



MARCLAIMED

Market, business strategy and exploitation plan

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ABSTRACT	The market analysis of MARCLAIMED examines the potential for implementing Managed Aquifer Recharge (MAR) technologies with Alternative Water Resources (AWR) in Europe. The study identifies key market segments, evaluates existing competitors, and proposes strategies to maximize the project's impact. The importance of MARCLAIMED as an integrated solution to address water management challenges in regions where water stress is highlighted.		

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EXECUTIVE SUMMARY

Within the context of the MARCLAIMED business model, exploitation, replicability and transferability, this document focuses on the market analysis and competitors in Europe. This is an essential task to understand the current situation of the European market on the Managed Aquifer Recharge (MAR) with Alternative Water Resources (AWR) area, as well to understand if there is an unsatisfied demand, and to assess whether MARCLAIMED results will be accepted and will provide added value to the target audience.

It must be noted, first of all, that this market analysis has been carried out both from a comprehensive project point of view (Market analysis for MAR with AWR to mitigate water stress and proactively manage droughts), and individually for each of the specific tools that compose it, both those of an operational efficiency and economic sustainability nature.

Firstly, a prior analysis has been carried out of the conditions that a MAR with AWR system requires, from the point of view of water quality, its availability, legal framework, etc.

Secondly, the current state of the aquifer recharge systems with alternative water resources market was done.

Thirdly, an analysis has been made of the competitors that exist in the market for each of the tools developed during the project: MARVIS, PREDMAR, MARAISER, OASIS FLOW, MARINSURE and RECOVER; who are the potential clients for their application, and what are the strengths, weaknesses, opportunities and threats that have been observed.

With all the analysis, the importance of carrying out a market analysis study is confirmed in order to give added value to each of the tools that make up the project, in such a way as to achieve maximum competitiveness.

1.0 INTRODUCTION

MARCLAIMED is an EU-funded project aimed at integrating the solutions of Managed Aquifer Recharge (hereinafter MAR) with Alternative Water Resources (hereinafter AWR) to mitigate water stress and proactively manage droughts. This integration is essential for the sustainable use of both surface and groundwater resources.

This document is a part of the “Work Package 5. Business model, exploitation, replication, and transferability”.

1.1 *Service description*

The proposed service aims to harmonize MAR and AWR practices within EU regulatory structures to address the complexities and challenges of ensuring long-term water sustainability.

Through MARCLAIMED, it seeks to bolster social acceptance, awareness, trust and reliability in the alternative water resource sustainability systems. The main goal is to improve not only their efficiency but also their cost-effectiveness.

The commitment is to engage a broad spectrum of stakeholders, including decision-makers, public and private water sector.

The project encourages a behavioural transition, promoting greater awareness and trust in MAR and AWR technologies.

It comprehends all the stages, from the initial characterization of the site (aquifer study, hydrogeological model, design of the MAR process and system) to decision support, stakeholder engagement and business model, covering the whole spectrum.

In this document we focus on **Work Package 5: Business model, exploitation, replication and transferability**; and more in detail in the market and competitor analysis in Europe.

For that, this document considers the next key parameters:

- Current market overview
- Analysis of the existing players
- (Final) target market and market adoption perspective (long-term adoption)
- Competitiveness of the solution from a customer point of view
- Value engineering study for the proposed technology
- SWOT/trend analysis

- Specific regulations and restrictions to apply AWR in MAR in each country
- Areas with AWR possibilities to be used (quantity of available water and quality required, distance between AWR generation and application)
- Quantity of the required water for each client

1.2 Specific regulations and restrictions to apply AWR in MAR in each country

In the European context, MAR with AWR implementation is taking on an increasing relevance as a water resource sustainable management strategy. However, the regulatory framework for this practice varies among various countries members of the European Union. Despite the existence of common European regulatory guidelines, which aim to homogenize resource management, every single country is subject to national and local specific regulations.

This diversity of legal approaches, not only shows different hydrogeological and environmental contexts, but many different developing levels of MAR in every country. Understanding the regulatory scene turns essential to the correct implementation and success of this solution, guaranteeing its sustainability and long-term effectiveness.

Below are detailed the main common regulatory frameworks, as the specific ones for the three demo sites of MARCLAIMED.

Legal Framework

It is important to ensure that MAR with reclaimed water does not compromise any of the protection aims related to water bodies and water uses as laid down in European or national legislation. In the absence of dedicated legislation concerning MAR with reclaimed water in Europe, the practice must at least not contravene existing regulations but should rather support their protection aims. This particularly refers to impacts on groundwater quality and human health and applies to water treatment processes, recharge techniques and final uses.

Water Framework Directive (2000/60/EC)

Currently, policy making in the water sector is occurring within the context of the implementation of the Water Framework Directive (2000/60/EC). The directive streamlines several existing pieces of legislation which are now either repealed or revised. Moreover, the new framework for water management prompts the establishment of new structures and types of consultation with stakeholders and the public. Its primary objectives are to

promote the sustainable use of water, reduce water pollution, particularly by 'priority' and 'priority hazardous' substances, lessen the effects of floods and droughts, while introducing a co-ordinated approach to water management based on the river basin as the appropriate scale for planning. The directive has a broad agenda, setting the protection of aquatic ecosystems as a priority and promoting public participation and information dissemination. Surface waters are required to meet 'good ecological and chemical status' and groundwater bodies to meet 'good chemical and quantitative status' by 2015 (delayed to 2027 as to give more time to states involved). Groundwater bodies are defined as distinct volumes of groundwater within an aquifer or aquifers. Significantly, the WFD also requires that no deterioration in water status may take place and that protected area objectives are met. A programme of measures is supposed to pave the way to meeting these objectives (Article 11 WFD).

As referred to under Article 11(4), artificial recharge of aquifers is mentioned as a possible supplementary measure in part B of Annex VI. However, 'controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies are mandatory. The water used may be derived from any surface water or groundwater, provided that the use of the source does not compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater. These controls shall be periodically reviewed and, where necessary, updated (Article 11(3)(f)). Recharge and reuse measures should not compromise the environmental objectives for groundwater quality as specified through the Groundwater Directive. In the process of evaluating the risk of failing the objectives the characterisation of groundwater bodies with respect to their chemical status (conductivity, concentrations of pollutants) is required and has to be related to defined quality standards or threshold values. This characterisation and evaluation procedure should therefore account for the potential impacts arising from recharge and withdrawal. Further details on how groundwater should be protected are provided in the Groundwater Directive.

Groundwater Directive (2006/118/EC)

The directive on the protection of groundwater against pollution and deterioration is a directive derived from the WFD. As provided for in Article 17 of the WFD, strategies to prevent and control pollution of groundwater should be adopted. The GWD seeks to establish specific measures to prevent and control groundwater pollution. In order to protect groundwater from deterioration and pollution, criteria to assess the chemical status of the resource are needed. According to Article 3(1)(a) and (b) of the GWD, these are defined as;

- groundwater quality standards (for nitrate and pesticides) and
- threshold values for pollutants and indicators of pollution

Member States are expected to define threshold values on a national, river basin or other appropriate level having regard to regional or even local conditions. Substances to be considered should be evaluated with regards to 'the interference with actual or potential legitimate uses or functions of groundwater'. The European Commission has recently published a Guidance Document on how to proceed in identifying relevant compounds and how to derive threshold values (EC, 2009).

Article 6 of the GWD demands establishment of measures to prevent and control input of pollutants into groundwater, where preventing input refers to hazardous substances. The input of any other non-hazardous substance 'considered to present an existing or potential risk of pollution' is to be limited so as to ensure that the status of groundwater does not deteriorate or cause an upward trend in concentration of pollutants. Measures to limit input so that maximum allowable concentrations (MAC) or quality standards are not exceeded shall at least be based on established best practices and best available techniques (Article 6(1)(b) GWD).

Following the interpretation provided in the Common Implementation Strategy (CIS) Guidance Document (EC 2007) 'preventing the input into groundwater' means 'taking all measures deemed necessary and reasonable to avoid the entry of hazardous substances' into groundwater. 'Reasonable' means technically feasible without involving disproportionate costs. It is acknowledged that it is often not technically or economically feasible to stop all input of hazardous substances, therefore exemptions are defined.

The natural attenuation capacity of the unsaturated zone may be taken into account when defining measures for both the preventing and limiting objective. For limiting even processes taking place in the saturated zone may be considered.

In summary, '**artificial recharge of aquifers**' is mentioned in Article 11(3)(f) of the WFD and article 6(3)(d) of the GWD. However, in these two directives, aquifer recharge is not defined precisely. Only the source of water is specified: 'the water used may be derived from any surface water or groundwater, provided that the use of the source does not compromise the achievement of the environmental objectives established for the source or the recharged or augmented body of groundwater'.

In principle, artificial recharge of groundwater with treated wastewater is not explicitly excluded by either the Water Framework Directive or the Groundwater Directive (GWD). Therefore aquifer recharge may be implemented as long as Member States take the following measures: permit or authorisation and control and monitoring (WWR-WG, 2007). Nevertheless a more explicit commitment to the legitimacy of unconventional water sources for groundwater recharge is desirable so as to avoid potentially controversial decisions.

The following presents the legal framework in Spain, Portugal, and the Netherlands. These three locations, selected as pilot sites for the MARCLAIMED project, represent different hydrogeological conditions and, therefore, different variants within the legislative framework. Thus, it will be possible to observe first-hand how MAR solutions with AWR are

implemented in different circumstances, with adaptations to various local and national regulations, as well as the specific peculiarities of each specific location.

Directive (EU) 2024/3019 concerning urban wastewater treatment

This directive lays down rules on the collection, treatment and discharge of urban wastewater, to protect the environment and human health, in line with the One Health approach, while progressively reducing greenhouse gas (GHG) emissions to sustainable levels, improving the energy balance of urban wastewater collection and treatment activities and contributing to the transition towards a circular economy. It also lays down rules on access to sanitation for all, on transparency of the urban wastewater sector, on the regular surveillance of relevant public health parameters in urban wastewater and on the implementation of the polluter-pays principle.

Among many other inputs, Article 15 of this directive talks about the “Water reuse and discharges of urban wastewater”. On it, it is detailed that where treated wastewater is reused for agricultural irrigation, it shall comply with the requirements of Regulation (EU) 2020/741. Where strategies on water resilience at Member State level are available, measures on promoting the reuse of treated wastewater and on the reuse itself shall be considered in those strategies.

Where treated urban wastewater is reused for agricultural irrigation, Member States may derogate from the requirements for tertiary treatment in Part B and Table 2 of Annex I of this directive, for the fraction of treated urban wastewater that is exclusively destined for reuse in agricultural irrigation.

Articles 21 and 22 of this directive apply to monitoring those parameters that may affect population or the environment while reusing the wastewater.

Legal situation in Spain

AWR regulation in Spain is found very scattered in many different normative texts referring to:

- Planification: *Texto Refundido de la Ley de Aguas, approved by Real Decreto Legislativo 1/2001, de 20 de julio; Reglamento de la Planificación Hidrológica, approved by Real Decreto 907/2007, de 6 de julio; Instrucción de Planificación Hidrológica de 2008 approved by the Orden ARM/2656/2008, de 10 de septiembre.*
- Waste Water: art. 100 and following from TRLA; art.245.1 from RDPH; art. 3.2.2.4 from Orden ARM/2656/2008.
- Reused Water: *Real Decreto 1085/2024, de 22 de octubre*, approving the regulation on water reuse and amending various royal decrees that regulate water management.

- Groundwater: *Real Decreto 1514/2009, de 2 de octubre*, by which it is regulated the groundwater protection to contamination and disrepair.

Moreover, for the specific implementation of MAR with AWR, the following requirements should be considered:

- Authorization from the corresponding Hydrographic Confederation, which will take into account:
 - Impact on the water balance of the basin
 - Quality of recharge water and its compatibility with the receiving aquifer
 - Possible effects on other aquifer users
- Detailed hydrogeological study including:
 - Numerical modeling of flow and solute transport
 - Characterization of soil infiltration capacity
 - Determination of aquifer hydraulic parameters (transmissivity, storage coefficient, hydraulic conductivity)
- Monitoring plan, taking into account:
 - Continuous piezometric control
 - Water quality tracking (physical-chemical parameters, microbiological and emerging pollutants)
 - Assessment of possible impacts on groundwater-dependent ecosystems
- Environmental Impact Assessment, as established in Law 21/2013, of December 9, on environmental assessment.
- In case of being located in protected areas or areas of special ecological interest, additional compliance with specific regulations (for example, Natura 2000 Network).
- Risk management plan that includes measures to prevent and mitigate possible negative impacts, such as aquifer contamination or changes in groundwater quality.

Legal situation in Portugal

Legal situation in Portugal, in the implementation of MAR context, is subject to the next regulatory framework:

- *Lei da Água* (Lei n.º 58/2005), which transposes Directive 2000/60/EC of the European Parliament and of the Council, 23 October, into national law. This law establishes the bases and institutional framework for sustainable water management, which achieves alignment with the standards and objectives established at European level, including aspects such as the protection of aquatic ecosystems, the prevention of pollution, and the promotion of sustainable water use.
- *Decreto-Lei* n.º 226-A/2007. This decree establishes guidelines regarding the regime of use of water resources, thus complementing and detailing the provisions of the *Lei da Água*. In the specific case of MARCLAIMED, it is especially necessary since it

regulates the conditions of use for the protection of groundwater, including water collection, occupation of the public domain, as well as specific rules for drilling wells and extracting groundwater. In addition, it establishes the sanctioning regime for unauthorized or inappropriate use, as well as control rules for monitoring, which includes the obligation to install measurement systems in certain uses. This decree is particularly relevant for managed aquifer recharge projects, since it establishes the legal framework for obtaining the necessary permits, and establishing the operating conditions of said systems.

However, 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.º 86/2022](#) - Recommends that the Government encourages managed aquifer recharge to reinforce water efficiency, and the [Resolução da Assembleia da República n.º 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 are known.

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. 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, de 10 de junho*).

Other normative framework that may influence:

- *Decreto-Lei n.º 382/99, de 22 de setembro* which establishes standards for delimiting the groundwater wellhead protection areas. It is relevant to determine that the Comporta MAR basins are not within these protection zones.
- *Lei n.º 54/2005, de 15 de novembro (Lei da Titularidade dos Recursos Hídricos)*. This regulation establishes the hydric resources titularity and could be relevant if the project affects hydric public domains.
- *Decreto-Lei n.º 77/2006, de 30 de março*, complements transposition of Directive 2000/60/CE (*Diretiva-Quadro da Água*), establishing a communitary action framework in water politics scope.
- *Decreto-Lei n.º 208/2008, de 28 de outubro*, establishes the groundwater protection regime against contamination and deterioration, transposing Directive 2006/118/CE. The Portuguese Water Authority has established the physical and chemical groundwater threshold values in https://apambiente.pt/sites/default/files/_Agua/DRH/ParticipacaoPublica/PGRH/2022-2027/3_Fase/PGRH_3_SistemasClassificacao.pdf, Table 8.1, pp. 115).

- *Decreto-Lei n.º 151-B/2013, de 31 de outubro*, complements transposition of Directive 2011/92/UE on the assessment of the effects of certain public and private projects on the environment. It regulates the procedures for consent to projects.

Case study: The system of four SAT-MAR infiltration basins, located in the Tejo-Sado aquifer, is a large multi-layer hydrogeological system, located in an area designated as a nature reserve. This implies various legal considerations added to the decrees detailed above, specifically, related to the *Regime Jurídico da Conservação da Natureza e da Biodiversidade* (Decreto-Lei n.º 142/2008).

The competent entity in charge of the evaluation and authorization of these projects is the *Agência Portuguesa do Ambiente* (APA). The following must also be taken into consideration:

1. Detailed hydrogeological.
2. Analysis of soil infiltration capacity.
3. Recharge water quality evaluation and its geochemical interaction with the receiving aquifer.
4. Piezometer monitoring, water quality, taking into account possible impacts in those ecosystems that depend on groundwater.
5. Other aspects to consider: hydraulic conductivity of non-saturated zone, transmissivity, aquifer storage capacity, as well as hydraulic gradients and resultant flow direction.

Legal situation in The Netherlands

In the Netherlands, storage system and aquifer recuperation (ASR) is located in the surroundings of a polder. In addition, this project involves two injection wells with a sandy low filtration system combined with granular activated carbon. These specifications make it necessary to accomplish many hydrogeological rigorous criteria.

Legal framework will be regulated by the following entities and decrees:

- *WaterWet* (Water Law). This is the main law that regulates water management in the Netherlands, including groundwater.
- *Wet milieubeheer* (Environmental management Law). Regulates environmental aspects including contamination prevention.
- *Besluit kwaliteitseisen en monitoring water 2009*. Decree on quality and monitoring water requisite, which establishes water quality standards, crucial for an ASR system.
- *Wet bodembescherming* (Soil Protection Law) Relevant for soil protection and groundwater against contamination.

- *Meststoffenwet* (Ley de Fertilizantes) Due to the intensive agricultural use component of the area, this law is relevant for the drained water quality.
- *Waterschapswet* (Water Board Law) It regulates water regional authorities (*Waterschappen*), who have a crucial role in water management in areas like a polder.

In short, these laws are those that regulate and conform the legal framework of this storage and aquifer recuperation (ASR) system, covering aspects as water management, soil and water quality protection, or taking into account few considerations related to specific agricultural regulations of the region where the demo site is taking place.

In addition, it is required a detailed characterization of the aquifer where the system is placed, where pumping tests to determine the hydraulic parameters as transmissivity, storage and hydraulic conductivity are done.

Numerical modeling for the ASR system is mandatory, and many aspects may be taken into account as the injection bubbles formation, density and viscosity flow effects, as well as seawater intrusion impacts in coastal environments.

The injection system, that combines a sandy low filtration and granular activated carbon, must be designed to accomplish with water quality standards for injection, paying special attention to the following aspects:

1. Parameters as turbidity, organic matter content and by-product formation potential.
2. It requires a comprehensive monitoring program that includes continuous measurements of head level and water quality (including physico-chemical parameters, microbiological and emergent contaminants).
3. Control possible impacts on terrain subsidence, which are common in polder areas.

Competent authorities, including local Waterschap and provincial authorities, must evaluate the project considering its impact on the regional hydric balance, the interaction with other aquifer users and the sustainability of a long-term system in the context of climate change and sea level rise.

1.3 Areas with AWR possibilities to be used (quantity of available water and quality required, distance between AWR generation and application)

To determine that an hydrogeological area has possibilities to be used in terms of AWR, there are certain aspects that must be considered.

In this chapter we will focus on a few of them, as well as the quantity of available water that a waterbody has to exploit, the required quality that must have AWR to be used in terms of aquifer recharge, and the distance between AWR generation and application.

QUANTITY OF AVAILABLE WATER

The main factors that contribute to turning a determined aquifer into an area with AWR possibilities to be used, in terms of quantity of available water, can be summarized in the following lines:

Overexploited aquifers that should be re-fed

- Intense agricultural exploitation areas or susceptible to any environmental interest areas.
- Intense extraction for drinkable uses aquifers.
- Predictable increase of extraction in the future areas, even planned or spontaneous (for example: demographic growth in a city or village (derived from tourism, for example) whose water supply system was fed from aquifers; expansion of agricultural area with plots supplied from groundwater, etc.).

Aquifer overexploitation occurs when the groundwater extraction exceeds natural aquifer recharge, during a long period of time. This can result in problems such as a head level continuous decrease, that can even invert the flow direction of the system; seawater intrusion in coastal aquifers, terrain subsidence and groundwater dependent ecosystems degradation, among others.

A map based on the water depletion indicator, which evaluates the relationship between total water consumption and available renewable reserves, is illustrated below. This index considers domestic as well as industrial, agricultural and livestock uses, while reserves consider the impact of upstream users and large water infrastructures on downstream availability.

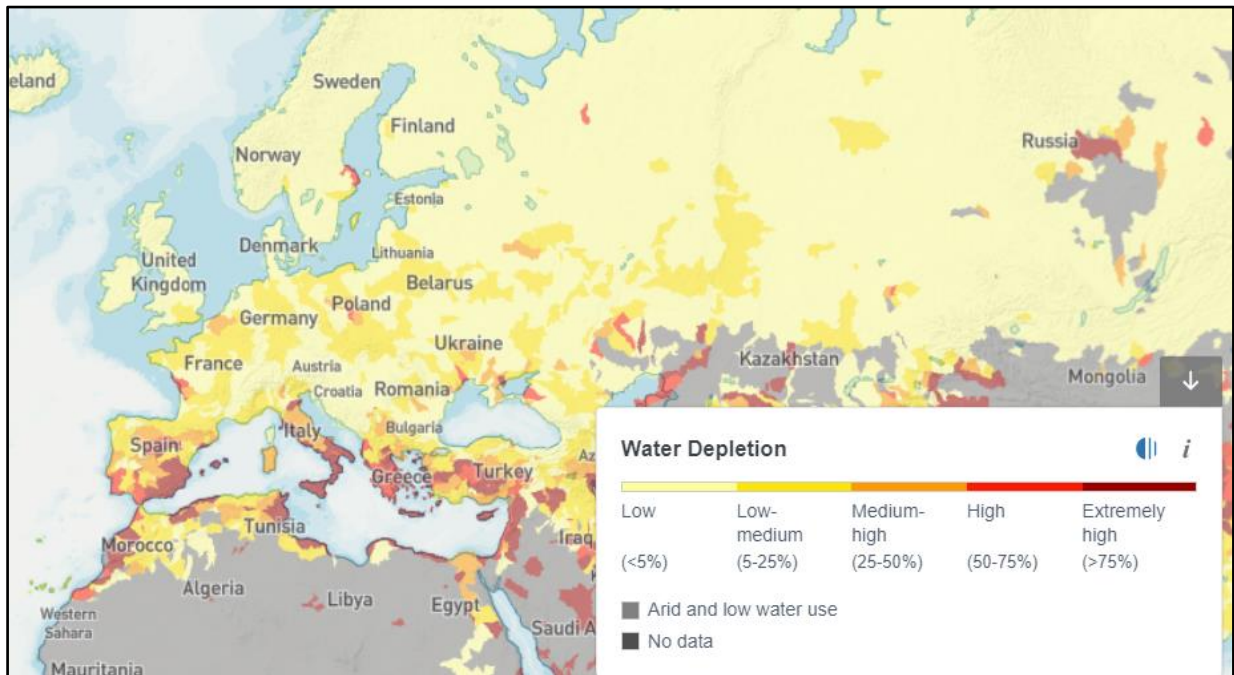


Figure 1 Water depletion, which measures the ratio of total water consumption to available renewable reserves. Source: Aqueduct 4.0.

Water exhaustion focuses exclusively on consumptive extraction, that is, it corresponds to a volume of water that is extracted and not returned to the same hydrological system in a short period of time. This provides a more precise measure of the actual impact on available water resources.

Higher values of this indicator, signified by intense red color on the map, indicate a greater impact on local water supply and a significant reduction in availability for downstream users.

This indicator is fundamental for understanding the pressure exerted on water resources and for planning long-term sustainable water management, especially in regions where demand exceeds the natural renewal capacity of water resources. In the context of Managed Aquifer Recharge (MAR), this type of analysis is crucial for identifying priority areas for action.

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Aquifers that show a progressive degradation of water quality

- High concentration of nitrates and pesticides areas.
- Deteriorated environmental values or danger of disappearing areas.
- Salt water intrusion problem areas, both continental or marine origin (coastal aquifers).

Degradation of groundwater quality can come from various causes, such as contamination from agricultural activities, seawater intrusion in coastal aquifers, contamination from urban wastewater, or natural elements mobilization such as arsenic or fluor, among others. The following includes a series of maps that depict the proportion of groundwater masses that have not reached the target good chemical status of the Water Framework Directive (WFD) , in each River Basin District (RBD) throughout the three cycles of River Basin Management Plans (RBMP).

In Figures 2, 3 and 4, the darker shades indicate a higher proportion of water bodies that do not meet the chemical quality standards, while the lighter shades represent areas with a better chemical status.

The display of maps corresponding to the three cycles of the River Basin Management Plans (RBMP) allows for a temporal evolution analysis of the chemical quality of water bodies, which is essential for the proper implementation of MAR.

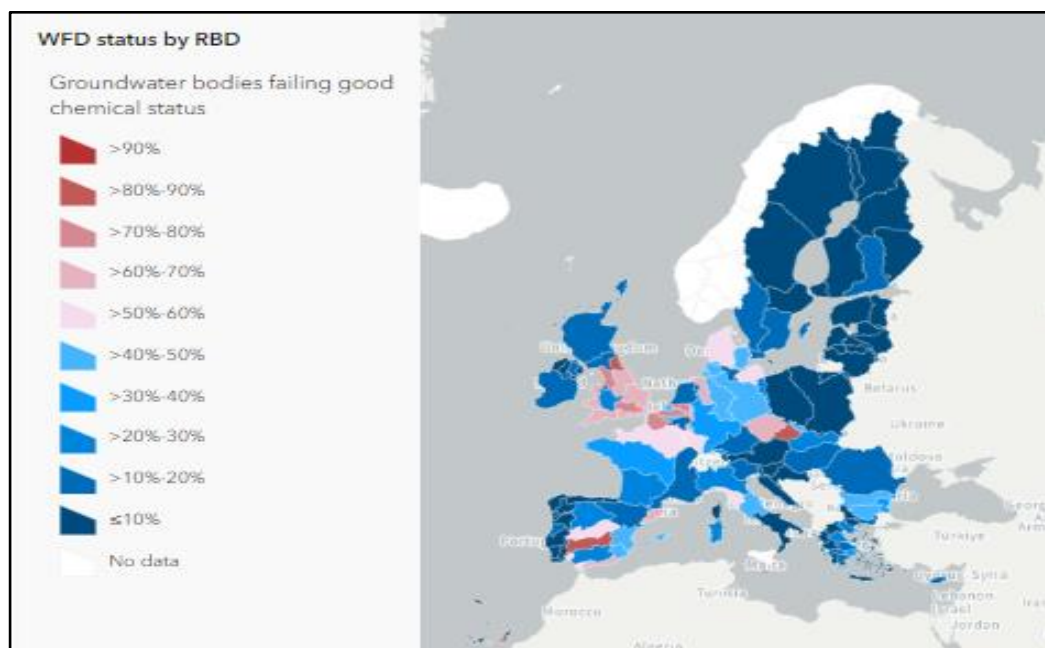


Figure 2 Data from the first Cycle of River Basin Management Plans (RBMP), includes countries that have electronically reported to the EEA. Data sources WISE WFD database; European Environment Agency (EEA), WISE Water Framework Directive Database, European Environment Agency (EEA).

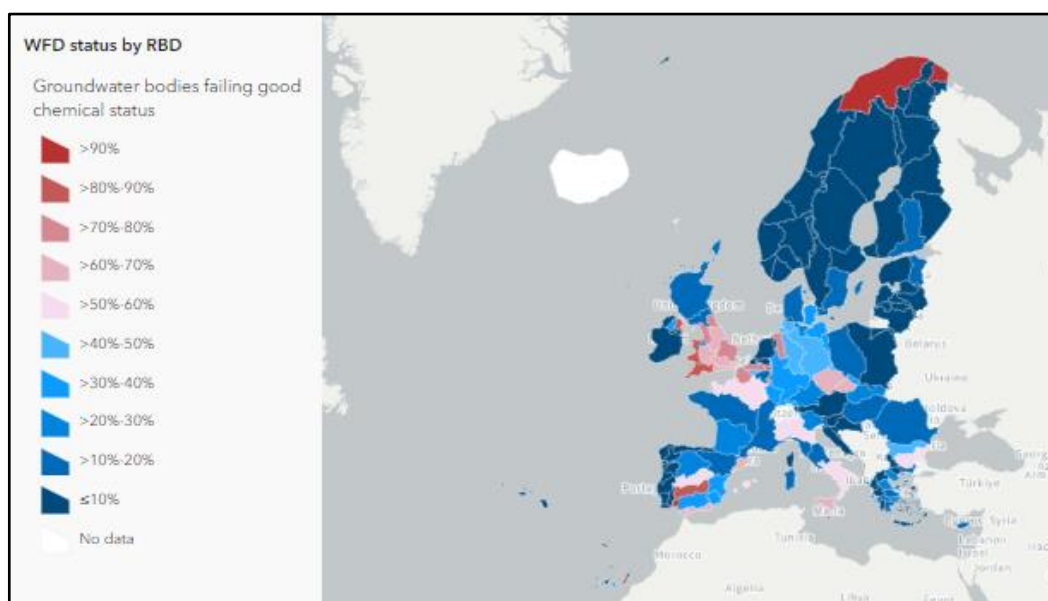


Figure 3 Data from the second Cycle of River Basin Management Plans (RBMP), includes countries that have electronically reported to the EEA. Data sources WISE WFD database: European Environment Agency (EEA), WISE Water Framework Directive Database, European Environment Agency (EEA).

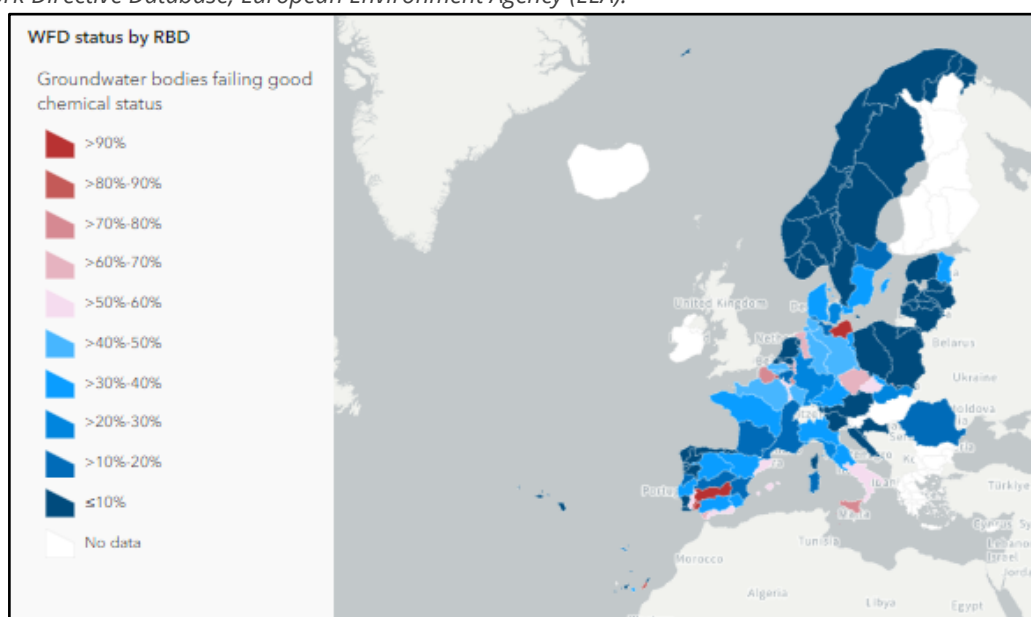


Figure 4 Data from the third Cycle of River Basin Management Plans (RBMP), includes countries that have electronically reported to the EEA. Data sources WISE WFD database: European Environment Agency (EEA), WISE Water Framework Directive Database, European Environment Agency (EEA).

Aquifers where water supply shows an important seasonal variation

- Availability of excess surface water during some months of the year.
- Areas where MAR and surplus management (flood control, etc.) can be combined.

Aquifers where water supply shows a big seasonal variation, are characterized by:

- Significant fluctuations on head levels between wet and dry seasons.
- Variability in the availability of groundwater resources for extraction in different periods of time.
- Possible water shortage during dry seasons

Below is a map reflecting seasonal variability, represented by a color code from light yellow to dark red. This indicates, respectively, low or extremely high seasonal variability.

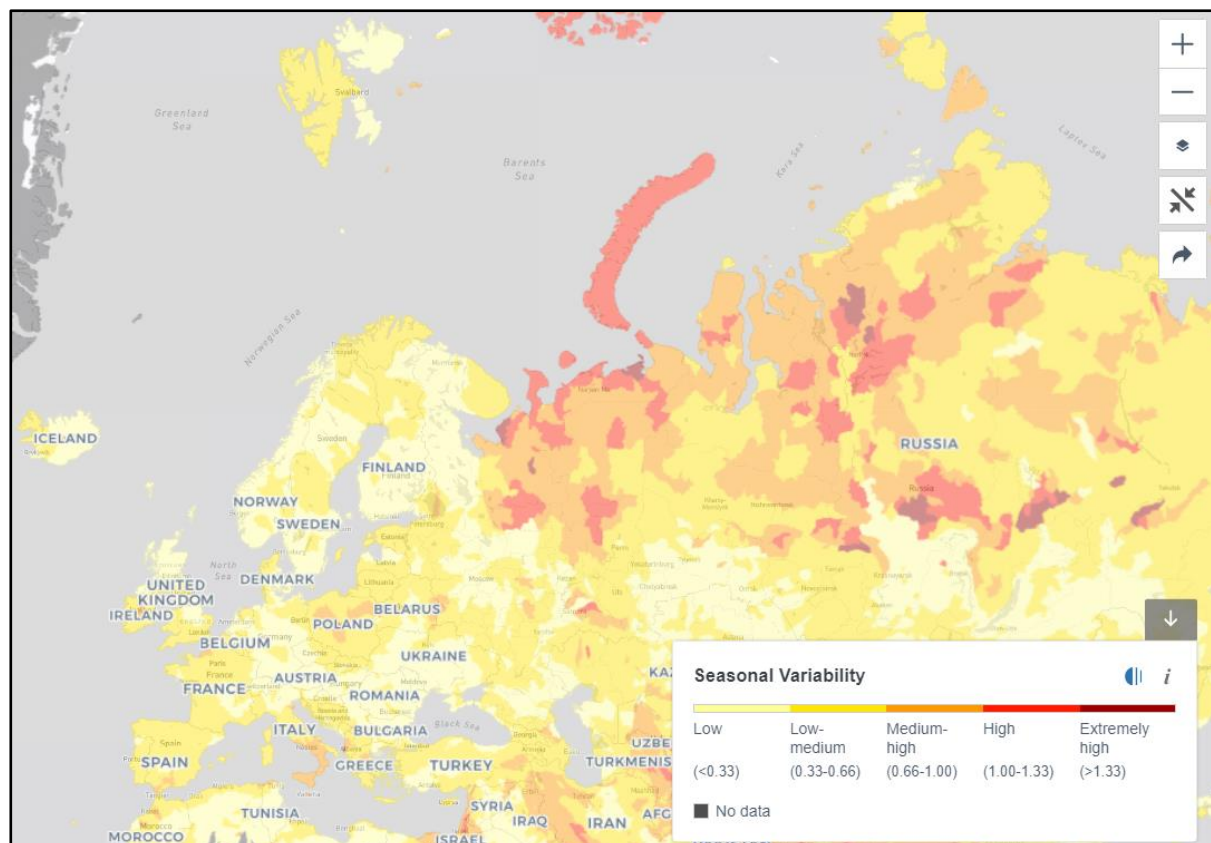


Figure 5 Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Source: Aqueduct 4.0.

Seasonal variability in water availability plays a crucial role in the planning and efficacy of Managed Aquifer Recharge (MAR) projects. Higher values of seasonal variability indicate more pronounced fluctuations in water supply throughout the year, which can significantly affect the quantity and quality of water available for recharge.

This variability can influence the selection of optimal periods for recharge, the design of necessary infrastructures, and the operational management of MAR systems, necessitating adaptive strategies to maximize recharge efficiency during seasons of higher availability and mitigate impacts during periods of scarcity.

In short, it is necessary an adaptive management, to equilibrate and ensure the offer and demand of hydric resources. In this context, developing solutions as Managed Aquifer Recharge with Alternative Water Resources could mean a big step for those decision makers in Basin Management Plans and Droughts, supporting adaptation and resilience of structural systems of supply in the context of climate change.

QUALITY REQUIRED

For European legislation, required quality for MAR with AWR, is basically regulated by Water Framework Directive (2000/60/CE) and Directive of Groundwater protection against contamination and deterioration (2006/118/CE), both detailed in chapter 1.2 from this report.

All countries with no specific legacy are governed by the World Health Organization (WHO) standards; and in any acting abroad, every stakeholder must assure that effluents from wastewater treatment plants meet the quality requirements from WHO, 2003.

Table 1 Proposal for regenerated water requirements for Artificial Water Recharge (WHO, 2003)

Type of Recharge		
Type of Pollutant	Surface Infiltration	Subsurface Injection
Pathogenic microorganisms	≤ 30	
Secondary treatment		
Filtration	≤ 2 NTU	
Disinfection	Virus inactivation 4-log $\leq 2\%$ total coliforms	
Retention time in the subsoil	6 months	12 months
Horizontal separation	153 m	610 m
Regulated contaminants	Drinkable law	
Non regulated contaminants		
Secondary treatment	DBO < 30 mg/L; COT > 16 mg/l	
Reverse osmosis	4 options considered Depth to groundwater at percolation rates: >0,2 inches/min to 10 feet >0,3 inches/min to 20 feet	
Surface extension with 50% of TOC extraction		
Upper limit monitoring option	Demonstrate variability in the upper limit	
Regenerated water percentage	> 50%	

Other quality standards for managed aquifer recharge are collected in the following table, where recommended values in many countries, and its authors, appear.

Table 2 Quality standards established by different authors in many countries (see table footer) to the main recharge water parameters

Concept	Type of system	Threshold	Comments
Physical Clogging	Deep system	⁹ [TSS] > 2 mg/L ^{1,9} [TSS] > 0,1 mg/L ² MFI > 3-5 s/l2 ^{1,3} Turbidity > 1 NTU ¹¹ [TSS] > 3-4 mg/L	If K < 40 m/day IF 4 m/day < K < 40 m/day
	Surface system	^{1,3,9,12,13} [TSS] < 10 mg/L Turbidity < 5 NTU	
Biological Clogging	Deep system	⁴ pH > 7,2 (Fe bacteria) ^{4,11,12,13} avoid CO ₂ ^{4,13} COD < 2 mg/L ⁴ Eh > 10 mV	By swiss legacy
	Surface system	TOC < 10 mg/L	
Chemical Clogging		⁶ [Fe ²⁺]GW < 0,2 mg/L ⁸ Ryznar Index > 7 ^{8,11,13} pH < 7,5 ⁸ Low [Ca ²⁺] Mg ²⁺ ⁸ TSD < 150 mg/L ⁸ [Cl] < 500 mg/L ¹¹ [total Fe] 0,02-0,1	More important for extraction than well recharge. Mineral saturation index are essential
Corrosion		⁸ OD < 2 mg/L ⁸ Ryznar Index < 9 ⁸ pH > 7 ⁸ Co ₂ < 0,50 mg/L ⁸ [TSS] > 1,000 mg/L ⁸ Avoid H ₂ S	Applicable to wells and pipes

K: conductivity. TSS: total suspended solids. MFI membrane failure index. NTU: nephelometric turbidity units. COD: organic carbon dissolved. TSD: Total dissolved solids. OD: dissolved oxygen

1 Netherlands rules (Peters, pers.comm.); 2 Olsthoorn (1995); 3 German rules (Schottler, pers.comm.); 4 Degalier (1987); 5 van der Kooij & Hijnen (1990); 6 Lucas *et al*, (1995); 7 Hills *et al*, (1989); 8 Ford (1990); 9 Pyne (1995); 10 Hurni; 11 Rinck Pfeiffer (2002); 12 NWQG Australian rules (National Water Quality Guidelines), CSIRO; Moran *et al*, 2001; 13 Standard Guidelines for artificial recharge (EWRI-ASCE, 2001). Modificado de Fernández, 2005.

There is regulation from the European Union, 2020/741, Section 2, that specifies the minimum requirements for water reuse, where the specific parameters for reused water quality for agricultural use are collected (European Parliament and Council, 2020).

It is defined as agricultural irrigation, the irrigation from different types of crops destined to human consumption in raw or transformed state, and non-food crops as pastures, forages, and ornamental and seed crops.

Minimum water quality requirements are shown in the following table:

Quality class of regenerated waters	Indicative treatment	Quality requirements				
		E.coli (n°/100 ml)	DBO ₅ (mg/l)	STS (mg/l)	Turbidity	Others
A	Secondary treatment, filtration and disinfection	≤ 10	≤ 10	≤ 10	≤ 5	Legionella spp.: < 1,000 CFU/l when there is a risk of aerosolization Intestinal nematodes (helminth eggs): ≤ 1 egg/l for the irrigation of pastures or fodder
B	Secondary treatment, filtration and disinfection	≤ 100	In accordance with Directive 91/271/EEC	In accordance with Directive 91/271/EEC	-	
C	Secondary treatment, filtration and disinfection	≤1.000	In accordance with Directive 91/271/EEC	In accordance with Directive 91/271/EEC	-	
D	Secondary treatment, filtration and disinfection	≤10.000	In accordance with Directive 91/271/EEC	In accordance with Directive 91/271/EEC	-	

Table 3 Quality requirements for reclaimed water for agricultural irrigation

In the particular case of Spain, for example, recharge water quality is governed by RD 160/2007, which establishes the maximum admitted values according to water use. Demanding parameters are scarce but highly restrictive, being one of the most demanding legislations in the world.

Table 4 Maximum admissible value for environmental destination in Spain (RD 1085/2024)

Environmental destination	<i>E.coli</i> (UFC/100 mL)	Turbidity (NTU)	Suspended Solids	Intestinal nematodes	Bacteriophages	Contaminants
Quality R.A+. Artificial aquifer recharge by direct injection	Absence	5	10	1	100 only when the aquifer is for supplying	See observation
Quality R.C. Artificial aquifer recharge by localized percolation through the ground	1.000	-	According DARU	-	-	See observation
Quality to be defined Contribution of water resources to wetlands and other aquatic ecosystems	It will be studied case by case					

Observations:

(1) The environmental application of reclaimed water will be authorized by guaranteeing compliance with the environmental objectives indicated in article 92 bis of the consolidated text of the Water Law approved by Royal Legislative Decree 1/2001, of July 20.

(2) The artificial recharge of aquifers shall be authorized in accordance with the provisions of the Public Domain Regulations, approved by Royal Decree 849/1986, of April 11, and in particular, the provisions of article 273 quater. As it is not a use, it is not subject to the legal regime established in this regulation. As provided in article 273 quater, the artificial recharge of aquifers is subject to an authorization subject to the requirements established in the previous table.

(3) Intestinal nematodes: At least the genera *Ancylostoma*, *Trichuris* and *Ascaris* will be controlled. When the treatment includes ultrafiltration, control of intestinal nematodes is not necessary.

(4) Bacteriophages: Control of total coliphages is recommended. However, if analysis of the coliphages is not possible, at least one of them will be analyzed (F-specific or somatic coliphages).

(5) According to DARU: the concentration of the parameter complies with the compliance requirements set out in Directive 91/271/EEC.

(6) Contaminants: In general, the contaminants limited in the wastewater discharge permit will be controlled so that the production and supply of regenerated water does not cause deterioration of the receiving medium in accordance with the provisions of Royal Decree 817/2015, of 11 September, and Royal Decree 1514/2009, of 2 October.

(7) *Escherichia Coli* will be considered to be absent when its concentration is less than 1 UFC/100 mL.

DISTANCE BETWEEN AWR GENERATION AND APPLICATION

Both in surface spreading and direct injection, locating the extraction wells as great a distance as possible from the spreading basins or the injection wells increases the flow-path length and the residence time of the recharged water. These separations in space and in time contribute to the mixing of the recharged water and the other aquifer contents, the

opportunity for favorable biological and chemical transformations to occur, and to the loss of identity of the recharged water originating from wastewater. The latter is an important consideration in successful reuse of treated wastewater in order to facilitate public acceptance.

The measures of access control, buffer zones (security distances) and withholding periods should be established as necessary to minimize exposure to health hazards to humans and animals. It is needed to consider access control for on-site workers, general public, and animals, and define specific withholding periods for livestock to be fed with irrigated pastures or fodder. The establishment of access control, buffer zones (security distances) and withholding periods has to be evaluated considering the reclaimed water quality used, the irrigation method, and the site specific conditions.

There are many factors that influence the determination of the distance between AWR generation and application, and are set out below:

1. **Initial quality of water.** Better initial quality water could require less distance or time treatment. Will take into account pathogen agents, nutrients and emergent contaminants.
2. **Hydrogeological characteristics of the aquifer.** Variables like porosity, hydraulic conductivity or heterogeneity of the aquifer (confined, unconfined, etc) will affect velocity and groundwater flow direction, influencing the distance. The depth of head will influence the vertical condition.

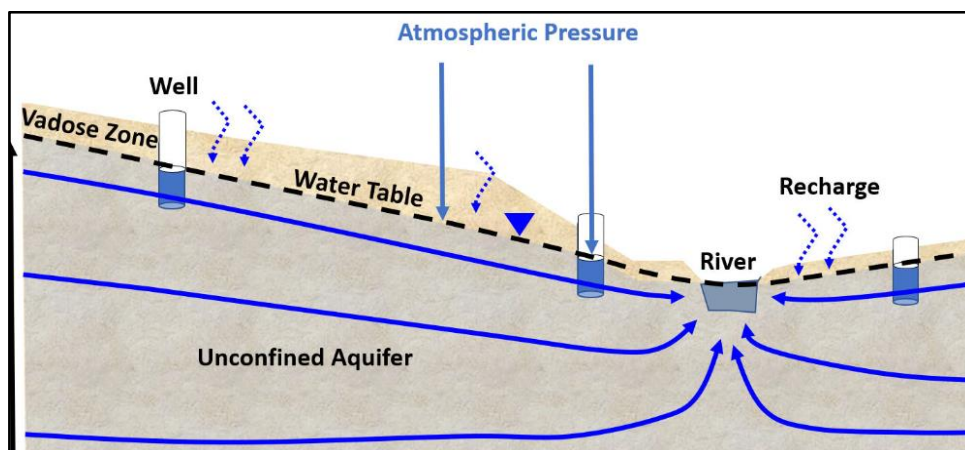


Figure 6 Schematic of an unconfined aquifer. The upper surface is the water table (dashed black line) and the bottom boundary is typically a lower permeability unit (black bar). The water at the water table is at atmospheric pressure, $h_p = 0$, so the elevation head, z , represents the hydraulic head. Water levels in wells penetrating to depths just below the water table are shown. Recharge occurs to the water table from infiltration at the land surface (blue dashed arrows). The long solid blue arrows show general groundwater flow directions. Source: the groundwater project.

3. **Mineralogical and biological composition of the aquifer.** It will significantly influence the required distance between AWT generation and application. One of the main aspects is the adsorption capacity of a few minerals, like clays and metal oxides. Due to its high adsorption capacity, they can retain contaminants reducing that distance.
4. **Ionic exchange reactions.** Ionic exchange reactions, also present in clay minerals, can trigger ionic exchange reactions with water (Figure 7), altering its composition, and affecting the distance required to achieve the desired quality.

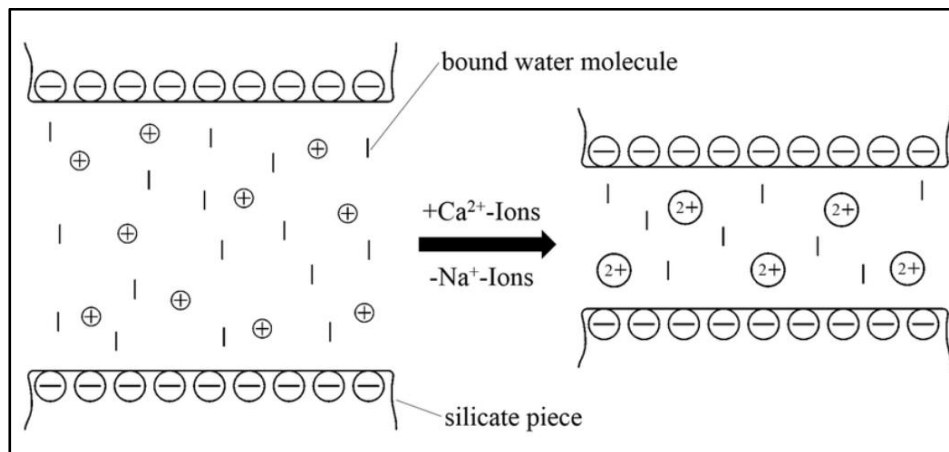


Figure 7 Chemical structure of ion exchanger. Ion exchange of monovalent sodium ions against bivalent calcium ions in bentonite (modified from Egloffstein, 2001)

5. **Dissolution and precipitation.** The presence of soluble minerals in the environment increases the mineralization of water. The precipitation of minerals in the environment can help to reduce the amount of contaminants in the water (Figure 8). Regarding the biological composition, biodegradation and the initial characteristics of microorganisms in the environment, as well as the existence of various microbial communities, can be key in deciding the distance between generation and application.

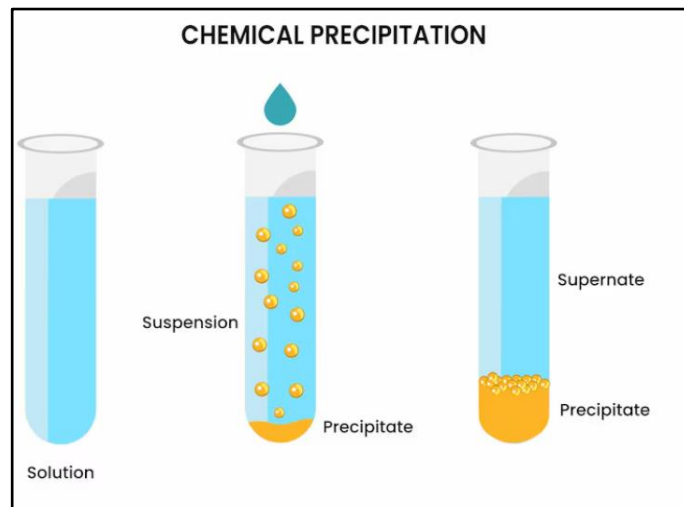


Figure 8 Diagram of a solution, suspension, precipitate and supersaturated solution. Source: free images.

Furthermore, certain microorganisms can act as catalysts in chemical reactions that transform contaminants, as occurs in denitrification or sulfate reduction processes.

6. **Other factors.** Environmental conditions of the area where AWR is being applied. For example, strong wind conditions could affect the human population if AWR is applied in irrigation areas, since the irrigation water could be taken up by the wind and contaminate urban areas.

Thus, it can be verified that the choice of distance between the generation and application of AWR in the managed recharge of aquifers is based on a multifactorial decision, which, in summary, has different implications in determining the distance:

1. Aquifers with high adsorption capacity and active microbial communities may require shorter distances to achieve the desired purification
2. Aquifers with low mineralogical reactivity and limited biological activity may require greater distances to achieve the same water quality objectives.
3. Spatial variability in mineralogical and biological composition may result in determining preferential treatment zones, affecting the optimal final distance.

1.4 Quantity of the required water for each client

The volumetric demand for recovered water (within an economic scale) or a clearly defined environmental benefit of recharge is essential for MAR. The purposes for which water will be recovered also need to be defined. Generally, this will provide the revenue stream to pay for the water supply cost elements of the project. In urban areas, the demand for stormwater detention to mitigate floods, improve coastal or receiving water quality, and enhance urban amenity and land value may also contribute revenue streams for MAR projects. For reclaimed water projects, the decline in discharge of treated effluent to water bodies may provide a motivation for investment in MAR. Demand may be steady, seasonal, or solely to secure water supplies during occasional droughts. Environmental benefits may include prevention of saline intrusion, sustaining base flow in streams and protecting wetlands and groundwater-dependent ecosystems. Unless one or more of these elements are present, the project is not a MAR project and rather may be a waste disposal or flood mitigation project without the intention and assured motivation to protect groundwater throughout the life of the project.

Therefore, in order to determine the amount of water required by each client, it will be necessary to define the following points:

1. Typology of Customers

It must be determined whether the clients will be urban users, or water management entities (small managers, large managers), or end users related to agriculture.

2. Determination of Current and Future Demand

In order to carry out a resilient management of water resources, especially in the context of managed recharge with AWR, it is necessary to undertake planning that allows for the prediction of current and future demand. To this end, historical consumption data must be analyzed, as well as projecting population or industrial growth or decline.

3. Evaluation of Seasonal Demand

Likewise, for proper management, it must be taken into account whether there are consumption peaks, such as demand peaks in summer in coastal areas or seasons of intensive irrigation in agriculture.

4. Analyze the available alternative sources

For this purpose, it is necessary to consider the amount available from different sources: urban rainwater, treated wastewater, surplus surface water, etc.

5. Calculation of the water balance of the aquifer

For the preparation of the balance, one must consider the natural recharge, as well as determine the existing extractions.

6. Implementation of monitoring system

To define the required amount of water, it is advisable to measure and control various qualitative and quality parameters.

7. Adaptive Management Plan

Adjust the recharge amount according to the monitoring results, in order to respond to changes in demand, weather conditions, etc.

8. Legal Aspects

One must take into account the compliance with environmental and public health regulations decreed by competent local or regional bodies, as well as European entities.

Case study: Standen et al. (2023) analyse the applicability of MAR in the Algarve region of Portugal, which experiences severe water scarcity with insufficient water supplies to meet demand. In the conceptualization of the site, the author demonstrates that MAR can cover over 10% of the total water demand of the region (24 Mm³/year) using water with quality that meets the requirements of the European Groundwater Directive. MAR can replace 15 Mm³/year used in public irrigation perimeters and 9 Mm³/year to develop and maintain a strategic groundwater resource.

2.0 OBJECTIVES

MARCLAIMED will be a breakthrough addressing in an efficient, sustainable, and trustworthy way the water scarcity and water stress mitigation. It supports decision makers to integrate MAR with AWR in River Basin and Drought Management Plans supporting the adaptation

and resilience of structural supply systems in the context of climate change. The main outcome will be the MARCLAIMED Integrated Decision Support Tool (IDST) that will provide solutions to tackle existing and emerging threats and support decision making and adaptation policies. MARCLAIMED IDST will ensure A) high level operational performance through three AI-based tools to: 1) monitor and control AWR quality, 2) forecast the water resources availability and 3) provide health, environmental and performance risk indicators; B) economic sustainability under uncertainty providing: 1) a municipal scale water scarcity indicator, 2) water security economic value of MAR with AWR and 3) a cost recovery-based system; and C) social acceptance, strengthen the engagement of national and EU policy makers in collaboration with a Community of Practice and the definition of EU MAR-lines, as rules and guidelines, to promote policy recommendations and boost regulatory framework.

MARCLAIMED results will be implemented and validated in 3 demo sites in southern (PT, ES) and western Europe (NL) chosen by their wide range of settings in terms of climatic conditions, alternative water sources, MAR scheme or MAR potential, as well as political and socio-cultural context. In addition, to cover a wide spectrum of economic sectors and activities, an industrial feasibility study (in the mining sector) will be carried out in central (PL) and eastern Europe RIS countries.

3.0 APPLICATION

The MARCLAIMED methodology utilizes specific tools to enhance the design, operation and planning of MAR with AWR, focusing on climate adaptation in water-scarce regions forecasting and virtual sensing technologies. More in detail, MARCLAIMED aims to:

- Implement advanced operational and digital tools to optimize MAR performance, assess water footprints, and promote water reuse strategies at the municipal and basin levels.
- Integrate MAR with AWR into strategic river basin management plans.
- Engage stakeholders to co-create effective AWR strategies and foster social acceptance.
- And finally develop and implement economic tools to assess benefits, forecast outcomes and enhance investment returns of MAR projects.

MARCLAIMED methodology is based on the following three pillars:

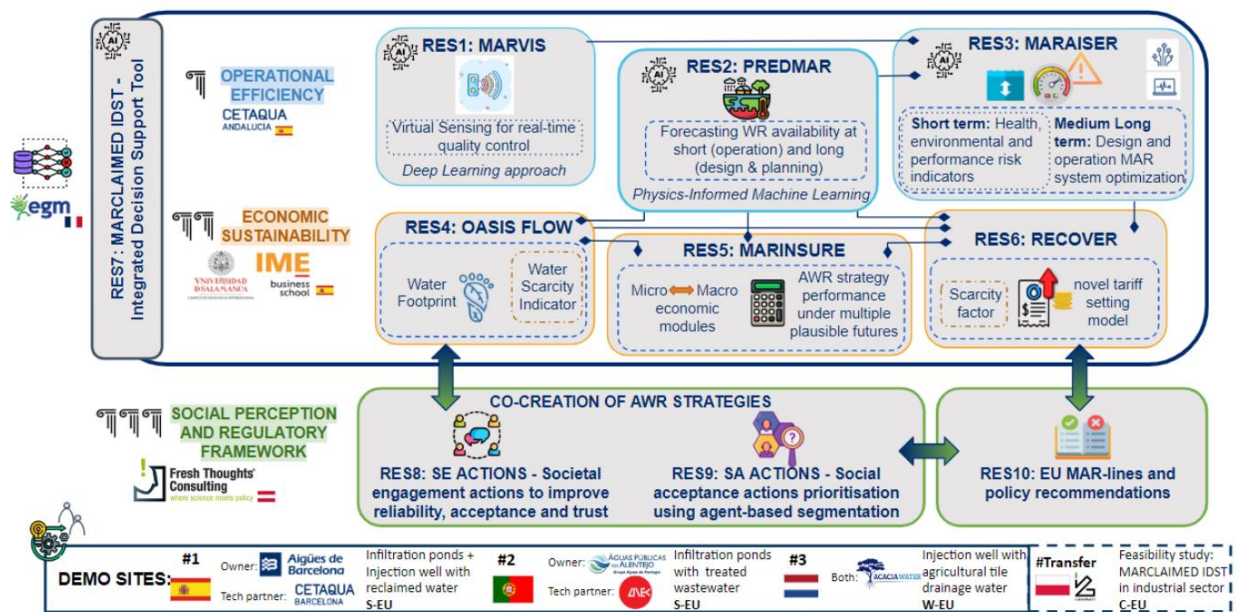


Figure 9 MARCLAIMED methodology along with the participants involved, to be validated in the MARCLAIMED demo sites (Legend: light blue boxes: operational efficiency tools, orange boxes: economic sustainability tools, and green boxes: social perception assessment)

The first pillar, OPERATIONAL EFFICIENCY, focuses on improving the performance of the MAR operation with AWR. To achieve this, 3 AI-based tools will be implemented in all 3 demo sites:

1. **MARVIS**: Virtual sensing tool for near real-time water quality monitoring (RES1)
2. **PREDMAR**: AI-based water availability and demand forecasting tool (RES2)

3. **MARAISER**: Short and long-term MAR performance optimization tool (RES3)

The second pillar, **ECONOMIC SUSTAINABILITY**, ensures the economic feasibility of MAR with AWR through the implementation of model-based tools.

4. **OASIS FLOW**: Digital tool for municipal-scale footprint performance (RES4)
5. **MARINSURE**: MAR insurance value calculator tool (RES5)
6. **RECOVER**: Tariff setting for cost recovery (RES6)

The third pillar, **SOCIAL PERCEPTION AND REGULATORY FRAMEWORK**, combines technological and non-technological approaches that will be implemented and assessed at the 3 demo sites.

SE ACTIONS: Societal engagement actions to improve reliability, acceptance and trust (RES8)

SA ACTIONS: Social acceptance actions prioritisation using agent-based segmentation

EU MAR-LINES AND POLICY RECOMMENDATIONS

All this is integrated in the seventh tool (RES7), **IDST: Integrated Decision Support Tool**, which will provide solutions to tackle existing and emerging threats and support decision making and adaptation policies.

Table 5 Resume of the main characteristics of every MARCLAIMED tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
MARVIS (RES 1)	Nitrate measurement	Short-term: Real time	Water quality (nitrates specifically)	Plant operators	Contaminating alerts	Deep learning, virtual sensing
PREDMAR (RES 2)	Quantify flow and volume Model climate change scenarios, changes in water demand and demographic fluctuations	Short-term: 3-6 months Long-term: decades	Reservoir volume and river flow Climatic, hydrologic and demographic data	Resource planners	Availability projections	Climatic models, machine learning
MARAISER (RES 3)	Define sanitary plans Optimize existing infrastructure	Short-term: Real time Long-term	Water quality (MARVIS) Water quantity (PREDMAR)	MAR managers	Early warning system Optimize recharge system	Risk analysis Optimization

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
OASIS FLOW (RES 4)	Water impact assessment on a municipal scale	Short-term Long-term	Socioeconomic and environmental data	Municipal authorities	Municipal water footprint	Water balance Scenario analysis
MARINSURE (RES 5)	Economic value for water use	Long-term	Economic and risk data	Farmers	Stored water value	Financial risk models, asset valuation
RECOVER (RES 6)	Cost recovery scenario	Short-term Long-term	Economic and water consumption	Public water managers	Tariff structure	Cost analysis, customer segmentation
IDST (RES7)	Provide solutions for decision making	Short-term Long-term	Integrated (RES1-RES6)	All water users	Water management MAR resilience indicator	Integration of different tools (operational and economical)

3.1 Potential market

The potential market for MARCLAIMED is broad and diverse, encompassing both public and private entities involved in water management and/or supply. This innovative project focuses on sustainable water management through multifactorial analysis technology, giving it a unique position in the water governance market. MARCLAIMED differentiates itself from other projects or services by integrating a series of digital tools covering various aspects, such as contaminant detection, water resource prediction, MAR operations optimization, water impact assessment and economic valuation of stored water.

As a comprehensive decision support solution, MARCLAIMED seeks to improve the efficiency, sustainability and resilience of water management systems, especially in regions prone to water stress, through the application of multi-criteria data analysis. The project also focuses on identifying and developing concrete functions that, when implemented, can effectively address current inefficiencies and solve existing problems in the field of water resources management.

Given the growing global concern about water scarcity and the need for more efficient management of water resources, the potential market for MARCLAIMED is broad, and includes local and national governments, river basin authorities, water utility companies,

large water-consuming industries such as agriculture, environmental consultancies and international organizations dedicated to sustainable water management. In a later section of this business model, the final target market will be defined more precisely and the specific target market that MARCLAIMED will address will be specified (**final target market**), thus allowing for a more focused and effective market entry strategy.

Market potential analysis is essential for achieving two strategic objectives: the effective future acquisition of the identified target customers, and the scalable implementation of the project results in various operational contexts. This allows going beyond the pilot demonstration sites where the different tools have been tested.

The methodology used for the market analysis incorporates quantitative and qualitative research techniques, which provide an **overview of the current market**.

To this end, an analysis of the current European market has been carried out, in addition to a compilation of the existing players, both in the MAR/AWR market and in each of the markets for the sub-tools that make up MARCLAIMED individually (**analysis of existing players**).

In addition, an inventory of different MAR technologies or services existing in different European locations has been made, attempting to analyse their level of development and implementation and thus determine the contribution of MARs to water resource planning and water governance.

Finally, these tools have been analysed and compared, highlighting the main advantages of MARCLAIMED over them (**SWOT**).

The information obtained through this market analysis will serve as a basis for the formulation of differentiated go-to-market strategies, the optimization of the business model, and the prioritization of product features, aligned with the specific needs of the different market segments.

3.1.1 Current market overview

The current MAR market landscape in 2024 shows accelerated growth and increasingly significant market potential, as shown in Figure 10, which shows the historical development of MAR in Europe. This method corresponds to an EU policy to achieve resource and energy efficient production and management.

According to studies conducted in 2010, the implementation of MAR in Europe has shown a significant contribution to the supply of drinking water in several countries. For example, in Hungary and Slovakia, MAR contributes more than 50% to the drinking water supply, while in the Netherlands it contributes approximately 24%. In Germany, MAR accounts for about 14% of the total public water supply, reaching 67% in cities like Berlin. However, despite

these notable advances, the contribution of MAR varies considerably between countries and it is still not enough to fully offset the rate of groundwater extraction throughout Europe.

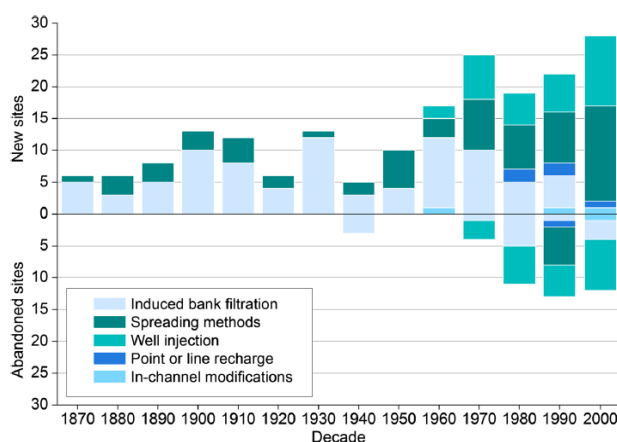


Figure 10 Outline of the historical development of MAR in Europe showing the number of MAR sites opened or closed per decade between the 1870s and 2000s. Retrieved from <https://doi.org/10.1007/s10040-017-1554-8>

MAR currently accounts for approximately 3.2% of groundwater withdrawals in countries reporting its use, which means around 1.5% of global withdrawals. Updated projections, based on experiences in regions where MAR is most advanced, suggest that this technology could reach up to 15% of global groundwater withdrawals by 2030, playing an increasingly crucial role in maintaining the quantity, reliability and quality of water supply.

As shown in Figure 11, in some countries such as The Netherlands, Finland and Germany, MAR is well established, and the contribution to water supply can reach to 10-24% of potable water supply in certain areas.

In Mediterranean countries such as Spain or Italy, MAR contribution has been increasing, but in general it supposes insignificant values (Figure 11). In Spain, for example, the figure of artificially regenerated water oscillates, according to sources, from 50 hm³/year (IGME 2000), to 350 hm³/year (*Libro Blanco del Agua en España, MIMAM, 2000*), and 380 hm³/year (DINA-MAR, 2011), figures that, in its higher values, represent a volume 10 times less to Central European countries.

In Eastern Europe, MAR implementation is rising, but its contribution to total supply is still relatively low, probably less than 5% in most of the areas.

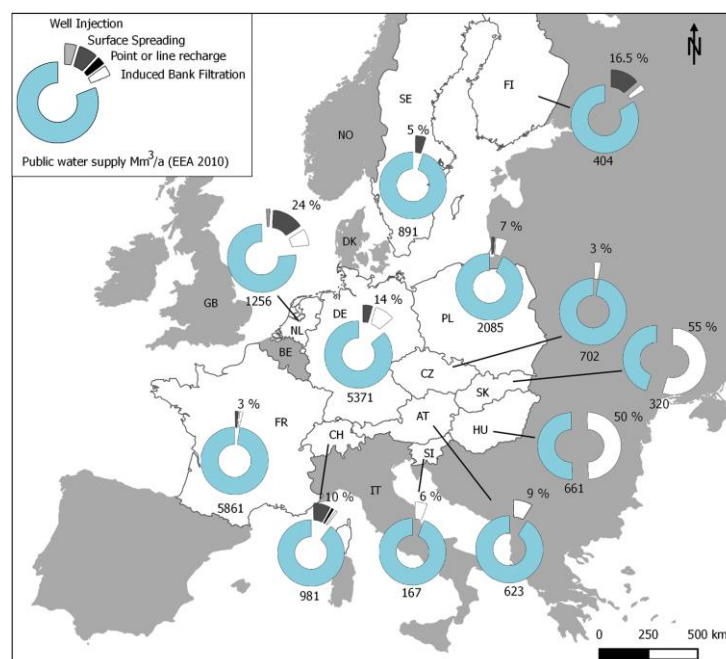


Figure 11 Percentage contribution of MAR-derived drinking water (calculated from the MAR catalog) to public water supply (taken from EEA 2010) for European countries. Countries with a MAR contribution <1% are not shown. Retrieved from <https://doi.org/10.1007/s10040-017-1554-8>

This European scenario represents a market opportunity, backed on significant advances in investigation and development in clue areas as AI technologies integration (climatic prediction modeling, future demand prediction modeling, etc.), improvements on energetic efficiency, and new methods on monitoring and water quality control.

Besides, increasing preoccupation with climate change and water security have promoted more favorable policies and a major MAR public acceptance, creating an even more propitious environment for innovative solutions on a sustainable water management.

3.1.2 Analysis of existing players

The analysis of existing competitors covers various key elements to provide a comprehensive view of the market's competitor landscape. In this study, the main competitors have been identified as follows:

1. **Direct competitors:** Companies or projects who develop multi-analysis tools focused on MAR with AWR.
2. **Indirect competitors:** Entities who develop tools which are not specifically focused to MAR and/or AWR, but that operate in the water management market, and with

light modifications or reorienting their software could turn into potential competitors.

An inventory that includes at least one competitor for every type of tool, integrated in MARCLAIMED, has been made. This inventory provides a brief description of every project, indicating the project where it is being or has been developed and/or the kind of tool it uses.

It is important to note that some of the analysed tools can compete or have the potential to compete with several of MARCLAIMED sub-tools, which underlines the complexity and dynamism of its market.

In the same way, the singularity of the project is reflected in the limited range of available tools which give a specific answer to the needs of the project.

Therefore, every single tool is analysed individually from an existing player point of view:

MARVIS

The main features and needs of this tool are the following:

Table 6 Main features and needs of MARVIS tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
MARVIS (RES 1)	Nitrate measurement	Short-term: Real time	Water quality (nitrates specifically)	Plant operators	Contaminating alerts	Deep learning, virtual sensing

This tool is probably the one with the greatest competition on the market, since the measurement of a parameter as standardized as nitrates is very common in many areas of the water sector: drinking water, domestic use, agricultural and livestock use, etc.

The main handicap that continuous nitrate monitoring tools usually have is their measurement range.

Currently, in the European Union, the maximum permitted level of nitrates in drinking water is 50 mg/l, with 25 mg/l being the guideline value.

In the current market, it is not common to find continuous nitrate control tools with high measurement ranges, and those that do exist are very expensive. This is why having a high detection limit would give a great qualitative leap to the tool.

Some of the projects that could be assimilated to the functionalities of this tool are the following:

EMERITUS (many countries): Detection of environmental waste crimes including virtual sensing components.

WQeMS (Greece, Italy, Germany, Finland and Spain): Development of an operational Water Quality Emergency Monitoring Service to the water utilities industry in relation with the quality of drinking water.

PATHOCERT (Spain, The Netherlands, Cyprus, Greece and Bulgaria): Development of detection and mitigation applications for pathogen contamination episodes in water bodies.

AQUIFER PROJECT (many countries): Capitalise, test, disseminate and transfer innovative practices for the preservation, monitoring and integrated management of aquifers.

PREDMAR

The main features and needs of this tool are the following:

Table 7 Main features and needs of PREDMAR tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
PREDMAR (RES 2)	Quantify flow and volume Model climate change scenarios, changes in water demand and demographic fluctuations	Short-term: 3-6 monts Long-term: decades	Reservoir volume and river flow Climatic, hydrologic and demographic data	Resource planners	Availability projections	Climatic models, machine learning

Quantifying water resources is increasingly one of the main needs of water managers, since trends indicate a decline in the amount of both stored surface and groundwater.

This is why monitoring these parameters is essential, as well as for controlling catastrophic events such as floods.

Some of the projects that could be assimilated to the functionalities of this tool are the following:

PRIMA GOTHAM (Spain, Lebanon and Jordan): Development of a governance tool for sustainable water resource allocation.

MAR2PROTECT (Spain, The Netherlands, Tunisia, Portugal, Italy and South Africa): Development of a DSS tool for MAR integrating technological and societal engagement information using AI-based evaluation to improve groundwater quality.

PRIMA AGREEMAR (Portugal, Spain, Cyprus, Tunisia): Application of a daily sequential soil-water budget hydrological model based on adjusted projections of rainfall and potential

evapotranspiration to better understand the magnitude and extent of the expected climate change impacts in the water availability, and assess the potential conventional water available for MAR.

ICARIA (Spain, Austria, Greece, UK and Italy): Aims to increase knowledge of the impacts of natural disasters on strategic infrastructures with a calibrated hydrological model as a main tool to drought impact assessments.

AQUIFER PROJECT (many countries): Capitalise, test, disseminate and transfer innovative practices for the preservation, monitoring and integrated management of aquifers.

MAIA (many countries): The MAIA project aims to act as an impact multiplier of climate research projects. The goal of the project is to make the current dispersed knowledge more interoperable, accessible, usable, and render the outcomes more economically sustainable.

AQUIGROW (Europe, Israel and South Africa): It is focused on sustainable aquifer recharge to enhance the resilience of groundwater services under increased drought risk. Quantify current recharge fluxes in several study aquifers used for irrigation and/or drinking water supply.

MARAISER

The main features and needs of this tool are the following:

Table 8 Main features and needs of MARAISER tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
MARAISER (RES 3)	Define sanitary plans Optimize existing infrastructure	Short-term: Real time Long-term	Water quality (MARVIS) Water quantity (PREDMAR)	MAR managers	Early warning system Optimize recharge system	Risk analysis Optimization

Setting limits on water quality is becoming vitally important, especially considering the current state of scarcity of this resource in which we find ourselves, in which quality is also being affected.

Defining control limits and a tool that provides an immediate response if they are exceeded becomes a real necessity and can offer a qualitative leap with respect to other competitors.

Some of the projects that could be assimilated to the functionalities of this tool are the following:

MARSOL (Portugal, Spain, Italy, Malta, Greece and Israel): Demonstration of MAR as a solution to water scarcity and drought where an assessment tool for risk evaluation and potential mitigation activities was developed.

QUEEN (many countries): Development of a guide of critical parameters to prevent clogging in deep injection MAR systems.

LIFE MATRIX (Spain): Integration of an aquifer recharge operational optimizer (short-term)

MAR2PROTECT (Spain, The Netherlands, Tunisia, Portugal, Italy and South Africa): Development of a new generation of MAR technologies and tools to prevent impacts on groundwater pollution in climate change scenarios.

MARSoluT (many countries): Advance of MAR to an accepted key technology for the mitigation of bottlenecks in water resources management concepts.

AQUIFER PROJECT (many countries): Capitalise, test, disseminate and transfer innovative practices for the preservation, monitoring and integrated management of aquifers.

OASIS FLOW

The main features and needs of this tool are the following:

Table 9 Main features and needs of OASIS FLOW tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
OASIS FLOW (RES 4)	Water impact assessment on a municipal scale	Short-term Long-term	Socioeconomic and environmental data	Municipal authorities	Municipal water footprint	Water balance Scenario analysis

The evaluation of the water footprint, both from a sustainability and efficiency and economic optimization point of view, is taking on a leading role in the projects being developed nowadays.

In this case, the impact of MAR on the availability of a territory will be evaluated at a municipal scale, and therefore with greater precision than if it were carried out on a larger scale, which can give a big qualitative step.

Some of the projects that could be assimilated to the functionalities of this tool are the following:

QUEEN (many countries): Study of the effects of direct aquifer recharge with sand-filtered and water footprint calculation in a particular scenario and INOWAS: provides a free web-

based groundwater modeling platform for planning, management and optimisation of MAR application.

HH TERRITORIAL (many countries): Development of the methodology for calculating the water footprint of municipalities including the main economic and social sectors.

ZOET OP SOUT (The Netherlands): Scaling-up of innovative water adaptation strategies for the agricultural sector, incorporating economic models combining hydrological climatic predictions, drought, and crop production to predict micro- and macro-economic effects.

MARINSURE

The main features and needs of this tool are the following:

Table 10 Main features and needs of MARINSURE tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
MARINSURE (RES 5)	Economic value for water use	Long-term	Economic and risk data	Farmers	Stored water value	Financial risk models, asset valuation

Ensuring the availability of resources for the users of a territory is vital for good management of it. For this, it is necessary to know the current and historical situation in order to predict possible future scenarios in the medium and short term and to evaluate the economic impact that each situation could have on the population.

Some of the projects that could be assimilated to the functionalities of this tool are the following:

PRIMA TALANOA (Egypt, Italy, France, Lebanon, Spain and Tunisia): aims to inform and catalyse the co-creation and adoption of transformational adaptation strategies to water scarcity under climate change that achieve social equity, economic efficiency and environmental sustainability.

TRANSCEND (Perú, Bolivia, Chile, Spain, Italy, Slovakia, Lebanon, Syria, Turkey, Greece, India): Aims to design innovative allocation systems and economic instruments that are robust and adaptable to uncertainty and change, while simultaneously achieving equitable and sustainable economic growth and welfare outcomes.

RECOVER

The main features and needs of this tool are the following:

Table 11 Main features and needs of RECOVER tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
RECOVER (RES 6)	Cost recovery scenario	Short-term Long-term	Economic and water consumption	Public water managers	Tariff structure	Cost analysis, customer segmentation

Some of the projects that could be assimilated to the functionalities of this tool are the following:

EFINET (many countries): Proposed innovative tariffs based on different rationale due to availability of hourly water consumption. The project was based on freshwater resources but not including alternative water resources.

IDST (Integrated Decision Support Tool)

The main features and needs of this tool are the following:

Table 12 Main features and needs of IDST tool

Tool	Main focus	Time scale	Data typology (Input)	Main users	Key result (Output)	Methodology
IDST (RES7)	Provide solutions for decision making	Short-term Long-term	Integrated (RES1-RES6)	All water users	Water management MAR resilience indicator	Integration of different tools (operational and economical)

Every tool for itself can be applied to a particular situation, but all together bring a broad meaning to MARCLAIMED. In that sense, all the competitors mentioned above could be assimilated to MARCLAIMED in the sense of comprehensive water management applied to MAR systems with AWR.

The following table resumes and classifies the players mentioned above in terms of what kind of relation they have with MARCLAIMED, direct or indirect:

Table 13 Classification of existing players in terms of their relation with MARCLAIMED.

Tool	Direct competitor		Indirect competitor	
	Use	Country	Use	Country
MARVIS (RES 1)	EMERITUS	WQeMS PATHOCERT AQUIFER PROJECT	WQeMS PATHOCERT AQUIFER PROJECT	EMERITUS
PREDMAR (RES 2)	PRIMA.GREEMAR ICARIA AQUIGROW	PRIMA GOTHAM MAR2PROTECT PRIMA.GREEMAR ICARIA AQUIFER PROJECT AQUIGROW	PRIMA GOTHAM MAR2PROTECT AQUIFER PROJECT MAIA	MAIA
MARAISER (RES 3)	MARSOL QUEEN LIFE MATRIX	MARSOL LIFE MATRIX MAR2PROTECT AQUIFER PROJECT	MAR2PROTECT MARsoluT AQUIFER PROJECT	QUEEN MARsoluT
OASIS FLOW (RES 4)	QUEEN HH TERRITORIAL	ZOET PO SOUT	ZOET PO SOUT	QUEEN HH TERRITORIAL
MARINSUR E (RES 5)	PRIMA TALANOA TRANSCEND	PRIMA TALANOA TRANSCEND		
RECOVER (RES 6)	EFINET			EFINET
IDST (RES7)	ALL ABOVE			

3.1.3 Final target market and market adoption perspective

After conducting an analysis of the current market and identifying the existing players in the field of water resource management, the final target market for MARCLAIMED has been defined. The methodology used for this determination has focused on identifying the key segments where the solution provides significant added value and meets specific needs. Next, the division of the final market is presented based on two fundamental criteria.

Entity Type Segmentation

1. This approach distinguishes between water management authorities and end users. For each segment, their key needs and the value proposition that MARCLAIMED offers to meet them will be detailed. This segmentation allows to adapt the offer to

the specific needs of each type of entity, thus maximizing the impact and adoption of the solution.

Geographical segmentation

2. This second approach is based on the identification of regions with specific needs in terms of water resource management. It is recognized that different geographical areas face unique challenges in terms of water availability, regulations, and climatic conditions. This segmentation allows to personalize the market strategy and adapt the solutions to the particularities of each region.

This dual segmentation (Figure 12) perspective provides a comprehensive view of the market, allowing for the development of more effective and focused entry and expansion strategies.

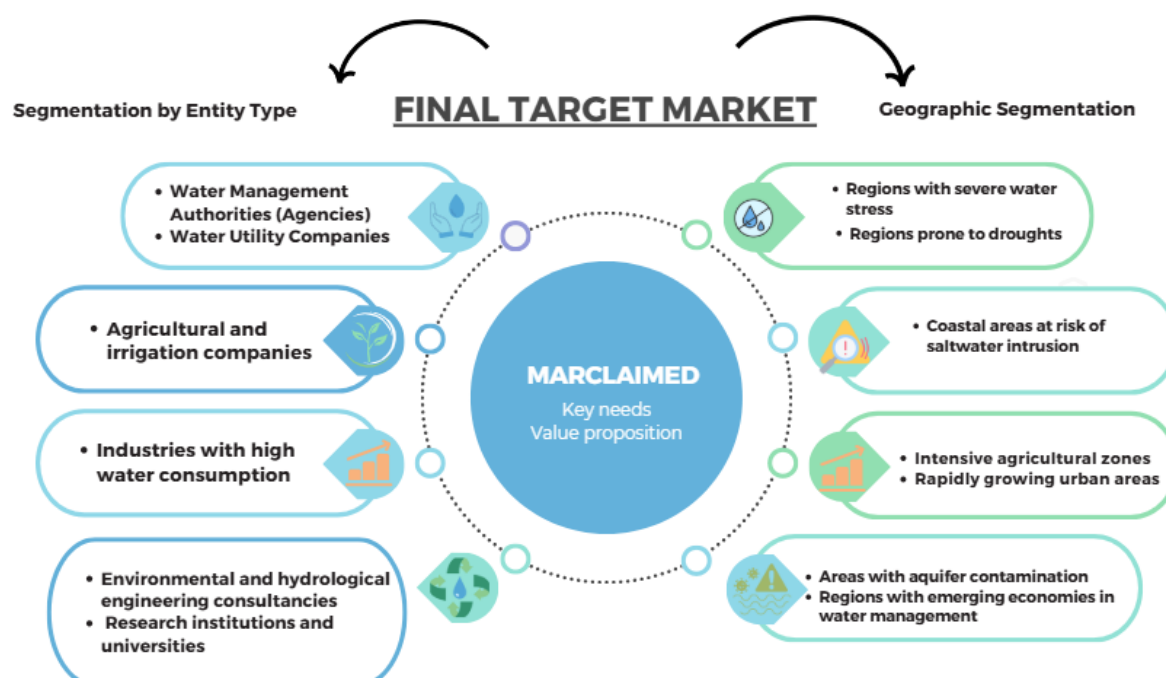


Figure 12 Final target market of MARCLAIMED

The following sections will detail each of these segments, their specific characteristics, and how MARCLAIMED is positioned to optimally meet their needs. Next, a detailed description of each segment identified by entity type is presented, including their key needs and the value proposition that MARCLAIMED offers for each of them.

1. Water Management Authorities (Agencies)

These entities are responsible for the planning, regulation, control, and administration of water resources at a regional or national level. Their role is crucial in terms of water

governance and sustainable management, as well as the protection of groundwater bodies and their associated surface ecosystems.

Key Needs

- **Strategic Planning:** Authorities increasingly require the availability of innovative tools that aid in decision-making regarding water resource management. Moreover, these tools are necessary for developing medium and long-term plans, considering factors such as climate change, population growth, or seasonal water demands, among many other factors.
- **Data-based decision making:** In an increasingly complex environment, water management entities need access to accurate, updated data to make informed decisions. This includes information on water availability, quality, demand, long-term trends or simulation of different scenarios (shortage, demand, supply), among others.
- **Comply with legislative requirements:** Results and Tools made in MARCLAIMED are in line with legislation, for example, being suitable for reporting.

Value Proposal of MARCLAIMED

- **Integrated decision support system (MARVS, PREDMAR and MARAISER):** MARCLAIMED offers a comprehensive solution that gathers data from multiple sources (continuous data collection, monitoring stations, models) into a single system. This tool allows authorities to visualize and analyze complex information intuitively, facilitating informed decision making.
- **Different scenario Analysis:** The solution provides advanced analysis capabilities that allow authorities to evaluate different management scenarios considering multiple factors simultaneously. This includes aspects such as environmental impact, economic efficiency, and long-term resilience, allowing for more conscious and balanced decision-making.

2. Water Utility Companies

These organizations are responsible for the supply and treatment of wastewater and, in some cases, management of urban drainage systems. They operate in an environment that in most cases, with the current situation, requires the development of plans in which it is possible to balance operational efficiency with service quality, sustainability, and resource allocation to the areas they manage.

Key Needs

- **Operation Optimization:** Public service companies are constantly looking for ways to improve efficiency in water collection, treatment, and distribution. This includes reducing losses, optimizing energy use, and improving planning.
- **Early Contaminant Detection:** Water quality is a primary concern. These companies need early detection systems, capable of quickly identifying the presence of contaminants to protect public health and comply with increasingly strict regulations.
- **Increase water availability and security:** MAR with AWR can be used to increase water availability and security, so as to hint that those utility companies are a good potential customer.

MARCLAIMED Value Proposition

- **MAR Optimization Tool:** MARCLAIMED offers an advanced solution to optimize aquifer recharge systems. This tool uses algorithms to determine the best times and places for recharge, maximizing efficiency and minimizing costs. This not only improves long-term water availability but also helps maintain the aquifer reserve.
- **Real-Time Contaminant Detection System (MARVIS and MARAISER):** The platform integrates advanced sensors and machine learning algorithms to continuously monitor water quality. It can detect a wide range of contaminants and immediately alert when anomalies are detected. This allows for a rapid response to water quality issues, improving public safety and reducing operational risks.

3. Agricultural and irrigation companies:

The agricultural sector is one of the largest consumers of water worldwide. This segment includes everyone from small farmers to large agro-industrial corporations, all facing the challenge of increasing efficiency while producing.

Key Needs

- **Water use efficiency:** With increasing water scarcity and associated extraction costs, agricultural companies seek to maximize productivity in terms of EUR/m³. They need tools to help them optimize irrigation and reduce waste.
- **Water risk management (PREDMAR):** Climate variability and uncertainty in water availability pose significant risks to agriculture. These companies need tools to anticipate and mitigate risks associated with both scarcity and the implementation of maximum water extraction efficiency.
- **Compliance with laws:** With the objective of saving paper work and administrative tasks to farmers and other agricultural and irrigation companies.

MARCLAIMED Value Proposition

- **Water availability prediction (PREDMAR):** MARCLAIMED uses advanced models that combine historical data, satellite information, and climate forecasts to predict short and medium-term water availability. This allows farmers to better plan their crops and irrigation strategies, reducing the risk of losses from drought, flooding, or even lack of planning.
- **Aquifer recharge optimization (MARIASER):** The platform offers specific tools for the agricultural sector that help maximize the efficiency of irrigation and aquifer recharge systems. This includes recommendations on when and how to irrigate to minimize evaporation and maximize crop absorption, as well as strategies for efficient aquifer recharge during seasons of excess water.

4. High Water Consumption Industries

This industrial segment, producer of approximately 25% of GDP at the European level according to Eurostat, includes sectors such as mining, manufacturing, energy production, and the food and beverage industry. These industries face increasing pressure to reduce their water footprint and operate in a more sustainable manner.

Key needs

- **Water consumption reduction:** Industries seek to minimize their water use to reduce operational costs, improve their sustainability, and comply with increasingly strict regulations.
- **Regulatory compliance:** Awareness of the environment, and the environmental regulations established to safeguard associated resources and ecosystems, means that these industries need to ensure adequate compliance with current legislation.

Value proposal from MARCLAIMED

- **Water footprint assessment (OASIS FLOW):** MARCLAIMED provides advanced tools to calculate and monitor the water footprint of industrial operations. This includes not only the water directly consumed, but also the water incorporated into the supply chain and impacts on local water resources.
- **Optimization of water resources use (MARIASER):** The set of tools developed in MARCLAIMED, offers customized solutions to identify opportunities for water consumption reduction and reuse. It uses advanced analysis techniques to model water flows and recommend improvements.

5. Environmental and Water Engineering Consultants

These companies offer advisory and design services in projects related to water management and the environment. Their success depends on their ability to provide accurate analysis and innovative solutions to their clients.

Key Needs

- Advanced analysis tools: The consultants require access to the latest technologies and analysis methods to offer high-quality services to their clients and remain competitive in the market.
- Scenario modeling: They need to rely on robust data to simulate different water management scenarios and their impacts, allowing them to offer well-founded and plausible recommendations to their clients.

Value Proposition of MARCLAIMED

- Complete suite of water analysis tools: MARCLAIMED offers an integrated set of tools covering from water resources assessment to environmental impacts modeling. This allows consultants to perform exhaustive and multidimensional analysis, improving the quality and scope of their services.
- Advanced modeling capabilities (PREDMAR): The MARCLAIMED tool provides the possibility to simulate complex water management scenarios. This includes the ability to integrate multiple variables such as climate change, population growth, and changes in land use, allowing consultants to offer more accurate projections and robust recommendations.

6. Research Institutions and Universities:

This segment includes research centers, universities, and other academic institutions focused on the study of water resources and environmental management. Their work is fundamental to advancing knowledge and developing new solutions for global water challenges.

Key Needs

- Advanced data analysis: Research-related entities require sophisticated tools to process and analyze large volumes of water and environmental data.
- Modeling of complex systems: They need capabilities to simulate complex interactions between water, climatic, and ecological systems, which are fundamental to understanding the long-term impacts of different water management strategies.

MARCLAIMED's Value Proposition

- Access to innovative analysis tools (PREDMAR): MARCLAIMED provides access to algorithms and analysis techniques applied to water management. This includes machine learning capabilities and AI predictive analysis that can help research centers handle their data in a more efficient way.
- Platform for applied research: The set of tools developed in MARCLAIMED offers a flexible environment that could enable researchers to develop and test new models and approaches in water resource management. The platform is highly customizable and can be integrated with other research tools, facilitating innovation and the development of new methodologies.

The following is a detailed description of each identified segment considering a geographical segmentation. The characteristics of each area, their specific needs, as well as the value proposition that MARCLAIMED offers for each of them are included. In addition, examples of significant areas that would fit within the potential market at the European level are included.

1. Regions with severe water stress

These areas, characterized by a chronic shortage of water and limited access to water resources, represent a challenge for sustainable water management in Europe.

The European Environment Agency (EEA) has recently published a climate risk assessment, revealing that in Europe, the total area affected by drought will reach 143,513 km² in 2023, exceeding the average observed in the period between 2000 and 2020.

More specifically, as shown in Figure 13, regions of southern Spain, such as Murcia and Almería, and areas of southern Italy, such as Puglia in Sicily, face constant pressure on their water resources due to a set of demands that require the use of water in different sectors. Other areas greatly affected are the Greek islands, Cyprus, and various areas of Portugal, thus directly becoming potential end users of MARCLAIMED.

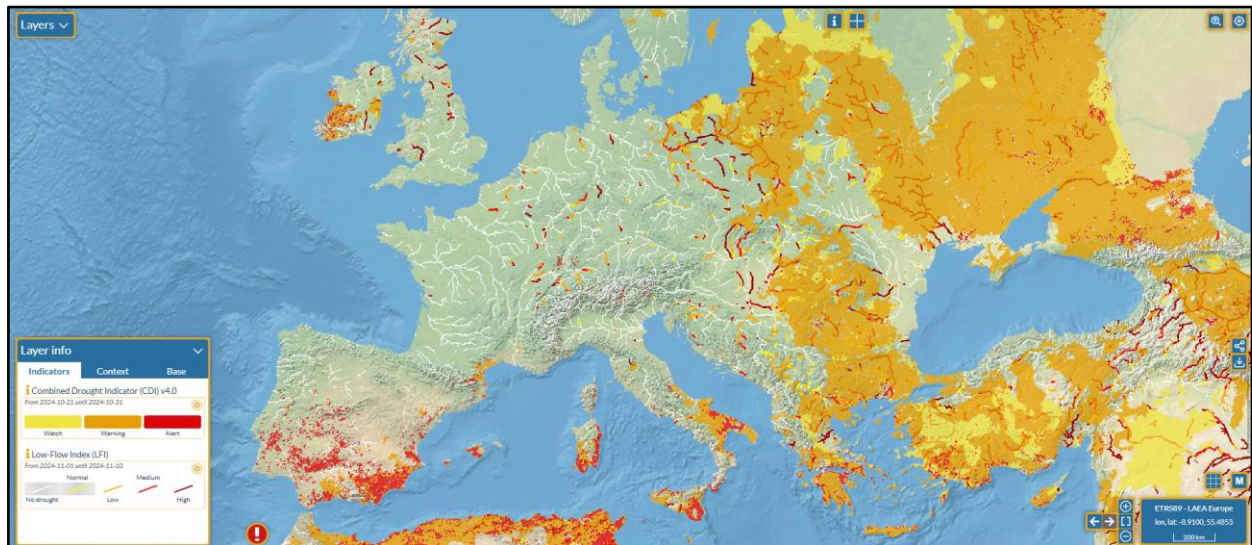


Figure 13 Drought indicator map, taken from the European Drought Observatory.

MARCLAIMED proposes addressing these needs through the optimization of Managed Aquifer Recharge (MAR) techniques to increase groundwater reserves, combined with advanced prediction tools for better planning (PREDMAR).

This approach will not only maximize the efficient use of limited water resources, but will also help prevent water conflicts between different sectors and users, thus contributing to the long-term water resilience of these vulnerable regions.

2. Coastal areas at risk of saltwater intrusion

Coastal areas of Europe, such as the Costa del Sol in Spain and the Po Delta in Italy, face the growing challenge of saltwater intrusion into their aquifers (Figure 16). This phenomenon has increased due to the overexploitation of groundwater, by the growing population density in the coastal areas of Europe, as can be seen in Figure 14.



Figure 14 Population density in European coastal areas, expressed in inhabitants/km². In burgundy, it represents >500 inhabitants/km²; in red, between 250 and 500; in dark pink between 100 and 200 and in light pink, less than 100 inhabitants/km². AEMA, 2005, based on population density figures broken down with CLC2000, CCI, 2005.

The following presents a series of saltwater intrusion maps in Europe. In them, you can observe the advance of saltwater intrusions in coastal areas since 1999.

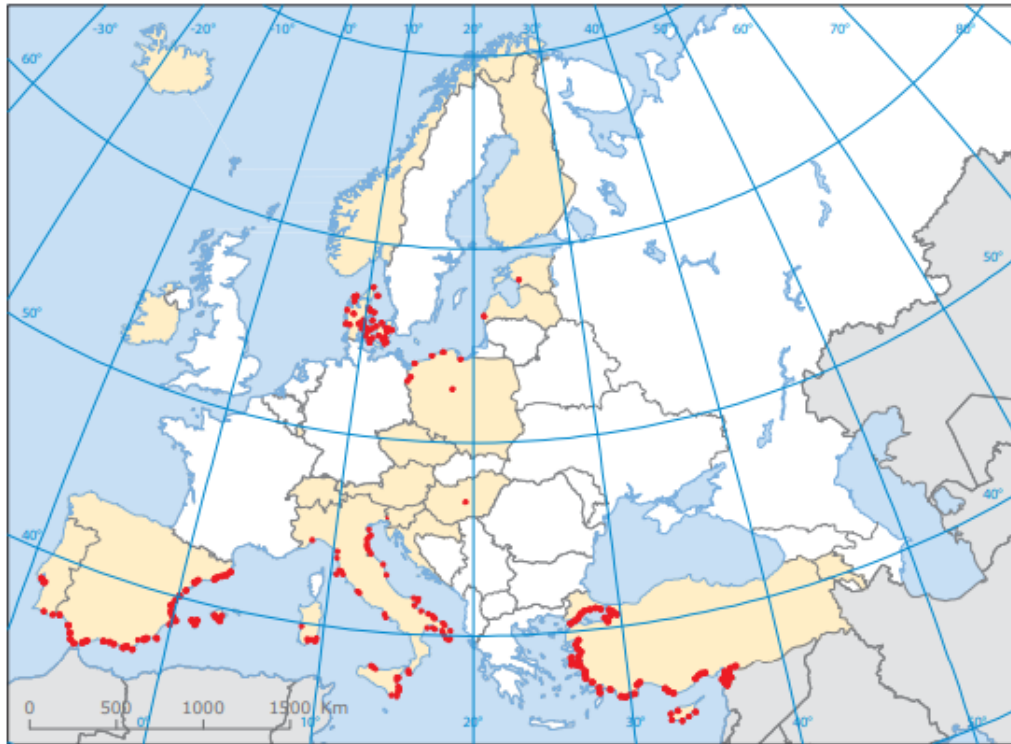


Figure 15 Saltwater intrusion into European groundwater (1999). Source: EMA.

Value proposition

MARCLAIMED proposes implementing real-time water quality monitoring systems (MARVIS and MARAISER), along with advanced models that can contribute to the problem of saltwater intrusion. These solutions would allow for early detection of the wedge's advancement and facilitate informed decision-making for the management of coastal aquifers. By preventing saltwater intrusion and maintaining water quality, the project will significantly contribute to the water security of coastal communities and the preservation of adjacent marine ecosystems.

3. Intensive agricultural zones:

Intensive agriculture regions (Figure 17), such as La Mancha in Spain and the Thessaly Plain in Greece, are characterized by high water consumption to support the area's agricultural activity, which poses a high risk of overexploitation of aquifers.

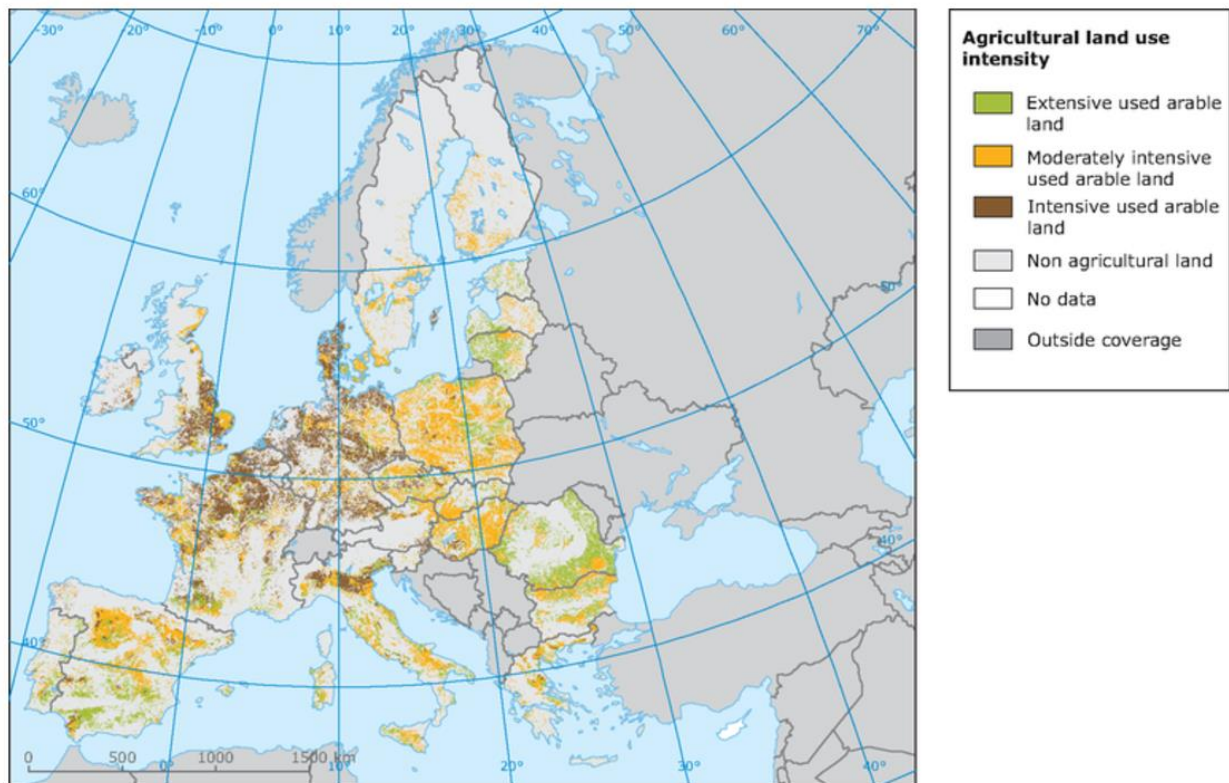


Figure 16. Agriculture land use intensity. Font: European Environment Agency.

These areas require specific solutions and often, individualized and with a high quality in terms of data processing. Thus, in this sector, the challenge is to achieve better efficiency in water use and at the same time ensure supply, along with the guarantee of long-term sustainability.

Value proposition

MARCLAIMED proposes to develop integrated systems that optimize both irrigation and aquifer recharge, adapted to the specific conditions of each region (PREDMAR). In addition, the existence of advanced models to evaluate the impact of agricultural practices on underground water resources would represent an improvement in the forecasting capacity of demand, and therefore, an improvement in agricultural productivity. This approach would ensure the conservation of aquifers, thus promoting sustainable and climate change resilient agriculture throughout Europe.

4. Rapidly growing urban areas:

Expanding metropolitan areas, such as London in the United Kingdom and the metropolitan area of Barcelona in Spain, face unique challenges in water management due to the rapid increase in demand and pressure on existing water infrastructure.

Value proposition

MARCLAIMED will address these needs by developing advanced tools for predicting future demand and evaluating options for urban MAR (PREDMAR).

These solutions would allow for more accurate planning of the necessary water infrastructure and more efficient management of the growing demand for water. In addition, it must be taken into account that certain European areas have a high seasonal demand, which can sometimes even triple the necessary water supply in urban areas and has a significant impact on both aquifers and urban supply management. By integrating MAR techniques in urban environments, the project will not only improve the water security of cities, but will also contribute to the creation of more sustainable urban spaces.

5. Drought-prone regions

Areas such as Alentejo in Portugal and Cyprus experience high climatic variability and recurring periods of water scarcity (Figure 13), making them particularly vulnerable to the impacts of climate change.

Value proposition

MARCLAIMED will focus on increasing the resilience of these regions to droughts by developing advanced drought scenario models and optimizing underground water storage techniques. These solutions will allow better use of wet periods to store water, thus creating strategic reserves for periods of drought (PREDMAR). By improving the adaptability of these regions to climatic variability, the project will significantly contribute to long-term water security and the socio-economic stability of communities affected by recurring droughts.

6. Areas with groundwater contamination

Industrialized regions such as the Ruhr Basin in Germany and the Lombardy Region in Italy face significant challenges related to the pollution of their aquifers.

The graph provides an overview of the main pollutants affecting the soil and therefore, some also to groundwater, according to the European Environment Agency.

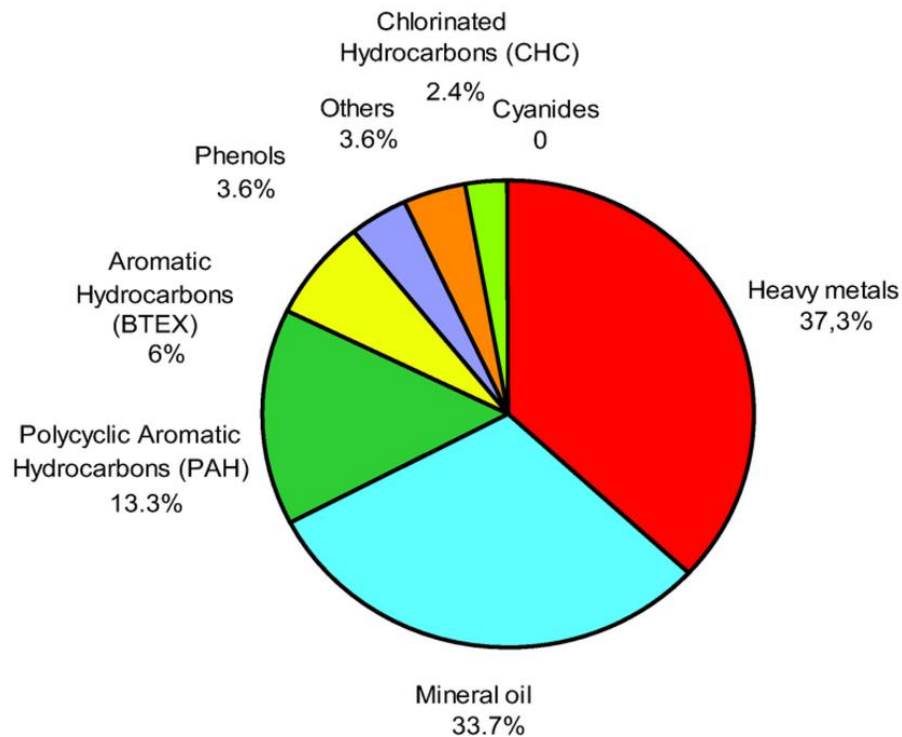


Figure 17. Main pollutants affecting the soil. Source: European Waters

Furthermore, Figure 18 shows the updated status of 12.028 European groundwater bodies. European aquifers and groundwaters face various challenges and risks that can affect their good quantitative and chemical status. Among the main impacts are the decrease in groundwater levels due to excessive extractions, pollution from nutrients from fertilizers and animal waste, and chemical pollution from pesticides, metals, and hydrocarbons. These factors can have serious consequences on terrestrial ecosystems dependent on groundwater and on the quality of associated surface waters. In addition, problems such as microbiological and organic pollution, acidification of water bodies, and alterations in habitats due to hydrological and morphological changes are observed.

These impacts vary in their intensity and can manifest themselves in different ways, from the decrease in water quality to changes in the direction of water flow. Therefore, it is crucial to monitor and address these risks to ensure the sustainability of underground water resources and the ecosystems that depend on them.

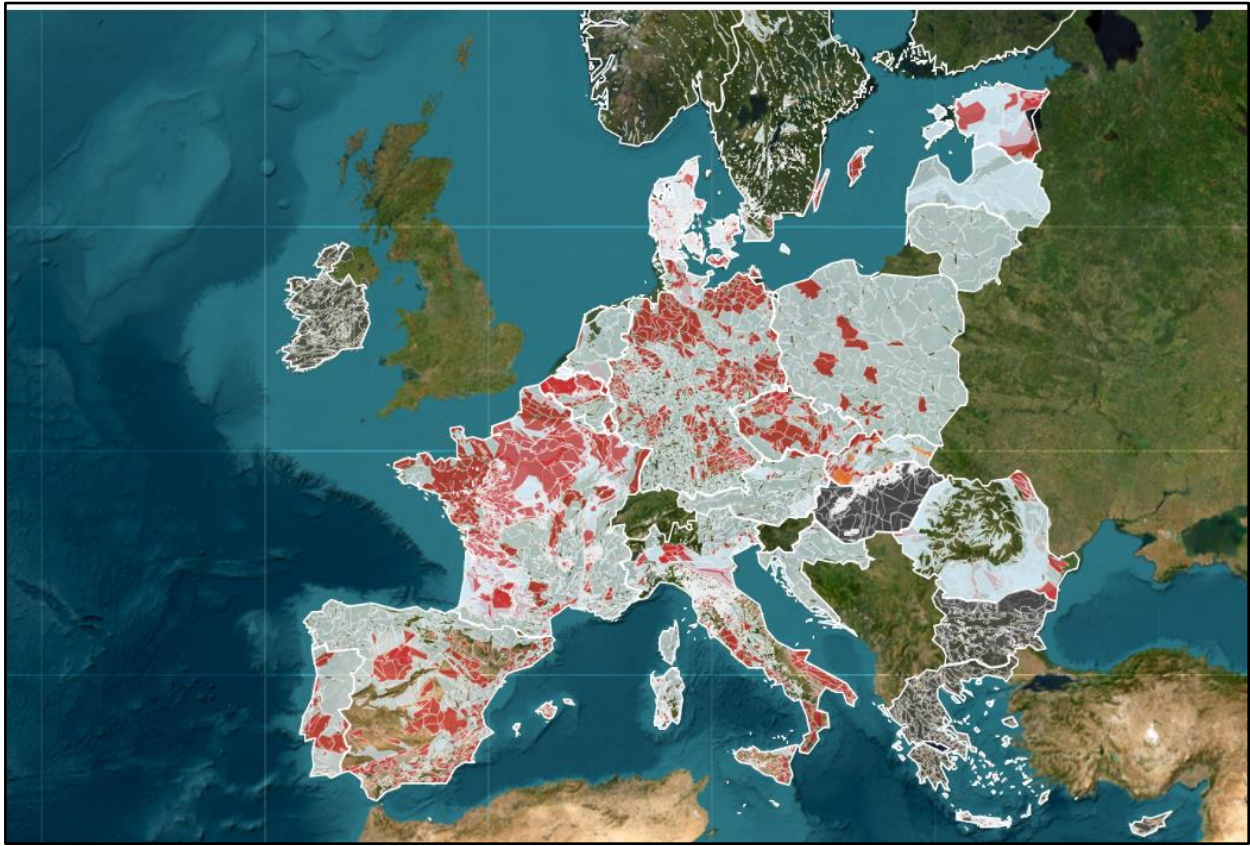


Figure 18. Status of 12,028 groundwater bodies according to third cycle plans (2022-2027). Blue: good condition; Red: bad condition; Orange: unknown condition; Black: non-reported data. Source: European Environment Agency. Data updated as of October 15, 2024.

Value proposition

MARCLAIMED will address this issue through the development of early contaminant detection systems and advanced contaminant transport models in groundwater (MARVIS and MARAISER). These tools will allow for faster and more accurate identification of pollution sources, facilitating the implementation of more efficient and effective remediation measures. In addition, the project will explore innovative MAR techniques for water quality improvement, thus contributing to the restoration and protection of underground water resources in these key industrial areas of Europe.

7. Regions with emerging economies in water management

Bulgaria and Romania, as relatively new members of the EU (2007) are in the process of aligning their water management practices with European standards, which presents challenges and opportunities to implement innovative solutions. Both countries face

problems such as aging infrastructure, water loss in distribution, limited access to drinking water in rural areas, and pollution of groundwater and its associated ecosystems.

Value proposition

MARCLAIMED (ALL TOOLS) can address these challenges as multi-criteria decision-making support tools, addressing different aspects.

1. Implementation of advanced MAR technologies: Adaptation and implementation of Managed Aquifer Recharge (MAR) solutions considering the specific geological and hydrological conditions of each area.
2. Decision support tools: Development of simulations with different demand and availability scenarios, to improve water management. International benchmarking:
3. Comparison and adoption of the best global practices in water management, adapted to the local context.
4. Promotion of sustainability: Implementation of solutions that ensure a more efficient and sustainable use of water resources.
5. Closing regional gaps: Contribution to reducing disparities in water management between different regions of Europe.

3.1.4 Competitiveness of the solution from a customer point of view

In a business model, the "Competitiveness of the solution from the customer's point of view" section should focus on how your product or service meets customer needs better than existing alternatives.

The key elements to consider are as follows:

- Unique value proposal
- Comparison with existing players
- Ease of use and application
- Customization and flexibility
- Innovation and continuous improvement
- Testimonies and success stories
- Sustainability and social responsibility
- Integration into existing ecosystems

Each MARCLAIMED tool offers some kind of unique value proposal that differentiates it from the other competitors known in the current market.

From a qualitative perspective, having a real time control of the concentration of different water parameters, as for example nitrates (**MARVIS**), to be able to give a fast answer in case of alert when rising the limits defined by every single user (**MARAISER**). From a quantitative point of view, monitoring the water volume stored in reservoirs or the flow of a river (**PREDMAR**).

Planning future scenarios by AI tools as well, a market which is active nowadays and with more than promising future.

From a socioeconomic perspective, calculating water footprint on a little scale as a municipal one (**OASIS FLOW**), defining economic value of water use (**MARINSURE**), or analyzing cost recovery scenarios, tariffing or alternative retribution methods (**RECOVER**) can give these unique value proposals for our tools.

The analysis on the comparison of existing players is useful to find shortcomings that water users may have. The current market is broad in this sector.

In the field of water quality, monitoring of many parameters is a common work both in hydrology and hydrogeology, as well as quantifying water resources by reservoir volume, river flows, etc. In the same way, artificial intelligence application in water management and water needs for future scenarios analysis is booming.

Water footprint evaluation, as well as pricing and cost recovery scenarios are usual calculus on water management. On the other hand, the market focused on the economic value of water use that **MARINSURE** gives is scarce or almost non-existent according to stakeholders.

As mentioned above, as MAR with AWR is a large market in this sector, analyzing which performances could be applied in a near future becomes of vital importance for giving a quality leap.

In that sense, it could be interesting to enlarge measurement ranges of a single parameter, as well as the total amount of analyzed parameters (**MARVIS - MARAISER**) based on users needs, and enlarging measurement elements, to obtain groundwater data as well.

In the same way, being able to use a tool on a different scale as planned, not just even on a political - administrative one but at a water body level (aquifer, groundwater body, etc.) could give too a quality leap (**OASIS FLOW**).

In some specific situations we find ourselves that the current market is limited, as for **MARINSURE** tools, with which the possible needs of the current market are responded to.

All tools are expected to present some difficulty in terms of data collection, analysis and presentation, so it is expected that specialized technical people will be in charge of their use. Beyond this, the final consultation and visualization of the data must be easy, concise and understandable for any possible user.

Nowadays, there are still no results available from any of the tools, because they are still being developed and beginning to be applied in the three demo sites of the project (Spain, Portugal and The Netherlands). The first results will be reported in the coming months.

The application of the list of tools mentioned above, besides giving a technical response to a set of needs, it is focused on ensuring a minimum environmental impact and a social responsibility over the population, mostly for resource users.

In that sense, MARCLAIMED bets on ensuring an environmental compromise by actions that improve reliability, acceptance and trust in the users.

This is to be achieved through training days, social media promotion, and other interest activities for all users.

It is important as well to emphasize the fact of traceability among the six developed tools for the project and the capacity they have to integrate each other with the other tools. Many of them, through the output data, feed others, as shown in the next figure:

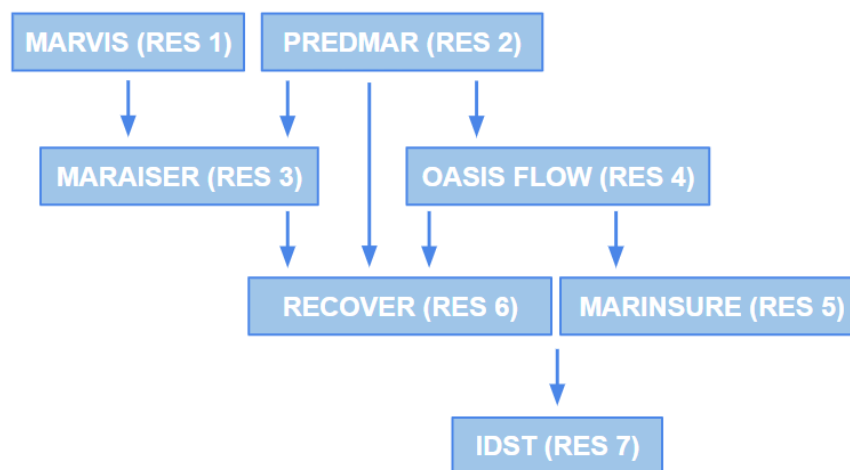


Figure 19. Ability to integrate with other tools.

3.1.5 Value engineering study for the proposed technology

The Value Engineering Study for a proposed technology is a systematic and structured process used to improve the value of a product, system or service. This approach focuses on optimizing the relation between functionality and cost. The main objectives, among others, of a kind of study are:

- Reducing costs
- Improve quality
- Increase efficiency
- Optimize performance
- Improve the customer satisfaction

For such purposes, the following typical process is established:

1. Functional analysis phase: Identification of main and secondary functions.
 - Evaluation of relative importance.
 - Determination of areas for improvement.
2. Cost analysis
3. Creative phase: Generation of alternative ideas to fulfill the functions.
4. Evaluation phase (feasibility): Analysis of the proposed alternatives.
5. Development phase: Refinement of the best alternatives.
6. Presentation phase (implementation): Proposal of recommendations.

1. Function Analysis

This analysis is essential for understanding and optimizing the value that MARCLAIMED offers to its future customers and end users of the technology. In this way, the various areas of potential improvement focused on the end user can be determined.

In addition to the main functions, the secondary functions of each tool that makes up MARCLAIMED have been identified. These functions, although they are not the main objective of the tools, could provide additional value to the end user, as well as improve the overall usage experience of the solution by complementing the main functions.

The main and secondary functions of the tools that make up MARCLAIMED are outlined below.

Table 14. Identification of the main and secondary functions of the MARVIS tool

Tool	Identification of main functions	Identification of secondary functions
MARVIS	Real-time monitoring of water quality parameters	Customizable report generation on water quality.
	Early detection of contaminants	Integration with external alert systems for a faster response.
	Generation of alerts based on predefined thresholds	Historical visualization of trends in water quality parameters

Table 15. Identification of the main and secondary functions of the PREDMAR tool

Tool	Identification of main functions	Identification of secondary functions
PREDMAR	Prediction of water resource availability	Simplified interactive display for users of water resource prediction scenarios
	Future scenario modeling using AI	Automatic comparison of predictions with historical data
	Trend analysis in water use	

Table 16. Identification of the main and secondary functions of the MARAISER tool

Tool	Identification of main functions	Identification of secondary functions
MARAISER	Optimization of Managed Aquifer Recharge (MAR) operations	Simulation of different aquifer recharge techniques
	Evaluation of the efficiency of recharge techniques	Calculation of operational costs associated with MAR operations
	Monitoring the impact of MAR on groundwater quality	Assessment of the environmental impact associated with recharge

Tool	Identification of main functions	Identification of secondary functions
		activities

Table 17. Identification of the main and secondary functions of the OASIS FLOW tool

Tool	Identification of main functions	Identification of secondary functions
OASIS FLOW	Calculation of the water footprint at the municipal scale	Comparison of the water footprint between different municipalities, locations or geographical sectors
	Analysis of the impact of water use in different sectors	Automated suggestions for reducing the water footprint in municipalities, locations or geographical sectors
	Visualization of water consumption data	Projection of future scenarios of the water footprint based on current data series

Table 18. Identification of the main and secondary functions of the MARINSURE tool

Tool	Identification of main functions	Identification of secondary functions
MARINSURE	Assessment of the economic value of water use	Sensitivity analysis for different economic variables related to water use
	Risk analysis associated with water management	Generation of personalized risk reports for different stakeholders
	Calculation of economic benefits of MAR strategies	Calculation of payback for water management projects

Table 19. Identification of the main and secondary functions of the RECOVER tool

Tool	Identification of main functions	Identification of secondary functions
RECOVER	Cost recovery scenario analysis	Simulation of the impact of different tariff structures on cost recovery

Tool	Identification of main functions	Identification of secondary functions
	Tariff structure modeling	Communication tools to explain tariff changes to end users
	Evaluation of alternative remuneration methods	Comparative analysis of tariff structures with other regions or countries

Table 20. Identification of the main and secondary functions of the MARCLAIMED solution

Tool	Identification of main functions	Identification of secondary functions
MARCLAIMED IDST	Data integration from all component tools (MARVIS, PREDMAR, MARAISER, OASIS FLOW, MARINSURE, RECOVER)	Simplified interactive visualization for the user of integrated data from all component tools
	Multidimensional analysis of water management, combining aspects of quality, quantity, economy, and sustainability	Generation of customized reports for water authorities, utilities, farmers, industry, research groups, etc
	Generation of predictive scenarios for decision-making in water resource management	Simulation of impacts of different water management policies with MAR at local and regional level
	Evaluation of risks and opportunities in Managed Aquifer Recharge (MAR) projects with Alternative Water Resources (AWR)	Integration with external water monitoring and management systems
	Optimization of water management strategies based on multiple criteria.	Potential for learning and continuous improvement based on the analysis of past decisions, together with historical data and their results associated with MAR

Within the analysis of functionalities, we found the **relative importance test**. The relative importance test is a commonly applied method based on simulating real decision scenarios,

forcing participants, who are usually users of the tool, to choose between different features of MARCLAIMED that are collected in the functionality analysis tables.

This process would reveal users' priorities, allowing them to identify which functions are most valued and which combination of benefits will be more attractive. This information is crucial to guide the project's development, ensuring that resources are focused on the features that will truly drive user adoption and satisfaction, thus maximizing the success of MARCLAIMED in the water management market.

As the MARCLAIMED solution is not defined as a product, but rather a development project, a methodology to be applied to the users of the pilot sites is proposed. In this way, the following issues will be presented to the users in the areas where the MARCLAIMED tools have been applied:

The evaluation of the relative importance of MARCLAIMED functions is recommended to be carried out through an internal, structured and efficient scoring process:

The main function lists of each MARCLAIMED tool, previously identified in this document, would be used as a basis for the evaluation.

A project development team meeting would be convened, which would include key researchers and technical experts involved in MARCLAIMED.

During the session, each team member would individually evaluate each function, assigning it a score on a scale of 1 to 5, where:

1 = Not important 2 = Slightly important 3 = Moderately important 4 = Very important 5 = Critical

After the individual evaluation, the average score for each function would be calculated, providing a collective view of its relative importance. Functions would be classified from highest to lowest score, creating a clear hierarchy of priorities.

The functions with the highest scores would be identified, which would be considered critical and prioritized in the early stages of development.

This method would allow a systematic and consensual evaluation of the importance of each function, facilitating an efficient allocation of resources and a strategic focus on the development of MARCLAIMED.

That is, for each identified function, an assessment of its relative importance will be carried out based on:

- Feedback from potential users and experts in the field.
- Analysis of market needs identified in previous studies.
- Alignment with the general objectives of the MARCLAIMED project.

Identification of areas for improvement:

Once the relative importance assessment has been carried out, areas where functions can be improved or simplified would be identified in pursuit of optimizing the MARCLAIMED tool and its 6 associated sub-tools. Based on discussions with the tool developers and the market analysis, the areas of improvement as described in Table 21 are identified.

Table 21. Identification of areas for improvement of the 6 tools, as well as MARCLAIMED ISDT.

Tool	Identification of areas for improvement:
MARVIS	• Possibility of expanding the range of contaminants detectable in real time. • Improvement of accuracy in the detection of emerging contaminants. • Development of more robust algorithms to identify false positives due to measurement errors.
PREDMAR	• Incorporation of climate change data to improve long-term predictions. • Optimization of AI models to handle scenarios of extreme events, which are more difficult to predict due to their randomness. • Integration of land use data for more accurate predictions.
MARAISER	• Development of specific models for different types of aquifers and geological and hydrogeological conditions. • Improvement of energy efficiency in recharge operations. • Incorporation of ecological impact analyses into recharge strategies.

Tool	Identification of areas for improvement:
OASIS FLOW	• Expansion of the tool's analysis scale to include complete watersheds, including cross-border ones. • Integration of remote sensing data to improve the accuracy of water footprint calculations.
MARINSURE	• Incorporation of risk models that can predict extreme climatic events. • Improvement of the user interface to facilitate the interpretation of complex economic analyses
RECOVER	• Improvement in the accuracy of cost recovery scenario analyses. • Expansion of the comparative analysis capabilities of tariff structures between different regions or countries. • Optimization of communication tools to explain tariff changes to end users more effectively and simply.
MARCLAIMED IDST	• Improvement of interoperability with external water management systems. • Development of machine learning capabilities to improve the accuracy of recommendations over time. • Implementation of an intuitive and customizable data visualization system.

This function analysis will provide a solid basis for the following stages of the value engineering study, allowing for a more precise focus on the development and optimization of MARCLAIMED.

2. Cost Analysis

This section functions as an introduction for the rationale for cost analysis. It is expected that the tool developers consider this, and estimate cost more precisely.

It is recommended to carry out, in more advanced stages of the MARCLAIMED project, a detailed cost analysis fundamental within the development of a Business Model, which includes both capital expenses (CAPEX) and operating expenses (OPEX) of each tool and also of MARCLAIMED IDST.

This process is crucial to optimize the cost-benefit ratio of each tool. It is suggested, in future stages of tool development, when there is more feedback and final data from the pilots, to evaluate the development and initial implementation costs (CAPEX), as well as the maintenance, upgrade, and continuous operation costs (OPEX) of each tool.

It would be advisable to identify areas where these expenses could potentially be reduced without compromising functionality. Likewise, it is recommended to make an estimate of the return on investment (ROI) for each proposed tool, which would allow prioritizing the development of those functions that offer the greatest value in relation to their total cost over the life cycle of the project.

This analysis could be fundamental to ensure the long-term economic viability and competitiveness of MARCLAIMED in the water management market.

3. Creative phase: Generation of alternative ideas

It is recommended that, in later stages of MARCLAIMED's development, time is allocated to the generation of creative ideas. In this phase, it would be advisable to assemble a multidisciplinary team that includes experts in hydrogeology, interface design, developers and water resource management.

It is suggested to use techniques such as brainstorming and analysis of the data obtained thanks to the experience of the three pilot sites, to explore approaches or points of improvement.

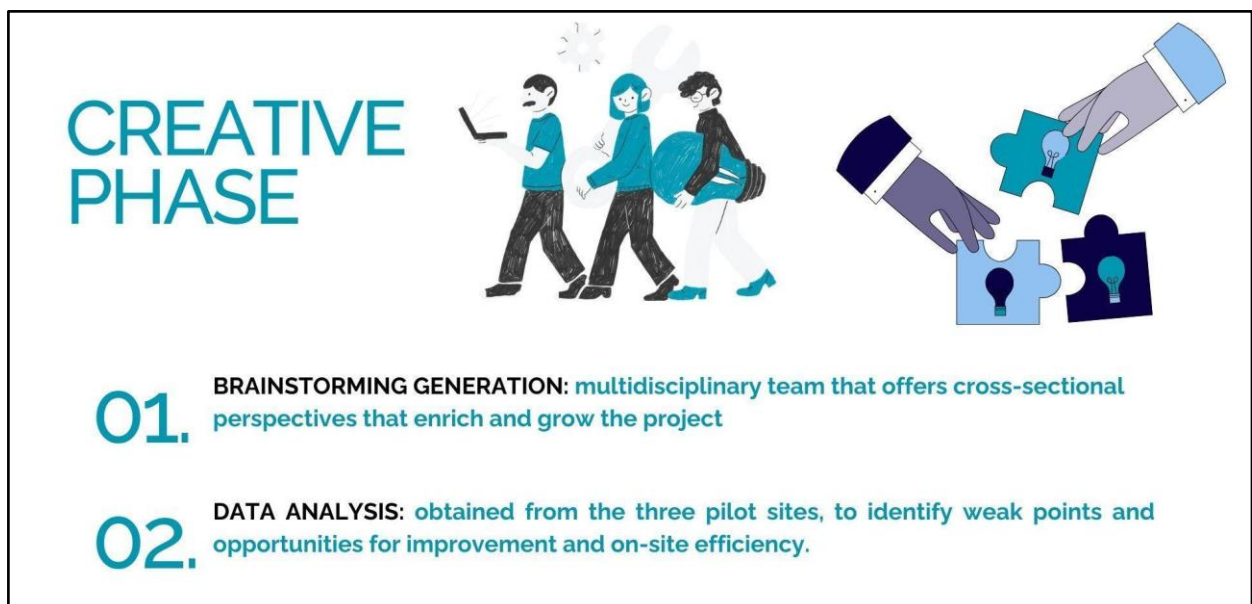


Figure 20 Outline of the creative phase and alternative generation of ideas

The objective would be to generate a wide spectrum of ideas that could potentially improve the performance, usability or scope of MARCLAIMED.

4. Evaluation phase (viability): Analysis of proposed alternatives.

In this phase, it would be advisable to carry out an evaluation of the alternatives that have been generated in the previous sections. At this stage, it is recommended that a multidisciplinary team analyze the technical, economic, and operational feasibility of each proposal.

It is suggested to use quantitative evaluation methods, such as cost-benefit analysis or weighted decision matrices, to compare alternatives in a measurable way. Likewise, it would be important to consider factors such as the scalability of the proposals, compatibility-interoperability with existing systems, and potential for adoption by end users. This phase should culminate with a prioritized list of viable alternatives for each component of MARCLAIMED.

5. Development Phase: Refinement of the best alternatives.

For the development phase, it is recommended to select the most promising alternatives identified in the previous evaluation phase. It is suggested that the development team work on refining these ideas, to provide greater robustness to the final tools. It would be important to carry out iterative tests, that is, to validate the functionality and usability of the solutions.

In this case, at the discretion of the technical team and specialists of each tool, if the results and data obtained at the pilot sites are considered sufficient, the application of functionality tests would not be necessary.

In this phase, it is recommended, if it has not yet been done, the integration of the improved alternatives of the six tools (MARVIS, PREDMAR, MARAISER, OASIS FLOW, RECOVER and MARINSURE) under the unifying framework of the integrated tool MARCLAIMED.

This integration process is fundamental to ensure that the various components not only function optimally individually, but also operate synergistically as part of a cohesive system if possible. Special attention is advised to the interfaces between the different tools, ensuring a smooth data flow and a consistent user experience as a MARCLAIMED solution.

The objective should be to optimize each chosen alternative to maximize its value and minimize implementation risks.

6. Presentation phase (implementation): Proposal of recommendations.

In the final phase, it is recommended to prepare a small meeting where the developed alternatives for each tool are discussed and the chosen path is explained, detailing which ideas have been discarded and which have been decided to implement. Including a description of each proposed solution, its expected benefits, the estimated implementation costs, and any necessary changes in existing processes or infrastructures is advised.

Developing a phased implementation plan, prioritizing solutions that offer the most immediate impact is suggested. Additionally, it would be advisable to include strategies for change management and user training, if necessary.

The presentation should culminate with concrete recommendations for implementation, including a proposed timetable and the necessary resources. The final goal would be to provide decision-makers with all the necessary information to proceed with the implementation of improvements in MARCLAIMED.

3.1.6 SWOT / trend analysis

The SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) is a fundamental strategic tool to evaluate the current position in which the MARCLAIMED tool is located, and future potential in the water resource management market.

This analysis allows the identification of internal factors, defining strengths and weaknesses that characterize the technology, and external factors, specifically opportunities and threats. This latter group analyzes more in-depth non-intrinsic factors to the tool, but when analyzed correctly can influence the development and implementation of the MARCLAIMED solution in the market.

Thus, through this evaluation, a general and clear vision of the competitive advantages and added value of MARCLAIMED, the challenges it faces, can be obtained, which will help locate areas of improvement that enhance its expansion and implementation in the market. This information will be very useful to define effective strategies that maximize strengths and opportunities while considering the weaknesses and threats of the environment.

The SWOT analyses of the various tools that make up the solution, as well as one of the MARCLAIMED technology itself, are presented in the following Tables 22 to 28.

Table 22. SWOT Analysis of MARVIS.

Tool	Strengths	Weaknesses	Opportunities	Threats
MARVIS	Real-time detection of nitrates using virtual sensors	It depends on the quality of historical data to function properly	Expansion to be able to analyze more groups of contaminants	Competition from established projects such as EMERITUS, WQeMS, and PATHOCERT
	Using advanced deep learning techniques for inferred detection of other contaminants	Need for continuous data validation as opposed to in-situ parameter measurements	Potential to reduce costs of traditional monitoring	Emergence of new pollutants not considered in the initial model
	Ability to integrate with other MARCLAIMED tools	Possible limitation on nitrate measurement	Growing demand for real-time water quality monitoring and control	Changes in regulations that may require adjustments to detection parameters
	Ability to provide early warning risk indicators	Complexity in interpreting results for non-expert users Need for robust data infrastructure for proper analysis	It can be applied in various industrial sectors	

Table 23. SWOT Analysis of PREDMAR

Tool	Strengths	Weaknesses	Opportunities	Threats
PREDMAR	Short-term (3-6 months) and long-term (decades) prediction of water resources	Complexity in integrating multiple models and data sources	Growing need for water planning in the face of climate change	Competition from projects such as PRIMA GOTHAM, MAR2PROTECT, ICARIA
	Integration of climate, hydrological and demographic models	Reliance on accurate historical data and climate projections	Potential to inform long-term water management policies	Associated uncertainty in long-term climate projections
	Adaptability and functioning in different contexts (demonstrated in ES, PT, NL)	Possible variability in accuracy between different regions	Applicability in various sectors (agriculture, urban planning, etc.)	Possible changes in water management policies that affect their relevance
	Ability to analyze climate change scenarios	Need for expertise to interpret and apply the results	Demand for tools for water risk management	Challenges in adoption due to perceived complexity
	Integration with other MARCLAIMED tools	Possible underestimation of extreme events	Potential for improving water resilience in vulnerable regions	Competition from simpler or more specific solutions for local contexts

Table 24. SWOT Analysis of MARAISER

Tool	Strengths	Weaknesses	Opportunities	Threats
MARAISER	Short- and long-term optimization of MAR systems	Complexity in implementing and maintaining the system	Growing demand for optimization in MAR systems	Competition from projects such as MARSOL, QUEEN, LIFE MATRIX
	Integration of multiple data sources (MARVIS, PREDMAR)	Need for customization for different regulatory contexts	Potential to improve operational efficiency and sustainability of MAR	Changes in regulations that may require significant adjustments
	Generation of early warnings and operational recommendations	Dependence on the accuracy of other tools (MARVIS, PREDMAR)	Applicability in regions with increasing water stress	Challenges in adoption by smaller organizations or those with limited resources
	Focus on aquifer efficiency and health	Possible complexity in the user interface	Growing interest in proactive water resource management	Uncertainty in data availability in some regions
	Capacity for environmental and health risk analysis	Need for continuous and accurate data for optimal operation	Potential to reduce long-term operating costs	

Table 25. SWOT Analysis of OASIS FLOW

Tool	Strengths	Weaknesses	Opportunities	Threats
OASIS FLOW	Comprehensive assessment of water impact at municipal level	High dependence on accurate and up-to-date local data	Growing interest in assessing the water footprint at municipal level	Competition from projects such as QUEEN, HH TERRITORIAL, ZOET OP SOUT
	Consideration of multiple criteria (supply, demand, economics, social aspects)		Applicability in sustainable urban planning	
	Capacity to simulate future scenarios	Complexity in integrating multiple factors at the municipal scale	Potential to contribute to achieving sustainable development goals	Possible changes in standard water footprint calculation methodologies
	Evaluation of the impact of MAR on the municipal water footprint	Possible difficulty in interpreting results for non-expert users	Demand for tools for sustainable water management in cities	Variability in data availability and quality at municipal level
	Integration with other tools of the MARCLAIMED system	Possible complexity in customizing for different municipal contexts		Challenges in adoption by smaller or resource-limited municipalities

Table 26. SWOT Analysis of MARINSURE

Tool	Strengths	Weaknesses	Opportunities	Threats
MARINSURE	Evaluation of the economic value of water stored by MAR	High complexity that may hinder its use and interpretation	Growing interest in the economic valuation of water and water risk management.	Project competition such as PRIMA TALANOVA-WATER, TRANSCEND
	Integration of micro and macroeconomic socioeconomic models.	Need for economic expertise for the interpretation of results.	Potential to inform investment decisions in MAR projects based on modeling of different scenarios (with MAR, without MAR).	Uncertainty in future economic scenarios, especially in the long term.
	Forecasting ability for uncertain future scenarios.	Dependence on accurate and up-to-date economic and risk data.	Applicability in the planning of economic policies related to water	Possible resistance to detailed financial analysis of water resources in some contexts or areas according to the problem.
	Develop a solid foundation that promotes secure investment, backed by accurate financial data from MAR projects, thus encouraging efficient and sustainable water management	Possible difficulty in communicating results to non-specialized stakeholders.	Demand for tools to assess the economic viability of water projects.	Volatility in economic markets that may affect projections
	Consideration and financial validation of multiple economic and climatic scenarios (applying MAR with AWR, without applying MAR)	Frequent need for updating economic models	Potential to improve the sustainability and financial planning of projects related to water management	Changes in economic policies that may affect the validity of the models

Table 27. SWOT Analysis of RECOVER.

Tool	Strengths	Weaknesses	Opportunities	Threats
RECOVER	Focus on the recovery of costs and economic sustainability of MAR.	Complexity in homogenizing and determining optimal rates that balance all factors to consider in each specific project.	Growing need in the market for sustainable water financing models	Limited but existing competence (e.g. EFINET project)
	Integration of multiple factors for rate design	Possible resistance to changes in existing tariff structures	Potential to improve the economic sustainability of MAR projects	Changes in government water pricing policies
	Based on global best practices for cost recovery	Dependence on accurate and updated economic and consumption data	Applicability in water pricing policy reform	Challenges in public acceptance of new tariff structures
	Consideration of future scenarios in tariff design	Possible complexity in adapting to different regulatory contexts	Demand for tools for sustainable financial management of water	Economic fluctuations that may affect the payment capacity of users
	Integration capability with other MARCLAIMED tools.	Need to balance cost recovery with water accessibility	Potential to inform more equitable and efficient water management policies	Political pressure to keep water prices low, regardless of the actual costs.

Table 28. SWOT Analysis of MARCLAIMED

Tool	Strengths	Weaknesses	Opportunities	Threats
MARCLAIMED IDST	Holistic approach that integrates technical, economic and environmental aspects of water resources management	High complexity of the integrated system that may make its implementation and use difficult	Growing global demand for integrated solutions for sustainable water resources management	Competition for simpler or more specific individual solutions that may be preferred for their ease of implementation
	Complete suite of advanced and interconnected tools	Need for multidisciplinary expertise for effective implementation and operation of the system	Rising concern about water scarcity and the need to optimize the use of alternative water resources	Rapid technological evolution that could render some tools or approaches obsolete
	It allows water managers and planners to identify areas of water stress and facilitates informed decision-making on where to implement MAR and AWR strategies.	Dependence on large volumes of diverse and accurate data for optimal functioning of all tools	Potential to set a new standard in advanced MAR management with AWR	Changes in water management regulations and policies that could affect the relevance or applicability of certain tools
	Adaptability to different contexts and scales (municipal, regional, national)	Possible steep learning curve for end users due to sophistication of tools		
	Integration of short and long-term analysis, allowing both operational management and strategic planning			
	Helps determine where MAR techniques could be most beneficial and necessary and identify priority areas of action	Potential difficulty in integrating all tools into a cohesive and easy-to-use system	Alignment with sustainable development goals and climate change adaptation policies	Challenges in adoption due to perceived complexity and initial implementation costs

4.0 CONCLUSIONS

By preparing the market and competition analysis in Europe, we have tried to answer the question of whether there is unsatisfied demand, and to assess whether MARCLAIMED will be accepted and will provide added value to the target audience.

In order to try to provide a response to this need, a detailed analysis has been carried out of the aspects that are considered to have a direct impact on the implementation of MAR with AWR and all the tools that are applied.

It is worth noting that the tools that make up MARCLAIMED are still in the development process, so their final functionality may be modified, which could fully affect the market analysis and require a review of the information.

Firstly, aspects of a more generic nature have been analysed.

The specific regulations and restrictions for applying AWR in MAR, have been analyzed both at European level and at national level (in the case of the three countries where the demo sites are being applied: Spain, Portugal and the Netherlands). The main regulations that govern it are the **Water Framework Directive (2000/60/EC)** and the **Groundwater Directive (2006/118/EC)**. It should also be noted that each country has a series of specific regulations that best fit its conditions and needs.

The areas with the greatest possibility of applying AWR have been studied from a point of view of availability or need for the resource, water quality, and the distance between the generation and the application of AWR. In the first case, the application of MAR may be more interesting in areas that have overexploited aquifers that should be re-fed, aquifers that show a progressive degradation of water quality or aquifers where water supply shows an important seasonal variation, among others. Regarding the quality of the water applied, this depends on the regulations that govern each country, although it is worth highlighting the regulations established by the WHO at an international level. Finally, the distance between the point of generation and application of AWR will depend on several factors, such as the initial quality of the water, the hydrogeological characteristics of the recharged aquifer, dissolution and precipitation processes, or resilience time, among others, which will define bigger or shorter distances.

As regards the quantity of water that may be required by each user, this will depend on their needs but above all on the capacity of the environment. Both the current demand and the future forecast, the possible seasonality of said demand, or the analysis of the water balance of the aquifer to evaluate its impact, among many other factors, must be considered.

Once the most general aspects have been contextualized, we have entered into detail into those elements that are considered key to carrying out a market analysis:

- Current market overview
- Analysis of existing players
- Final target market and market adoption perspective
- Competitiveness of the solution from a customer point of view
- Value engineering study for the proposed technology
- SWOT

The current market overview shows us that applying MAR with AWR technologies is growing rapidly in recent years, as can be seen in the following figure:

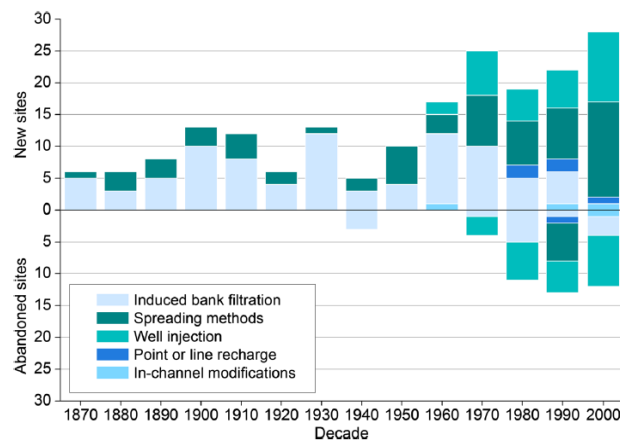


Figure 21 Outline of the historical development of MAR in Europe showing the number of MAR sites opened or closed per decade between the 1870s and 2000s. Retrieved from <https://doi.org/10.1007/s10040-017-1554-8>

Specifically, there are countries where this technology is widely implemented, especially in Central and Northern Europe, while in many others it still has a very scarce or even non-existent use.

However, if the water supply from MAR is compared with that from other conventional or alternative systems, the percentages are still relatively low, so it is considered that there is still work to be done, especially from the point of view of public acceptance.

As regards the analysis of existing players, which has been carried out for each of the developed tools, it varies according to their applicability. For some of them, especially those related to operational efficiency (MARVIS, PREDMAR and MARAISER), competition is high or relatively high, so working on possible improvements that provide a qualitative leap can guarantee a better entry into the market. On the other hand, in the economic sustainability tools (OASIS FLOW, MARINSURE and RECOVER) the market is more limited or even almost

non-existent at the level of detail with which they work, according to the information shared with the various partners involved, so their entry into the market can provide a quicker response to a need that is currently less covered, and gives the opportunity to work on improvements in the future.

Some of the existing players evaluated are shown in the table below, classified as if they are direct or indirect competitors:

Table 29 Classification of existing players in terms of their relation with MARCLAIMED.

Tool	Direct competitor		Indirect competitor	
	Use	Country	Use	Country
MARVIS (RES 1)	EMERITUS	WQeMS PATHOCERT AQUIFER PROJECT	WQeMS PATHOCERT AQUIFER PROJECT	EMERITUS
PREDMAR (RES 2)	PRIMA.GREEMAR ICARIA AQUIGROW	PRIMA GOTHAM MAR2PROTECT PRIMA.GREEMAR ICARIA AQUIFER PROJECT AQUIGROW	PRIMA GOTHAM MAR2PROTECT AQUIFER PROJECT MAIA	MAIA
MARAISER (RES 3)	MARSOL QUEEN LIFE MATRIX	MARSOL LIFE MATRIX MAR2PROTECT AQUIFER PROJECT	MAR2PROTECT MARsoluT AQUIFER PROJECT	QUEEN MARsoluT
OASIS FLOW (RES 4)	QUEEN HH TERRITORIAL	ZOET PO SOUT	ZOET PO SOUT	QUEEN HH TERRITORIAL
MARINSURE (RES 5)	PRIMA TALANOA TRANSCEND	PRIMA TALANOA TRANSCEND		
RECOVER (RES 6)	EFINET			EFINET

Regarding the final target market and market adoption perspective, this has been analyzed taking into account two key segments where the solution provides added value: Type of management entity and geographic.

From the point of view of the type of entity, the following have been analyzed: Water Management Authorities (Agencies), Water Utility Companies, Agricultural and irrigation companies, Industries and engineering consultancies, among others.

As far as geographic location is concerned, it is worth highlighting those regions with severe water stress, coastal areas at risk of saltwater intrusion, intensive agricultural zones, rapidly growing urban areas or drought-prone regions, among others.

The following figure perfectly summarises which target market may be of greatest interest:



Figure 22 Final target market of MARCLAIMED

In a business model, the "Competitiveness of the solution from the customer's point of view" section should focus on how your product or service meets customer needs better than existing alternatives.

To this end, several key elements have been analyzed such as a unique value proposal, comparison with existing players, ease of use and application, customization and flexibility, innovation and continuous improvement, testimonies and success stories, sustainability and social responsibility and integration into existing ecosystems .

Regarding the value engineering study, the following analyses have been done:se han realizado los siguientes análisis:

1. Functional Analysis:
2. Cost Analysis
3. Creative Phase:

4. Evaluation Phase:
5. Development Phase:
6. Presentation Phase:

It is important to underline that the presented scheme constitutes a general and flexible recommendation. Given that this deliverable is framed in the initial stages of the MARCLAIMED project, it is foreseeable that, as it progresses, new perspectives and priorities may arise. Consequently, it is possible that in more advanced stages of the project, the team may decide to adapt, modify or even dispense with some of the suggested points. Likewise, new aspects not initially contemplated may emerge that require more focused attention to optimize the development of the final product. This flexibility in the application of recommendations is essential to ensure that MARCLAIMED evolves in the most efficient way possible, responding to the changing needs of the project and the criteria of the technicians specialized in the development of each tool. Value engineering study for the proposal technology.

The following is a summary of the SWOT analysis, simply highlighting the most important key concepts of each one.

MARVIS

Strengths: Real-time detection, Advanced deep learning techniques, Integration with other MARCLAIMED tools, Early warning risk indicators.

Weaknesses: Quality of historical data, Continuous data validation as, Limitation on nitrate measurement, Complexity in interpreting results, Robust data infrastructure.

Opportunities: More groups of contaminants, Reduce costs of traditional monitoring, Growing demand, Application in industrial sectors.

Threats: Competition with EMERITUS, WQeMS, and PATHOCERT, Emergence of new pollutants, Changes in regulations.

PREDMAR

Strengths: Short-term and long-term prediction, Integration of different models, Adaptability and functioning in different contexts, Analyze climate change scenarios, Integration with other MARCLAIMED tools.

Weaknesses: Complexity in data integration, Reliance on accurate historical data, Possible variability in accuracy, Need of expertise, Possible underestimation of extreme events.

Opportunities: Growing need for water planning, Potential to inform long-term water management policies, Applicability in various sectors, Demand for tools for water risk management, Potential for improving water resilience.

Threats: Competition with PRIMA GOTHAM, MAR2PROTECT, ICARIA, Uncertainty in long-term climate projections, Possible changes in water management policies, Challenges in adoption due to perceived complexity, Competition for local contexts.

MARAISER

Strengths: Short and long-term optimization, Integration of multiple data sources, Generation of early warnings, Aquifer efficiency and health, Environmental and health risk analysis.

Weaknesses: Complexity in implementing and maintaining, Need for customization, Dependence on the accuracy of other tools, Possible complexity in the user interface, Need for continuous and accurate data.

Opportunities: Growing demand, Potential to improve operational efficiency, Applicability in many regions, Growing interest, Potential to reduce long-term operating costs.

Threats: Competition with MARSOL, QUEEN, LIFE MATRIX, Changes in regulations, Challenges in adoption by smaller organizations, Uncertainty in data availability in some regions.

OASIS FLOW

Strengths: Comprehensive assessment, Consideration of multiple criteria, Capacity to simulate future scenarios, Evaluation on municipal water footprint, Integration with other tools of the MARCLAIMED system.

Weaknesses: High dependence on local data, Complexity in integrating multiple factors, Difficulty in interpreting results, Complexity in customizing.

Opportunities: Growing interest, Applicability in sustainable urban planning, Contribution to achieving sustainable development goals, Demand for tools for sustainable water management in cities.

Threats: Competition with QUEEN, HH TERRITORIAL, ZOET OP SOUT, Possible changes footprint calculation methodologies, Variability in data availability, Challenges in adoption.

MARINSURE

Strengths: Evaluation of the economic value of water, Integration of micro and macroeconomic models, Forecasting ability for uncertain future scenarios, Develop a solid

foundation that promotes secure investment, Consideration and financial validation of multiple economic and climatic scenarios.

Weaknesses: High complexity, Need for economic expertise, Dependence on accurate and up-to-date data, Difficulty in communicating results, Frequent need for updating economic models.

Opportunities: Growing interest, Potential to inform investment decisions in MAR projects, Applicability in the planning of economic policies, Demand for tools to assess the economic viability of water projects, Improve the sustainability and financial planning of projects.

Threats: Project competition with PRIMA TALANOVA-WATER, TRANSCEND, Uncertainty in future economic scenarios, Resistance to detailed financial analysis, Volatility in economic markets, Changes in economic policies.

RECOVER

Strengths: Recovery of costs, Integration of multiple factors, Based on global best practices, Consideration of future scenarios, Integration with other MARCLAIMED tools.

Weaknesses: Complexity in homogenizing and determining optimal rates, Resistance to changes, Dependence on accurate and updated data, Complexity in adapting to different regulatory contexts, Need to balance cost recovery.

Opportunities: Growing need in the market, Improve the economic sustainability, Applicability in water pricing policy reform, Demand for tools, Inform more equitable and efficient water management policies.

Threats: Limited but existing competence, Changes in government water pricing policies, Challenges in public acceptance, Economic fluctuations, Political pressure.

IDST

Strengths: Holistic approach, Complete suite of advanced and interconnected tools, Identify areas of water stress and facilitate informed decision-making, Adaptability to different contexts and scales, Integration of short and long-term analysis, Determine where MAR techniques could be most beneficial and necessary.

Weaknesses: High complexity of the integrated system, Multidisciplinary expertise for effective implementation and operation, Large volumes of diverse and accurate data, Steep learning curve for end users due, Difficulty in integrating all tools into a cohesive and easy-to-use system.

Opportunities: Growing global demand for integrated solutions, Rising concern about water scarcity, Potential to set a new standard in advanced MAR management with AWR, Alignment with sustainable development goals and climate change adaptation policies.

Threats: Competition for individual solutions, Rapid technological evolution, Changes in water management regulations and policies, Challenges in adoption due to perceived complexity and initial implementation costs.

To conclude the report, it should be noted that MAR technologies with AWR are currently a reality, although scarce in some sectors of Europe, but its use is expected to increase considerably in the coming years. That is why the development of MARCLAIMED tools will be a response to several of the needs of users of these systems, or even improvements to needs currently covered.

Water managers, public water authorities, industries with high water demands or farmers will be the main target clients, and its application will be of greater interest in those areas with a greater tendency to drought, with a propensity for water salinization, or with strong variations in the water table, among others.

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ANNEX: TITLE

Pellentesque molestie, justo sed ullamcorper tristique, libero nibh luctus ante, et accumsan enim lectus sed leo. In dictum, nisl a eleifend placerat, arcu nisl mattis turpis, et mollis erat odio nec augue. Sed porta erat in ultricies euismod. Mauris ut elit nisi. Cras metus elit, dictum vitae risus quis, placerat eleifend metus. Pellentesque vestibulum congue quam, eu porta nibh luctus non. Nullam sed leo et odio sollicitudin luctus ut vel tellus. Praesent feugiat sagittis turpis ut aliquam. Ut in libero aliquam, laoreet purus sed, mollis enim.

MARCLAIMED will support decision makers to integrate Managed Aquifer Recharge (MAR) with Alternative Water Resources (AWR) in River Basin and Drought Management Plans supporting the adaptation and resilience of structural supply systems in the context of climate change. The main outcome will be the MARCLAIMED Integrated Decision Support Tool (IDST) that will provide solutions to tackle existing and emerging threats and support decision making and adaptation policies.



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