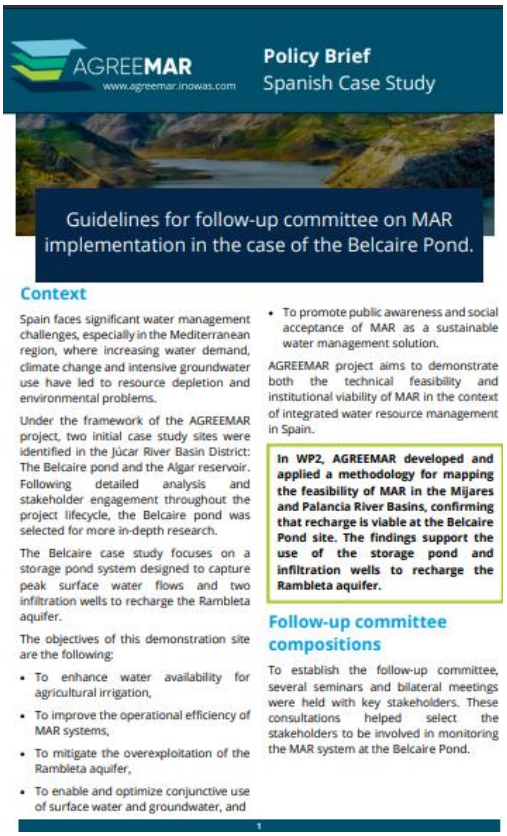
Acknowledgement

The AGREEMAR project is funded by National Funding Agencies from: Germany (Bundesministerium für Bildung und Forschung – BMBF, grant no. 02WPM1649), Cyprus (Research & Innovation Foundation – RIF, grant no. 0321- 0024), Portugal (Fundação para a Ciência e a Tecnologia – FCT, grant no. PRIMA/0004/2021), Spain (Agencia Estatal de Investigación, Ministerio de Ciencia e Innovación – MCI, grant no. PCI2022-133001) and Tunisia (Ministère de l'Enseignement Supérieur et de la Recherche Scientifique – MESRSI, grant no. PRIMA/TN/21/07). The project is funded under the Partnership for Research and Innovation in the Mediterranean Area (PRIMA). The PRIMA Programme is supported under Horizon 2020 by the European Union's Framework for Research and Innovation.

Annex. AGREEMAR Policy briefs



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Policy Brief
Spanish Case Study

Guidelines for follow-up committee on MAR implementation in the case of the Belcaire Pond.

Context

Spain faces significant water management challenges, especially in the Mediterranean region, where increasing water demand, climate change and intensive groundwater use have led to resource depletion and environmental problems.

Under the framework of the AGREEMAR project, two initial case study sites were identified in the Júcar River Basin District: The Belcaire pond and the Algar reservoir. Following detailed analysis and stakeholder engagement throughout the project lifecycle, the Belcaire pond was selected for more in-depth research.

The Belcaire case study focuses on a storage pond system designed to capture peak surface water flows and two infiltration wells to recharge the Rambleta aquifer.

The objectives of this demonstration site are the following:

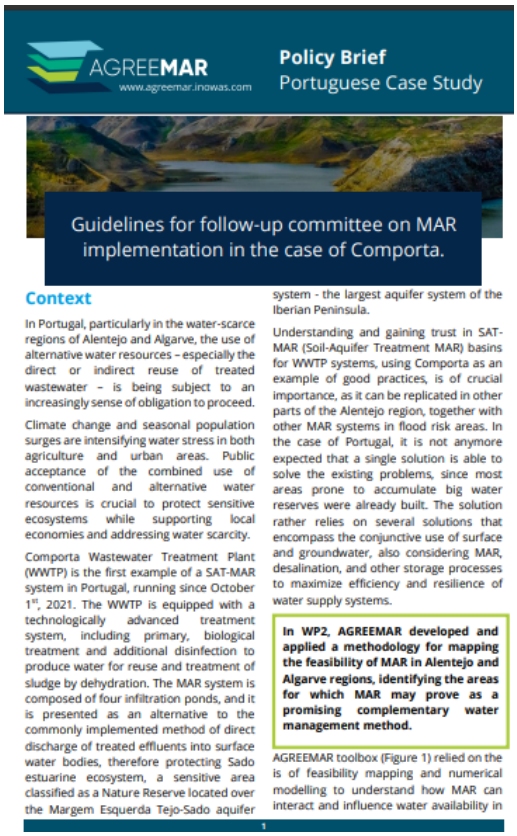
- To enhance water availability for agricultural irrigation,
- To improve the operational efficiency of MAR systems,
- To mitigate the overexploitation of the Rambleta aquifer,
- To enable and optimize conjunctive use of surface water and groundwater, and
- To promote public awareness and social acceptance of MAR as a sustainable water management solution.

AGREEMAR project aims to demonstrate both the technical feasibility and institutional viability of MAR in the context of integrated water resource management in Spain.

In WP2, AGREEMAR developed and applied a methodology for mapping the feasibility of MAR in the Mijares and Palancia River Basins, confirming that recharge is viable at the Belcaire Pond site. The findings support the use of the storage pond and infiltration wells to recharge the Rambleta aquifer.

Follow-up committee compositions

To establish the follow-up committee, several seminars and bilateral meetings were held with key stakeholders. These consultations helped select the stakeholders to be involved in monitoring the MAR system at the Belcaire Pond.



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Policy Brief
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Guidelines for follow-up committee on MAR implementation in the case of Comporta.

Context

In Portugal, particularly in the water-scarce regions of Alentejo and Algarve, the use of alternative water resources – especially the direct or indirect reuse of treated wastewater – is being subject to an increasingly sense of obligation to proceed.

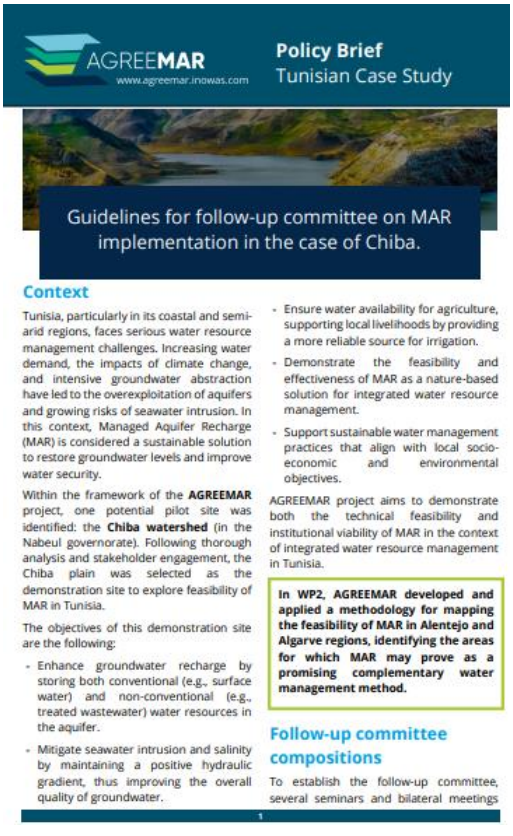
Climate change and seasonal population surges are intensifying water stress in both agriculture and urban areas. Public acceptance of the combined use of conventional and alternative water resources is crucial to protect sensitive ecosystems while supporting local economies and addressing water scarcity.

Comporta Wastewater Treatment Plant (WWTP) is the first example of a SAT-MAR system in Portugal, running since October 1st, 2021. The WWTP is equipped with a technologically advanced treatment system, including primary, biological treatment and additional disinfection to produce water for reuse and treatment of sludge by dehydration. The MAR system is composed of four infiltration ponds, and it is presented as an alternative to the commonly implemented method of direct discharge of treated effluents into surface water bodies, therefore protecting Sado estuarine ecosystem, a sensitive area classified as a Nature Reserve located over the Margem Esquerda Tejo-Sado aquifer system - the largest aquifer system of the Iberian Peninsula.

Understanding and gaining trust in SAT-MAR (Soil-Aquifer Treatment MAR) basins for WWTP systems, using Comporta as an example of good practices, is of crucial importance, as it can be replicated in other parts of the Alentejo region, together with other MAR systems in flood risk areas. In the case of Portugal, it is not anymore expected that a single solution is able to solve the existing problems, since most areas prone to accumulate big water reserves were already built. The solution rather relies on several solutions that encompass the conjunctive use of surface and groundwater, also considering MAR, desalination, and other storage processes to maximize efficiency and resilience of water supply systems.

In WP2, AGREEMAR developed and applied a methodology for mapping the feasibility of MAR in Alentejo and Algarve regions, identifying the areas for which MAR may prove as a promising complementary water management method.

AGREEMAR toolbox (Figure 1) relied on the is of feasibility mapping and numerical modelling to understand how MAR can interact and influence water availability in



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Policy Brief
Tunisian Case Study

Guidelines for follow-up committee on MAR implementation in the case of Chiba.

Context

Tunisia, particularly in its coastal and semi-arid regions, faces serious water resource management challenges. Increasing water demand, the impacts of climate change, and intensive groundwater abstraction have led to the overexploitation of aquifers and growing risks of seawater intrusion. In this context, Managed Aquifer Recharge (MAR) is considered a sustainable solution to restore groundwater levels and improve water security.

Within the framework of the **AGREEMAR** project, one potential pilot site was identified: the **Chiba watershed** (in the Nabeul governorate). Following thorough analysis and stakeholder engagement, the Chiba plain was selected as the demonstration site to explore feasibility of MAR in Tunisia.

The objectives of this demonstration site are the following:

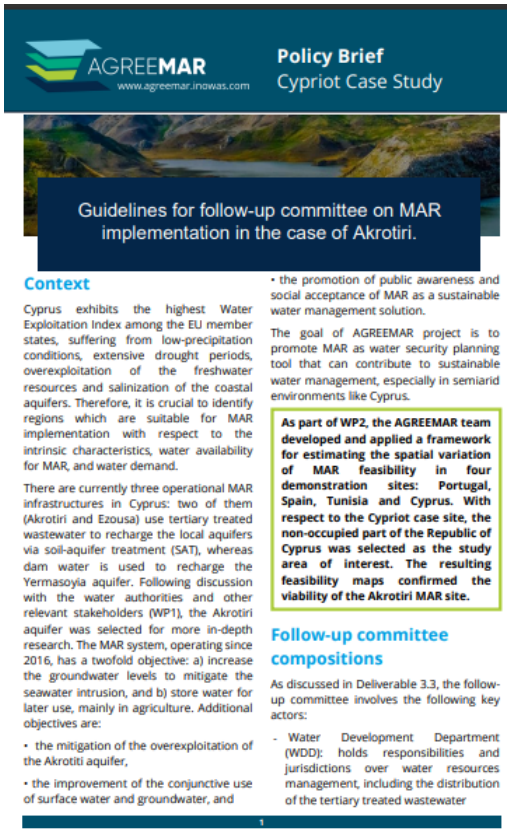
- Enhance groundwater recharge by storing both conventional (e.g., surface water) and non-conventional (e.g., treated wastewater) water resources in the aquifer.
- Mitigate seawater intrusion and salinity by maintaining a positive hydraulic gradient, thus improving the overall quality of groundwater.
- Ensure water availability for agriculture, supporting local livelihoods by providing a more reliable source for irrigation.
- Demonstrate the feasibility and effectiveness of MAR as a nature-based solution for integrated water resource management.
- Support sustainable water management practices that align with local socio-economic and environmental objectives.

AGREEMAR project aims to demonstrate both the technical feasibility and institutional viability of MAR in the context of integrated water resource management in Tunisia.

In WP2, AGREEMAR developed and applied a methodology for mapping the feasibility of MAR in Alentejo and Algarve regions, identifying the areas for which MAR may prove as a promising complementary water management method.

Follow-up committee compositions

To establish the follow-up committee, several seminars and bilateral meetings



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Policy Brief
Cypriot Case Study

Guidelines for follow-up committee on MAR implementation in the case of Akrotiri.

Context

Cyprus exhibits the highest Water Exploitation Index among the EU member states, suffering from low-precipitation conditions, extensive drought periods, overexploitation of the freshwater resources and salinization of the coastal aquifers. Therefore, it is crucial to identify regions which are suitable for MAR implementation with respect to the intrinsic characteristics, water availability for MAR, and water demand.

There are currently three operational MAR infrastructures in Cyprus: two of them (Akrotiri and Ezousa) use tertiary treated wastewater to recharge the local aquifers via soil-aquifer treatment (SAT), whereas dam water is used to recharge the Yermasoyia aquifer. Following discussion with the water authorities and other relevant stakeholders (WP1), the Akrotiri aquifer was selected for more in-depth research. The MAR system, operating since 2016, has a twofold objective: a) increase the groundwater levels to mitigate the seawater intrusion, and b) store water for later use, mainly in agriculture. Additional objectives are:

- the mitigation of the overexploitation of the Akrotiti aquifer,
- the improvement of the conjunctive use of surface water and groundwater, and
- the promotion of public awareness and social acceptance of MAR as a sustainable water management solution.

The goal of AGREEMAR project is to promote MAR as water security planning tool that can contribute to sustainable water management, especially in semiarid environments like Cyprus.

As part of WP2, the AGREEMAR team developed and applied a framework for estimating the spatial variation of MAR feasibility in four demonstration sites: Portugal, Spain, Tunisia and Cyprus. With respect to the Cypriot case site, the non-occupied part of the Republic of Cyprus was selected as the study area of interest. The resulting feasibility maps confirmed the viability of the Akrotiri MAR site.

Follow-up committee compositions

As discussed in Deliverable 3.3, the follow-up committee involves the following key actors:

- Water Development Department (WDD): holds responsibilities and jurisdictions over water resources management, including the distribution of the tertiary treated wastewater

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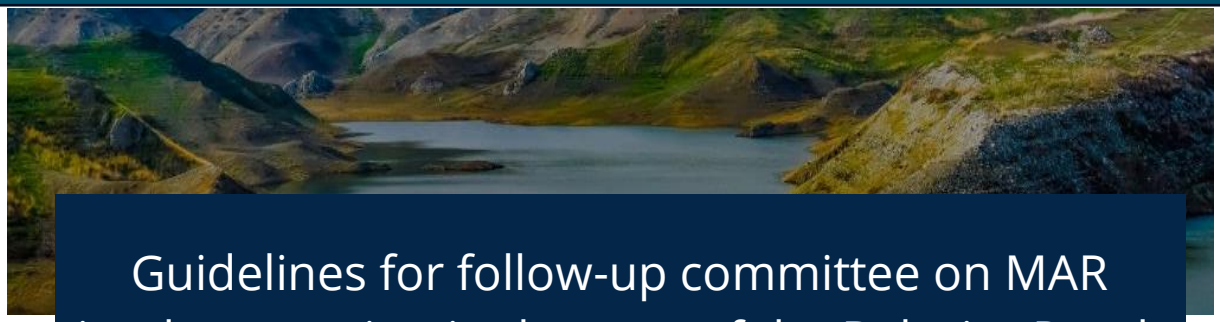
Spanish Case Study



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Follow-up committee compositions

To establish the follow-up committee, several seminars and bilateral meetings were held with key stakeholders. These consultations helped select the stakeholders to be involved in monitoring the MAR system at the Belcaire Pond.

The committee in this case study should include the following representatives:

- Representative from the Water Commissariat (*Comisaría de Aguas)* at the CHJ to control water policy compliance and monitoring permits.
- Representative from the Hydrological Planning Office (*Oficina de Planificación Hidrológica)* at the CHJ to ensure alignment with planning and basin management frameworks.
- Representative from the company responsible for the construction and maintenance of the Belcaire pond (ACUAMED) to ensure the infrastructure functionality and to provide technical support.
- Representative from the irrigation community of Vall d'Uixó to represent local irrigation users and provide feedback on water availability.
- Representative of environmental NGOs (e.g., Acció Ecologista-Agró).
- Scientific representative (UPV) to provide scientific and technical expertise.

In WP1, AGREEMAR developed a stakeholder engagement strategy to identify key stakeholders in the Belcaire pond case study and support the joint development of a governance framework for MAR in WP3. The project provided tailor-made engagement formats adapted to stakeholder needs, offered guidance on managing common engagement challenges and conflicts, and helped to establish mechanisms to monitor and evaluate engagement progress.

Guidelines

Governance and social aspects

- Define shared objectives with stakeholders, such as improving aquifer recharge, ensuring equitable water distribution, and building social acceptance of MAR.
- Assign responsibilities within the follow-up committee. CHJ oversees regulation, legal compliance and infrastructure operations, UPV provides technical and modelling support, and NGOs ensure environmental accountability.

- Hold meetings to review MAR operations guided by written protocols, and to review monitoring data and address issues.
- Organize regular local information sessions in Vall d'Uixó, communicating project progress and benefits.
- Maintain open and continuous communication among stakeholders via committee meetings, shared monitoring reports, and regional publications coordinated with CHJ and UPV.

In WP3, AGREEMAR developed an adaptive governance framework to support MAR implementation. This framework provides a basis for the co-creation of committed and responsible agreements that are aligned with long-term sustainability principles for MAR.

Legal aspects

- Ensure that all recharge operations at the Belcaire pond are compliant with the Public Hydraulic Domain regulation, particularly in relation to storage pond usage and aquifer injections.
- Ensure that permit renewals and environmental authorizations for MAR infrastructure are processed by CHJ.
- Ensure that the legal status of MAR does not interfere with other right-holders in the Mijares exploitation system.

Technical aspects

- The water level in the Belcaire pond should be measured continuously using, for example, automated level sensors to monitor storage capacity and guide recharge operations.
- The piezometric level of the Rambleta aquifer should be monitored continuously using the existing or future observation wells to track the response of the aquifer to recharge activities.
- The groundwater quality in the aquifer needs to be measured regularly. Parameters such as salinity, nitrate concentration, and possible emerging contaminants should be analyzed to ensure that recharge operations do not worsen water quality.

- The infiltration efficiency should be measured for each recharge event.
- The evolution of the aquifer needs to be evaluated through regular comparison of water level and quality data.
- The potential for additional artificial recharge methods is recommended to be studied to determine whether they can help improve the quantitative and chemical status of the aquifer under future scenarios.

In WP4, AGREEMAR developed water allocation and aquifer models using AQUATOOL to quantitative evaluate the effects of MAR at basin scale. The models assess water allocation, the impact of MAR on the groundwater evolution and the reliability of water demands, and potential future scenarios to improve the mitigation of the aquifer overexploitation based on the conjunctive management of surface water, groundwater and non-conventional water resources, among other aspects.

Environmental aspects

- Conduct water quality monitoring in the Rambleta aquifer and at the recharge points to detect salinization risks and groundwater pollution.
- Ensure that surface water from the pond meets predefined physicochemical thresholds established by CHJ and agreed upon in the pilot recharge protocols.
- Avoid recharge during periods of low dilution or upstream contamination and ensure any potential future use of treated wastewater is subject to tertiary treatment and pathogen screening, as explored in the pilot framework.

Economic aspects

- Quantify economic benefits for the Vall d'Uixó irrigation community, including reduced pumping costs and improved water reliability during droughts.
- Assess the main economic aspects of the project, including the financing of the construction of the Belcaire pond

and the ongoing costs of its operation and maintenance.

- A transparent cost-sharing model should be developed between key stakeholders.

Monitoring aspects

- Operate a monitoring protocol that includes continuous groundwater level and electrical conductivity measurements in the Rambleta aquifer.
- Include efficiency indicators such as infiltration rates during recharge events, response in piezometric levels, and reduction in salinity near the coast.
- Ensure that all data is compiled into a shared digital platform accessible to all follow-up committee members.

In WP5, AGREEMAR developed a methodology for drafting local MAR agreements incorporating lessons learned from the demonstration sites. 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. As a consequence, a charter for MAR was agreed among stakeholders, marking their interest in considering the AGREEMAR outcomes for future implementation and scale-up of MAR in Spain.

More details and updates available at https://www.agreemar.inowas.com

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In WP2, AGREEMAR developed and applied a methodology for mapping the feasibility of MAR in Alentejo and Algarve regions, identifying the areas for which MAR may prove as a promising complementary water management method.

AGREEMAR toolbox (Figure 1) relied on the is of feasibility mapping and numerical modelling to understand how MAR can interact and influence water availability in

Alentejo, providing a framework for integrated planning and informed decision-making. Relevant stakeholders have been involved and the results obtained were shared to help understanding potential areas for MAR, together with the benefits and challenges associated, allowing to facilitate MAR agreements.

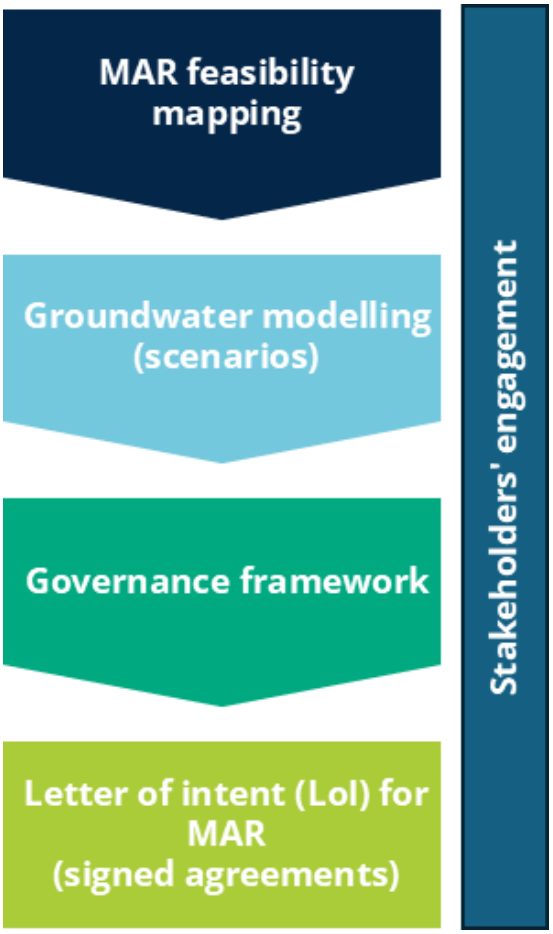

Figure 1. AGREEMAR Toolbox example

Follow-up committee compositions

Regional and local key-stakeholders were engaged in several meetings and workshops. These events allowed for the understanding of the institutional and legal relationships between the main players in the water sector at both regional and local levels. It is concluded that a supervising committee must include, not only the water authority as the main figure for enforcing any regulatory framework, but, as expected, the main potential MAR promoter as well as the potential beneficiaries (Figure 2).

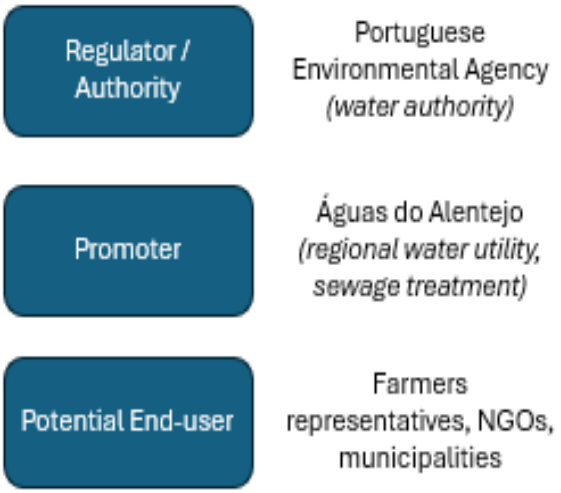

Figure 2. Follow-up committee potential composition

Academia and external experts (National laboratories, universities) should advise on this committee and follow closely the follow-up implementation conclusions/observations to identify potential problems and offer scientific-based recommendations.

In WP1, AGREEMAR developed a stakeholder engagement strategy to identify key stakeholders for each case study and support the joint development of a governance framework for MAR in WP3. The project provided tailor-made engagement formats adapted to stakeholder needs, offered guidance on managing common engagement challenges and conflicts, and helped to establish mechanisms to monitor and evaluate engagement progress.

Figure 3. Stakeholders' engagement sessions outcomes – the participative assembly of the constellation analysis example for the Comporta case study. Actors and processes relationships

Guidelines

Legal and Governance aspects

In Portugal, the management of water resources is set by various laws and regulations, namely the Portuguese Water Law (Lei n. º 58/2005), which transposes the main European legislation relating to water – the Water Framework Directive –, and the Groundwater Directive (Decreto-Lei 208/2008), also transposing an EU directive.

There is no specific regulation for MAR in Portugal. Nevertheless, there are two resolutions from the Parliament about MAR: Resolução da Assembleia da República n 86/2022 - Recommends that the Government encourages MAR to reinforce water efficiency, and the Resolução da Assembleia da República n 87/2022 - Recommends the Government to increase the reuse of treated wastewater. The watershed management plans also refer to the use of MAR, but no specific actions have been proposed. In 2024, the XIV Government Program refers as one action to be done "Implement a pilot project for artificial aquifer recharge".

The MAR systems where natural recharge is enhanced are generally accepted (e.g., infiltration basins typically built to decrease flood impacts) and no restrictions are known. Typically, those projects are not "labeled" as MAR.

For the MAR systems using alternative water sources, such as treated wastewater as the source of water for recharge, the water quality must comply with the quality standards listed in the Annex I of Directive 91/271/EEC (which regulates the discharge

of wastewater, transposed into Decreto-Lei 152/97). The proponent must have a permit from the APA (Portuguese Water Authority) that defines the necessary Environmental Impact Assessment (EIA) studies to be able to acquire a license and the necessary monitoring procedures (before and after MAR).

Regarding Water Reuse methods, the Portuguese legal framework already integrates a set of legal instruments, namely Decreto-Lei 119/2019, which establishes the legal regime to produce water for reuse, obtained from the treatment of wastewater, as well as its use.

In WP3, AGREEMAR developed an adaptive governance framework to support MAR implementation. This framework provides a basis for the co-creation of committed and responsible agreements that are aligned with long-term sustainability principles for MAR.

Technical and Environmental aspects

With the implementation of MAR installations like the one established in Comporta, the following technical aspects should be taken into account:

- Evaluate continuously the infiltrated water quality and evaluate the qualitative impacts in the replenished aquifer.
- Ensure proper treatment of infiltrated water and implement a diversion system to contain treated wastewater in the event of a treatment system failure.
- Establish an adequate warning system and clear guidelines in case of MAR system failure.

Economic aspects

To assess the success of the MAR implementation, the following economic aspects should be addressed:

- Evaluate the short and long-term economic benefits of MAR (e.g., water for agriculture, tourism, and ecosystems) against infrastructure, operation, and maintenance costs. This will involve the operator, AgdA, in assessing return of investment and potential savings compared to alternative options for disposing of the infiltrated water.
- Quantify the value of environmental benefits resulting from MAR (e.g., reducing seawater intrusion or protecting wetlands).
- Monitor how MAR supports key sectors like agriculture or tourism by stabilizing water availability.
- Identify financing sources, such as public-private partnerships, EU or national funding programs, and potential tariffs.

In WP4, AGREEMAR developed a local groundwater flow model for Comporta using MODFLOW via the INOWAS online modelling platform to assess the influence of the existing SAT-MAR site on the water table and delineate its radius of influence.

Monitoring aspects

- APA emitted a license in October 2021 for the SAT-MAR at Comporta to operate. The license considers the discharge valid if the requirements of Decreto-Lei 152/97 are accomplished,

meaning lower than the maximum levels for BOD5, COD, TSS, Ntotal, Ptotal, oils and grease. The groundwater monitoring program approved considers the following parameters: temperature, pH, EC, HCO3-, Cl-, Na+, Ca2+, Mg2+, K+, SO42-, Br, being the maximum concentration levels the ones defined by APA for the groundwater (APA, 2021).

- Additional to the mandatory monitoring plan established by APA, AgdA the operator and LNEC have established an additional sampling plan in the MAR installation critical points (through MARCLAIMED project) that include the evaluation of concentration of substances such as pharmaceuticals, together with real-time monitoring of the infiltrated water as well as the groundwater quality downstream of the infiltration basins.

References

APA, 2021 – *Critérios para a Classificação das Massas de Água* (in English: Criteria for the Classification of Water Bodies). DRH/DEQA, 2021. https://apambiente.pt/sites/default/files/_SNIAMB_Agua/DRH/PlaneamentoOrdenamento/PGRH/2022-2027/PGRH_3_PTCONT_SistemasClassificacao.pdf

In WP5, AGREEMAR developed a methodology for drafting local MAR agreements incorporating lessons learned from the demonstration sites. 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. As a consequence, a letter of intent on MAR was signed by APA and AgdA, expressing their interest in considering the AGREEMAR outcomes for future implementation and scale-up of MAR in Portugal.

More details and updates available at https://www.agreemar.inowas.com

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Policy Brief
Tunisian Case Study

Guidelines for follow-up committee on MAR implementation in the case of Chiba.

Context

Tunisia, particularly in its coastal and semi-arid regions, faces serious water resource management challenges. Increasing water demand, the impacts of climate change, and intensive groundwater abstraction have led to the overexploitation of aquifers and growing risks of seawater intrusion. In this context, Managed Aquifer Recharge (MAR) is considered a sustainable solution to restore groundwater levels and improve water security.

Within the framework of the **AGREEMAR** project, one potential pilot site was identified: the **Chiba watershed** (in the Nabeul governorate). Following thorough analysis and stakeholder engagement, the Chiba plain was selected as the demonstration site to explore feasibility of MAR in Tunisia.

The objectives of this demonstration site are the following:

- Enhance groundwater recharge by storing both conventional (e.g., surface water) and non-conventional (e.g., treated wastewater) water resources in the aquifer.
- Mitigate seawater intrusion and salinity by maintaining a positive hydraulic gradient, thus improving the overall quality of groundwater.
- Ensure water availability for agriculture, supporting local livelihoods by providing a more reliable source for irrigation.
- Demonstrate the feasibility and effectiveness of MAR as a nature-based solution for integrated water resource management.
- Support sustainable water management practices that align with local socio-economic and environmental objectives.

AGREEMAR project aims to demonstrate both the technical feasibility and institutional viability of MAR in the context of integrated water resource management in Tunisia.

In WP2, AGREEMAR developed and applied a methodology for mapping the feasibility of MAR in Chiba watershed, identifying the areas for which MAR may prove as a promising complementary water management method.

Follow-up committee compositions

To establish the follow-up committee, several seminars and bilateral meetings

were held with key stakeholders. These consultations helped identify the most relevant institutions and representatives involved in monitoring the MAR system at the Korba MAR SAT.

The committee in this study should include the following representatives:

- General Directorate of Water Resources (DGRE) for strategic oversight and regulatory alignment on groundwater and aquifer recharge policies.
- Office of Planning and Hydraulic Balances (BPEH) for expertise in planning and balancing water resources.
- General Directorate of Rural Engineering and Water Exploitation (DGGREE) for technical implementation and monitoring of rural water management infrastructures.
- National Sanitation Utility (ONAS) for integration of treated wastewater as a potential non-conventional water source.
- Regional Commissariat for Agricultural Development (CRDA) of Nabeul for local coordination and implementation, particularly regarding irrigation and agricultural use.
- National Environmental Protection Agency (ANPE) to ensure environmental compliance and impact assessments.
- Tunisian Union of Agriculture and Fisheries (UTAP) to represent farmers and ensure their needs and perspectives are integrated.
- Center for Water Research and Technologies (CERTE) for scientific and technical support on aquifer recharge and water quality issues.
- Tunisian Association for the Protection of Nature and the Environment (ATNPE) – Korba branch for community engagement and environmental advocacy at the local level.
- INAT (National Agronomic Institute of Tunisia) for academic input, research coordination, and capacity building.

In WP1, AGREEMAR developed a stakeholder engagement strategy to identify key stakeholders for each case study and support the joint development of a governance agenda for MAR. The project provided tailor-made engagement formats adapted to stakeholder needs, offered guidance on managing common engagement challenges and conflicts, and helped to establish mechanisms to monitor and evaluate engagement progress.

Guidelines

Governance and social aspects

- Stakeholder preferences: Tunisian stakeholders expressed a preference for low-binding legal instruments such as Memoranda of Understanding (MoUs) or charters, rather than formal contracts. These tools aim to reflect mutual intentions and understanding without legal obligation.
- Stakeholder engagement: the agreement should provide a clear overview of the different stakeholders involved, including their roles, benefits, and responsibilities.
- Public involvement: engagement activities already carried out highlight the importance of involving local actors in the MAR planning and implementation processes.

In WP3, AGREEMAR developed an adaptive governance framework to support MAR implementation. This framework provides a basis for the co-creation of committed and responsible agreements that are aligned with long-term sustainability principles for MAR.

Legal aspects

- Authorization procedure: the General Directorate of Water Resources (DGRE), under the Ministry of Agriculture, Hydraulic Resources, and Fisheries, is the competent authority for granting permission to implement MAR projects.
- Legal requirements: authorization is conditional upon a prior impact assessment of the MAR project's effects on groundwater quantity and quality.
- Regulatory framework: while not formalized in a contract, the agreement should outline procedures in line with national water law.

Technical aspects

- MAR typology: the feasibility mapping study identifies suitable locations and appropriate MAR methods.
- Numerical modeling: hydrological and hydrogeological models can support impact evaluations and decision-making.
- Implementation timeline: the agreement should specify the project implementation phases and expected duration.

In WP4, AGREEMAR developed water allocation model using AQUATOOL to quantitative evaluate the effects of MAR at basin scale. The model assesses water allocation, the impact of MAR on the groundwater evolution and the reliability of water demands, and potential future scenarios to improve the mitigation of the aquifer overexploitation. A groundwater flow model was developed for the shallow aquifer in the Chiba watershed using MODFLOW via the INOWAS online modelling platform to simulate changes in groundwater levels before and after MAR-SAT implementation.

Environmental aspects

- Recharge water quality: assessment should include parameters such as

salinity, nitrate, BOD, COD, suspended solids, colloids (primary cause of clogging), and selected Contaminants of Emerging Concern (CECs).

- Water source and availability: the source of recharge water must be clearly identified, along with its temporal availability and any potential conflicts with other uses.
- Impact assessment: environmental impact evaluations are required to ensure the sustainability of MAR operations.

Economic aspects

- Cost estimation: once the MAR typology is defined, implementation, operation, and maintenance costs must be estimated.
- Economic feasibility report: a detailed report outlining infrastructure development costs and financing mechanisms should be shared with stakeholders.

In WP5, AGREEMAR developed a methodology for drafting local MAR agreements incorporating lessons learned from the demonstration sites. 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. As a consequence, a letter of intent was issued by the DGRE, expressing their interest in considering the AGREEMAR outcomes for future implementation and scale-up of MAR in Tunisia.

More details and updates available at https://www.agreemar.inowas.com

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Policy Brief
Cypriot Case Study

Guidelines for follow-up committee on MAR implementation in the case of Akrotiri.

Context

Cyprus exhibits the highest Water Exploitation Index among the EU member states, suffering from low-precipitation conditions, extensive drought periods, overexploitation of the freshwater resources and salinization of the coastal aquifers. Therefore, it is crucial to identify regions which are suitable for MAR implementation with respect to the intrinsic characteristics, water availability for MAR, and water demand.

There are currently three operational MAR infrastructures in Cyprus: two of them (Akrotiri and Ezousa) use tertiary treated wastewater to recharge the local aquifers via soil-aquifer treatment (SAT), whereas dam water is used to recharge the Yermasoyia aquifer. Following discussion with the water authorities and other relevant stakeholders (WP1), the Akrotiri aquifer was selected for more in-depth research. The MAR system, operating since 2016, has a twofold objective: a) increase the groundwater levels to mitigate the seawater intrusion, and b) store water for later use, mainly in agriculture. Additional objectives are:

• the mitigation of the overexploitation of the Akrotiti aquifer,

• the improvement of the conjunctive use of surface water and groundwater, and

• the promotion of public awareness and social acceptance of MAR as a sustainable water management solution.

The goal of AGREEMAR project is to promote MAR as water security planning tool that can contribute to sustainable water management, especially in semiarid environments like Cyprus.

As part of WP2, AGREEMAR developed and applied a framework for estimating the spatial variation of MAR feasibility in the non-occupied part of the Republic of Cyprus, identified as the area of interest. The resulting feasibility maps confirmed the viability of the Akrotiri MAR site.

Follow-up committee compositions

As discussed in Deliverable 3.3, the follow-up committee involves the following key actors:

- Water Development Department (WDD): holds responsibilities and jurisdictions over water resources management, including the distribution of the tertiary treated wastewater among the different end-users. The regional offices of WDD exist for facilitating the implementation of the activities for each district.

- Water Board: responsible for distributing drinking water to the end users.
- Sewage Board: responsible for collecting the raw wastewater and providing treated wastewater at the exit of the wastewater treatment plant stations (WWTPs).
- Department of Geology Survey: acts as a consultant of the WDD with respect to hydrogeological considerations, such as assessment of groundwater status, hydrogeological studies, monitoring network etc.

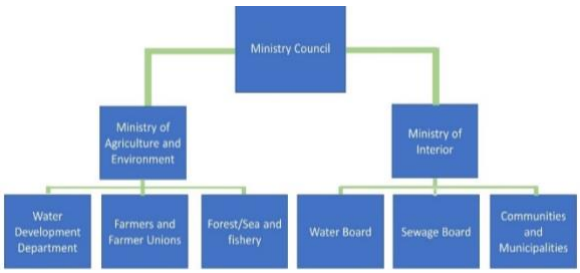

Figure 1. Decision-making structure for water management in Cyprus

Consequently, the follow-up committee should include representatives from both the national and regional offices of WDD, whereas representatives from the other relevant governmental bodies should be consulted and/or informed.

In WP1, a stakeholder map was compiling for each demonstration site, involving actors from three societal sectors: policy/decision makers, practitioners/civil, and science. These actors were also classified based on their level of engagement in the project, enabling the Cypriot partner to identify the most relevant ones, facilitating the subsequent stakeholder-related activities.

Guidelines

Governance and social aspects

The implementation of MAR in Cyprus requires a strong institutional foundation and active involvement of all relevant stakeholders.

To support collaborative governance, the follow-up committee is encouraged to:

- Engage relevant stakeholders, including MAR beneficiaries and end-users,
- Clearly assign roles and responsibilities, Establish mechanisms for transparency, inclusivity, and accountability.
- Prioritize open dialogue with local

communities to address both potential risks and perceived benefits of MAR implementation.

In WP3, AGREEMAR developed an adaptive governance framework to support MAR implementation. This framework provides a basis for the co-creation of committed and responsible agreements that are aligned with long-term sustainability principles for MAR.

Legal aspects

There is currently no specific legislation for MAR regulation in Cyprus. Instead, the management of water resources in Cyprus is regulated mainly from the following laws:

- **Law regarding Unified Water Management (N. 79/2010):** All responsibilities/jurisdictions regarding the water resources management are assigned to the Water Development Department.
- **Law regarding the protection and Management of the Water resources (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 the evaluation, management, and treatment of flood hazards (N. 70/2010):** Harmonization with the European guidelines for floods (2007/60/EK)

- **Law regarding the control of Water Pollution/contamination (N. 106/2002):** Harmonization with the European guidelines for urban sewage treatment (91/271/EOK)

Hence, the specific measures and provisions outlined in the laws and regulation are aligned with the recommendations of the European guidelines.

Specifically, the above laws aim at implementing the following water-related European guidelines:

-**WFD for Water (2000/60/EK):**

- Compile a River Basin Management Plan that contains Drought Management Plan and mitigation measures.
- Revision/update of the Management Plan every six years.

-European directive for management and assessment of flood risks (2007/60/EK):

- A Flood Hazard Management plan has been compiled in 2015.
- Revision/update of the Management plan every six years.

-European directive for urban waste-water treatment (91 /271/EOK):

- Installation of central sewage networks and wastewater treatment plant stations in communities and municipalities with human population greater than 2000.
- Update in 2022 (annual report of WDD).

Technical aspects

- The water level in the infiltration ponds should be measured continuously during the wet-dry cycles of the SAT processes, enabling the monitoring of the infiltration capacity and recharge operation.
- The groundwater level of the Akrotiri aquifer should be monitored continuously in different distances from the coastal border, both in terms of quantity and quality, to enable the quantification of the response of the aquatic system to the MAR processes.
- The groundwater quality in the aquifer needs to be measured regularly. Parameters such as salinity, nitrate concentration, and possible emerging contaminants should be analyzed to ensure that recharge operations do not worsen water quality.
- Numerical models, along with sampling data, should be integrated to assess the spatiotemporal status of the aquifer, and test the impact of the MAR system to the aquifer for different scenarios, including the expansion of the MAR system in local and large-scale (watershed) levels. A groundwater model was developed with the use of MODFLOW in WP4 to map the groundwater levels under steady flow conditions in the presence of artificial recharge. The outcomes of this model provided quantitative information regarding the risks of seawater intrusion near the coastal border, together with the spatial extent of depression cones in the proximity of extraction wells (drinking and irrigation).

In WP4, AGREEMAR developed water allocation model using AQUATOOL to quantitative evaluate the effects of MAR at basin scale. The model assesses water allocation, the impact of MAR on the groundwater evolution and the reliability of water demands, and potential future scenarios to improve the mitigation of the aquifer overexploitation. A groundwater flow model for the Akrotiri aquifer was developed under steady-state flow conditions using MODFLOW, via the INOWAS online modelling platform, to evaluate MAR performance.

Environmental aspects

- Conduct water quality monitoring in the Akrotiri aquifer and at the recharge points to detect salinization risks and groundwater pollution.
- Ensure that surface water from the pond meets predefined physicochemical thresholds established by the EU guidelines and agreed upon in the pilot recharge protocols.
- Avoid recharge during periods of low dilution or upstream contamination and ensure any potential future use of

treated wastewater is subject to tertiary treatment and pathogen screening, as explored in the pilot framework.

Economic aspects

- Quantify economic benefits for the Akrotiri irrigation community, including reduced pumping costs and improved water reliability during droughts.
- Assess the main economic aspects of the project, including the financing of the construction of the Akrotiri infiltration ponds and the ongoing maintenance and operation costs.

Monitoring aspects

- A monitoring network is currently operating in Cyprus for assessing the chemical and quantitative status of the water systems. Particularly, water samples from all groundwater monitoring stations are collected and analysed twice per year. The first sampling campaign occurs at the end of the winter/wet period (Spring) and the second one at the end of the summer/dry period (Autumn). Regarding the surface waters, monthly samples are obtained. This network is also related to the implementation of the European directive 91/676/EEC for water protection against nitrate pollution of agricultural origin, also relation to National Law (N 106/2002).

In WP5, AGREEMAR developed a methodology for drafting local MAR agreements incorporating lessons learned from the demonstration sites. 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. As a consequence, a Letter of Intent was signed by the General Director of the Water Development Department, expressing the authority's interest in considering the AGREEMAR outcomes for future implementation and scale-up of MAR in Cyprus.

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