

**Co-managed aquifer recharge (Co-MAR) concept.**  
 Groundwater users are bettering integrated water resources management in regards to improved designs, governance, rural development, and water security

*Demo-sites from Castile and Leon (Spain)*

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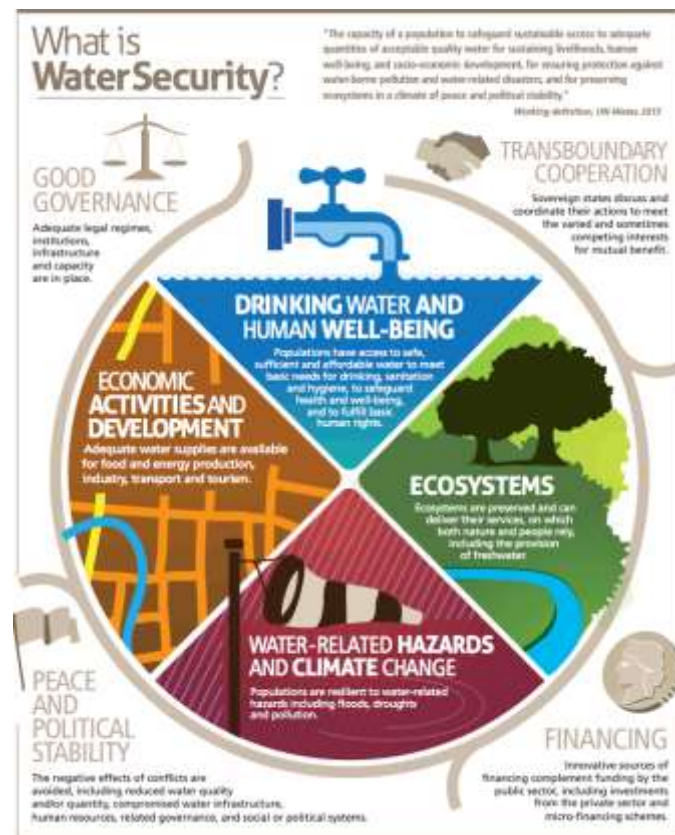
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Tehran, 2024 April 23th-24th



# Introduction

- ✓ **Managed Aquifer Recharge (MAR)** is a promising set of techniques to improve **IWRM** and cope a variety of water management-related issues.
- ✓ International **governance approach** is changing from a top-down to a **bottom-up approach**.
- ✓ The obligation (by law) of being organized in “water users associations” (CUAS) to negotiate with water authorities in Spain is creating “spaces of trust”, and driving to an innovative and more social decision making perception.
- ✓ The participation of end-users in decision making may improve IWRM, governance schemes, rural development, and water security.
- ✓ This presentation exposes some **IWRM advances** thanks to **GW user’s associations** and **Co-MAR application** in the central part of Spain



# Key issues addressed

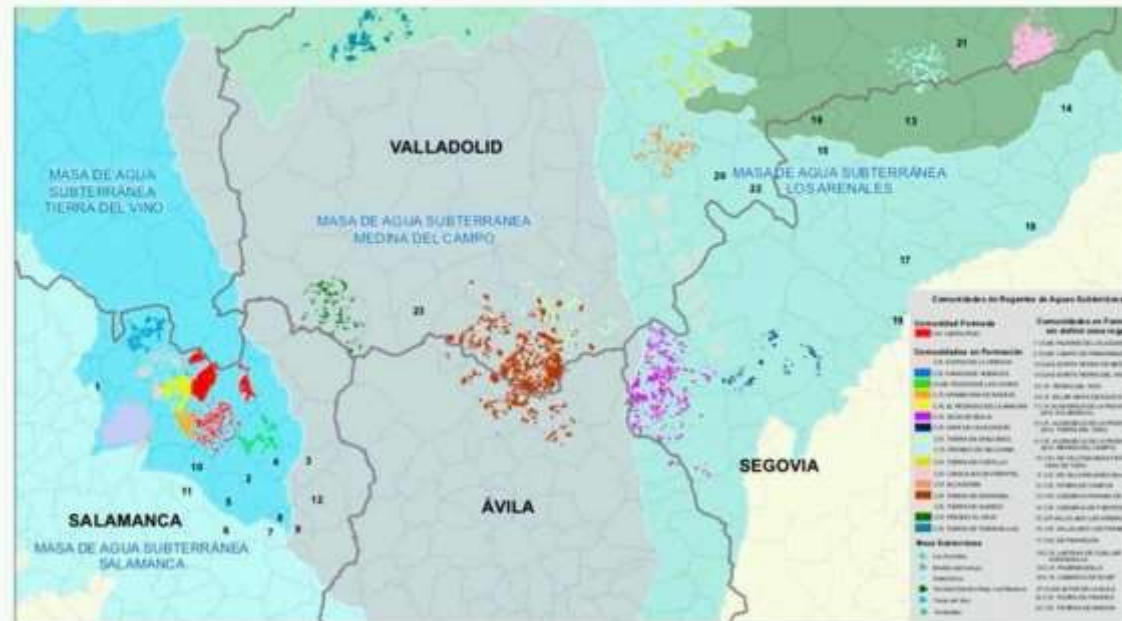
- ✓ **Public-Private People Partnership (PPPP\*)** enhances governance and water security.
- ✓ The **intervention of end-users in the Decision Support Systems (DSS) improves hard and soft management measures for IWRM.**
- ✓ **CUAS** in areas where Managed Aquifer Recharge (MAR) is applied **have introduced the concept Co-MAR.**
- ✓ **Spaces of trust are key** in these achievements.

*\*The term PPP in Spain refers to a collaboration to manage, in this case water resources, between the government or public authorities and private landowners. Occasionally private landowners intervene to build infrastructure under this arrangement*

## La CHD tramita la creación de 39 comunidades de usuarios de aguas subterráneas



Confederación Hidrográfica del Duero



- Dieciséis de ellas han presentado ya los estatutos para su constitución y han definido la superficie regable, que alcanza las 20.000 hectáreas en rotación.
- El objetivo de la Confederación es disponer, al menos, de una comunidad de usuario por cada masa de agua.

# Key concepts

- ✓ **Space of collaboration.** *Social environment created based in confidence for the fair use of (ground)water resources and organizational measures with a direct influence on groundwater quality.*
- ✓ **Collaborative Governance.** *'Governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is **formal, consensus-oriented, and deliberative** and that aims to make or implement **public policy** or manage public programs or assets'* (Ansell and Gash, 2008)
- ✓ **Managed Aquifer Recharge (MAR).** *Water management method that allows water to be introduced into underground aquifers. Once stored in these, it can be extracted for different uses ([DINA-MAR, 2011](#)).*
- ✓ **Co-Managed Aquifer Recharge (Co-MAR).** MAR system in which end-users participate in the decision making system related to their water resources thanks to the creation of an “environment of trust” (supported by law).



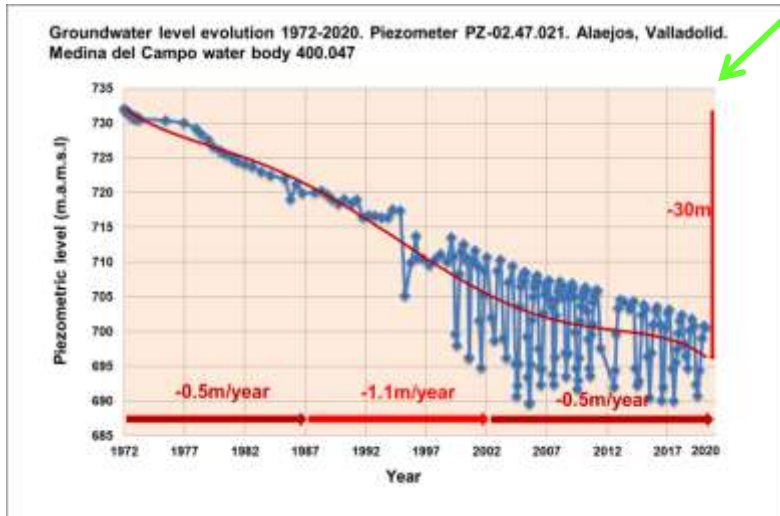
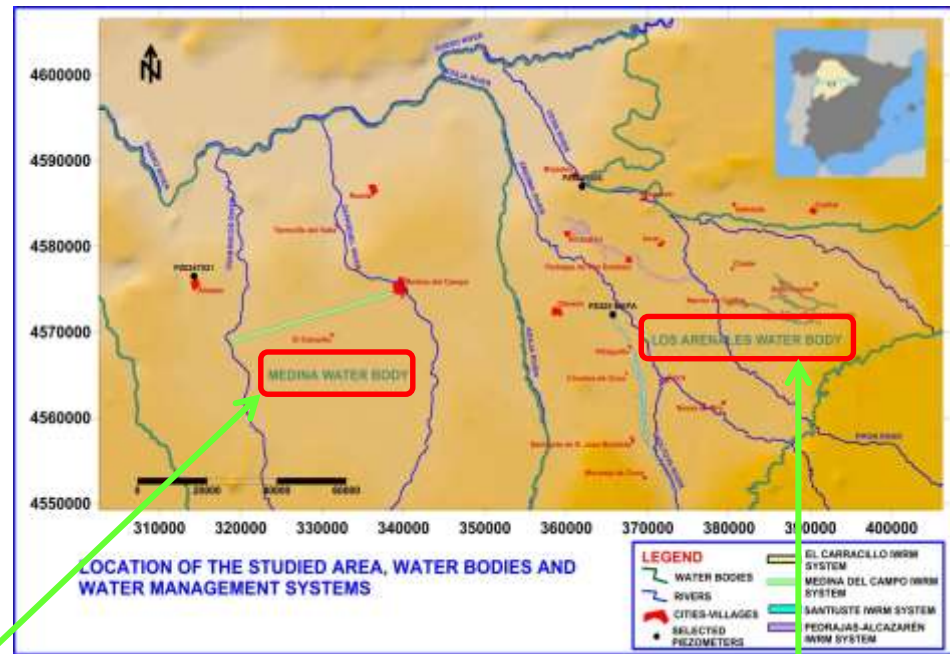
# Background (1/10)

## Intensive groundwater use cases in the Los Arenales aquifer, Castilla y León (Spain)

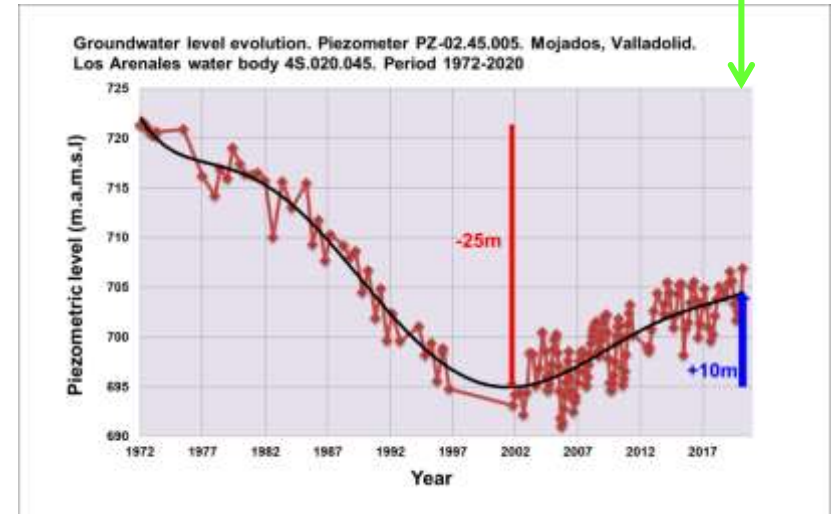
### Water Exploitation Index (WEI).

According to the Spanish Water Act, Art. 40, **each aquifer with a WEI exceeding 0.80 requires intervention by the Water Authorities:**

- ✓ WEI Los Arenales water body: 1.30
- ✓ WEI Medina del Campo water body: 1.65

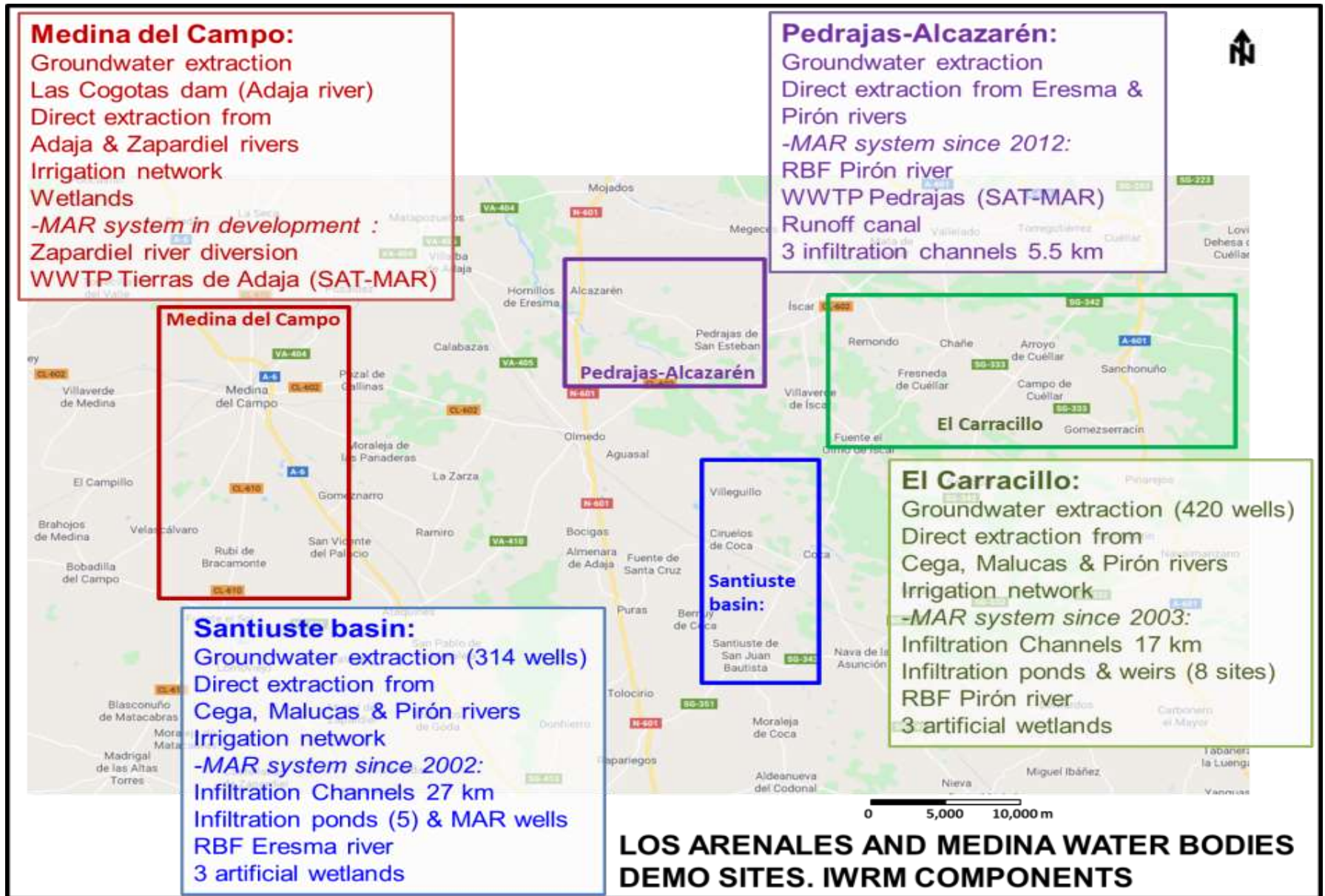


**Medina del Campo Groundwater Body (1975-2020)**  
MAR activities have still not been fully implemented  
Water table decline: -30 m

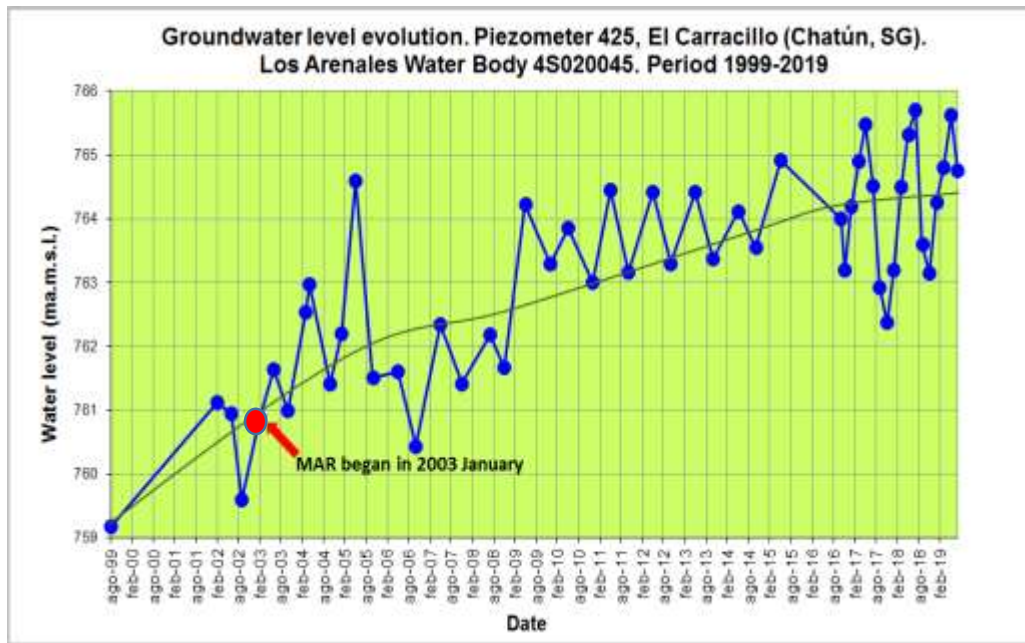


**Los Arenales.** Between 1972 and 2002, a 25 m groundwater decline was registered in the whole aquifer. In the last 18 years there has been a small recovery thanks to MAR, to -15 m (+10).

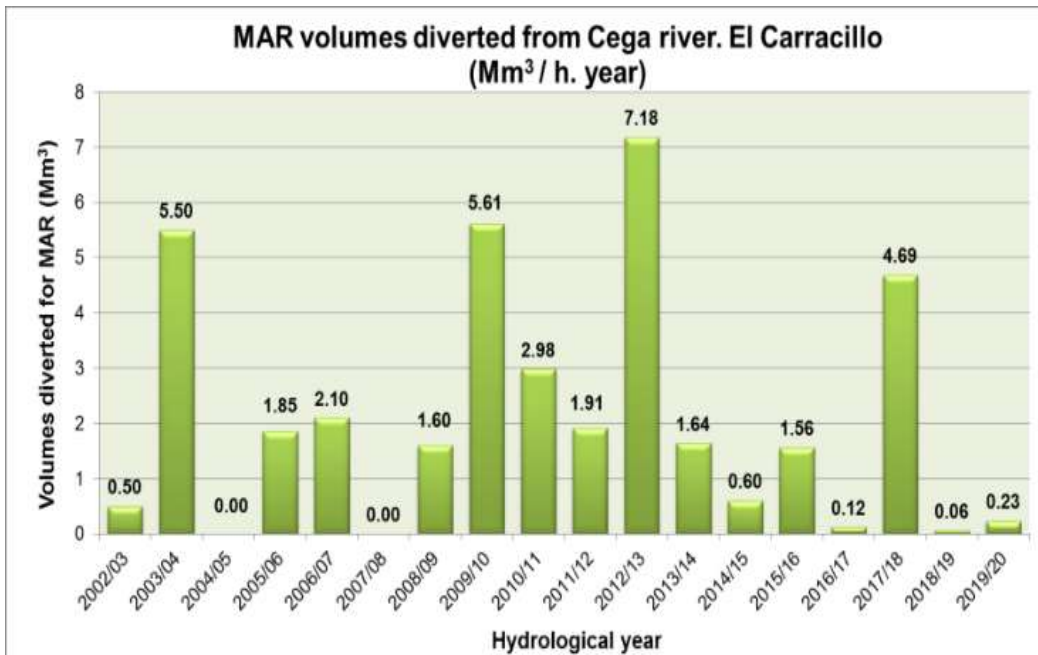
# Background (2)



Case study sites and their IWRM main components



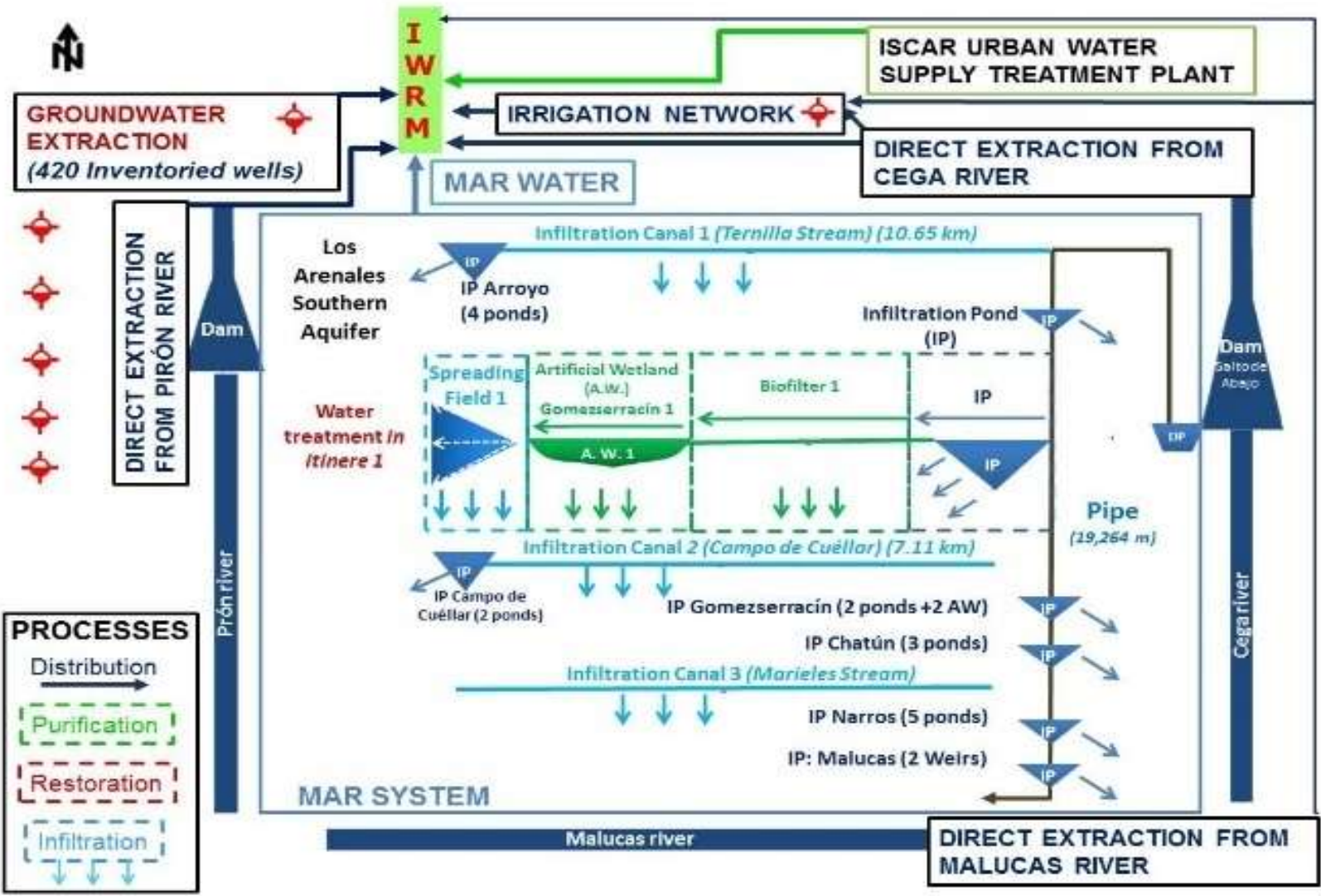
Evolution of the groundwater level in El Carracillo, piezometer MAPA-425 (Chatún) from 1999 to 2019. MAR began in 2003



El Carracillo. Contribution of MAR to the water balance (2003-2020)



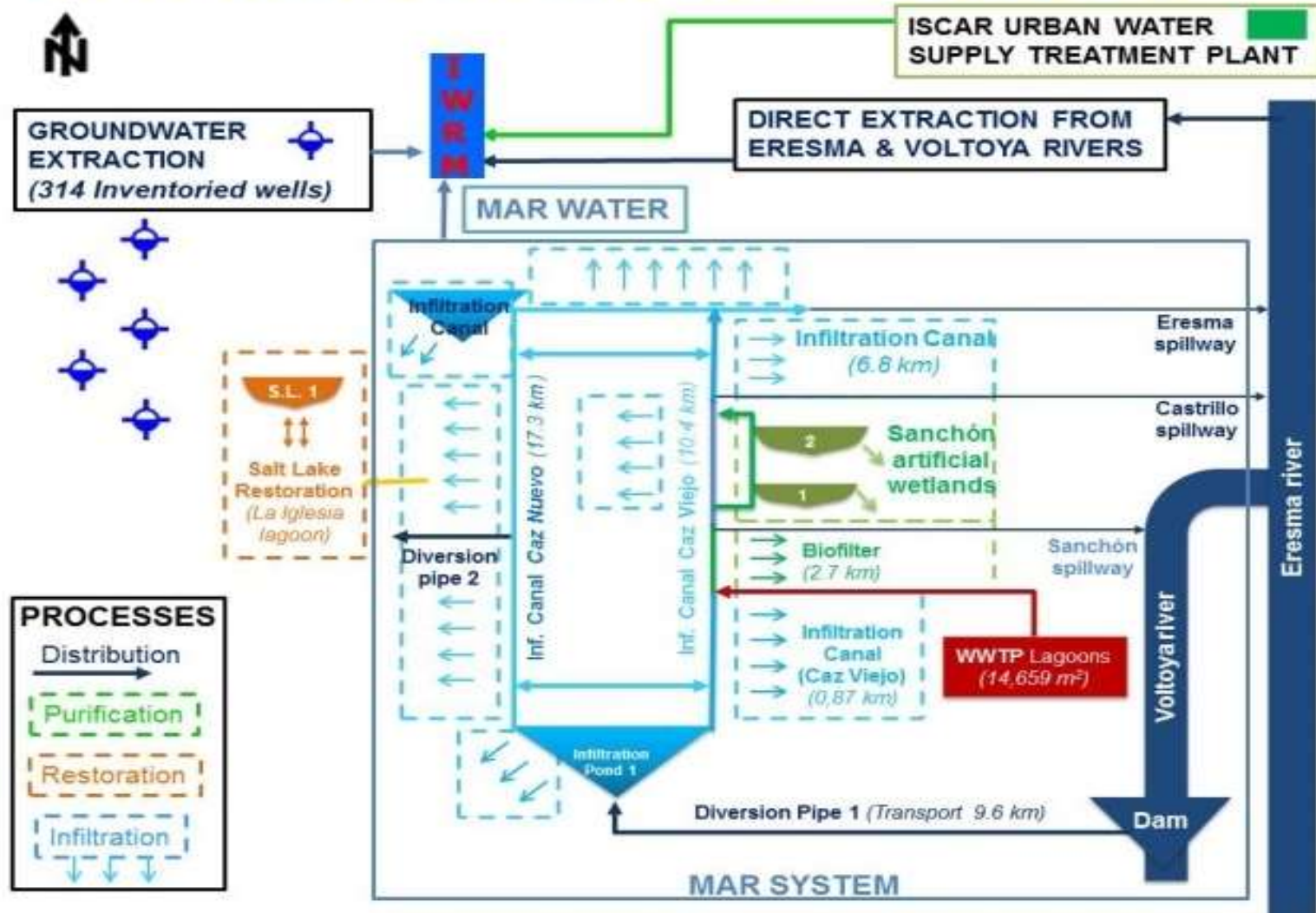
# EL CARRACILLO IWRM SKETCH



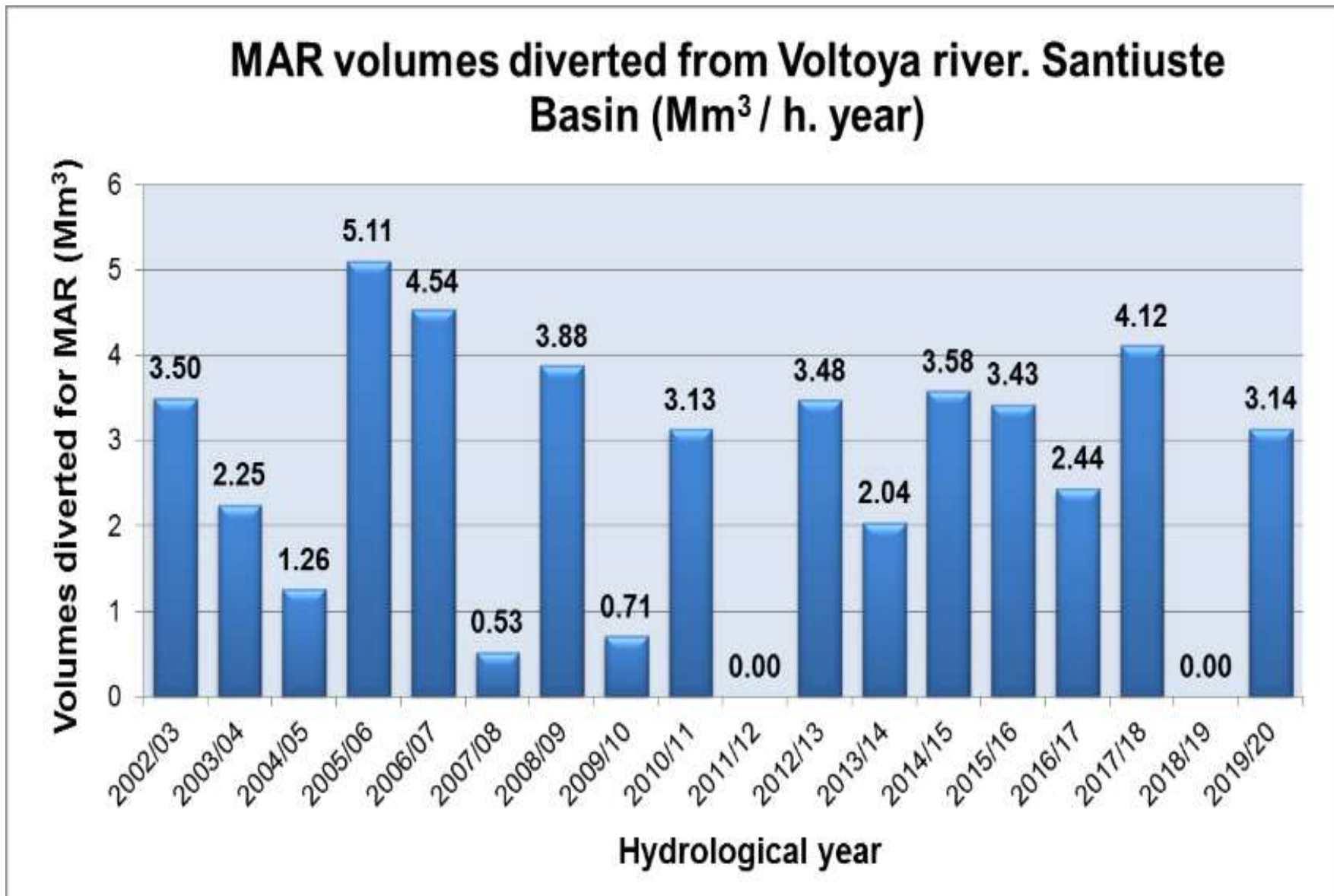
El Carracillo IWRM scheme



# SANTIUSTE BASIN IWRM SKETCH

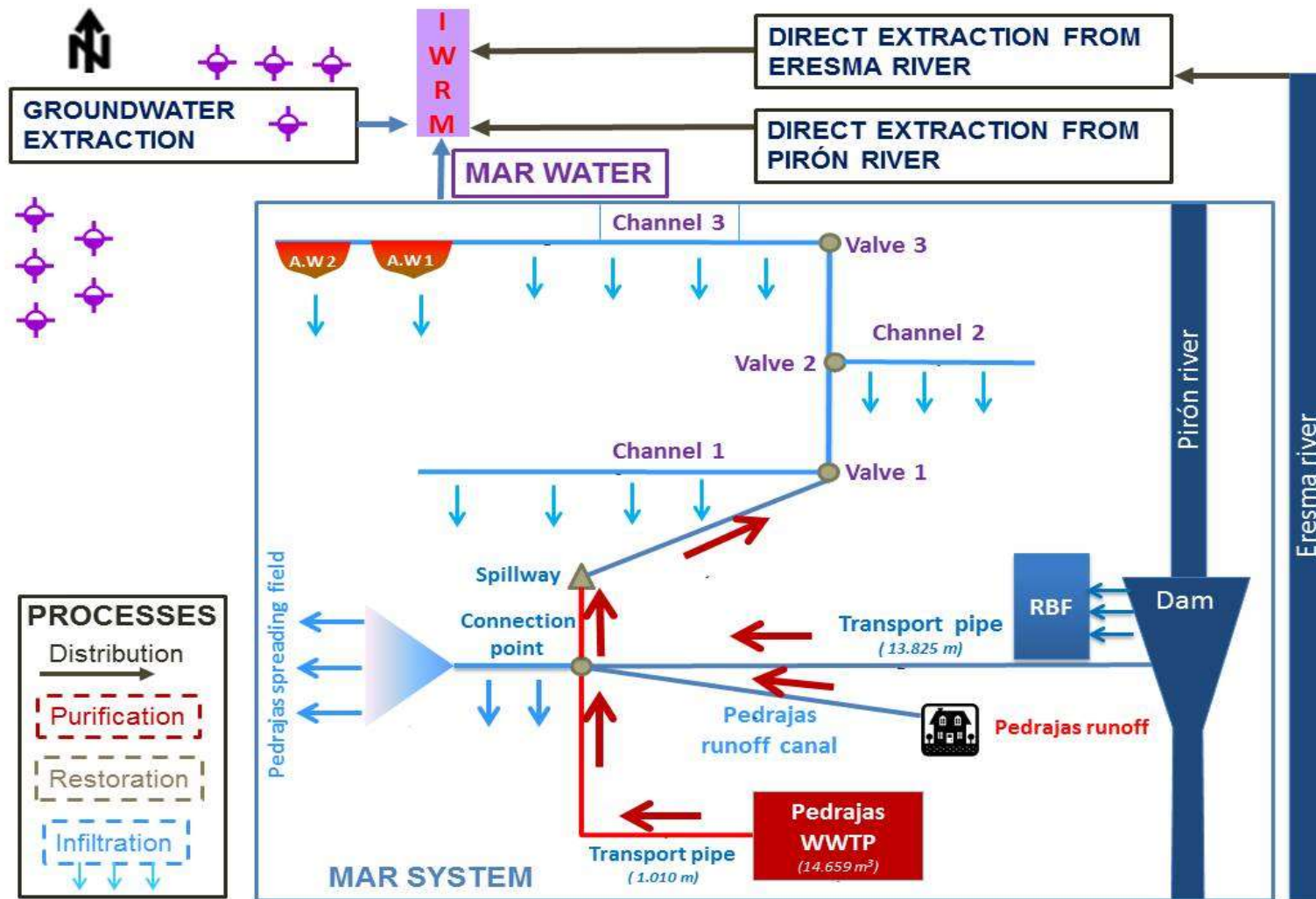


Cubeta de Santiuste IWRM scheme

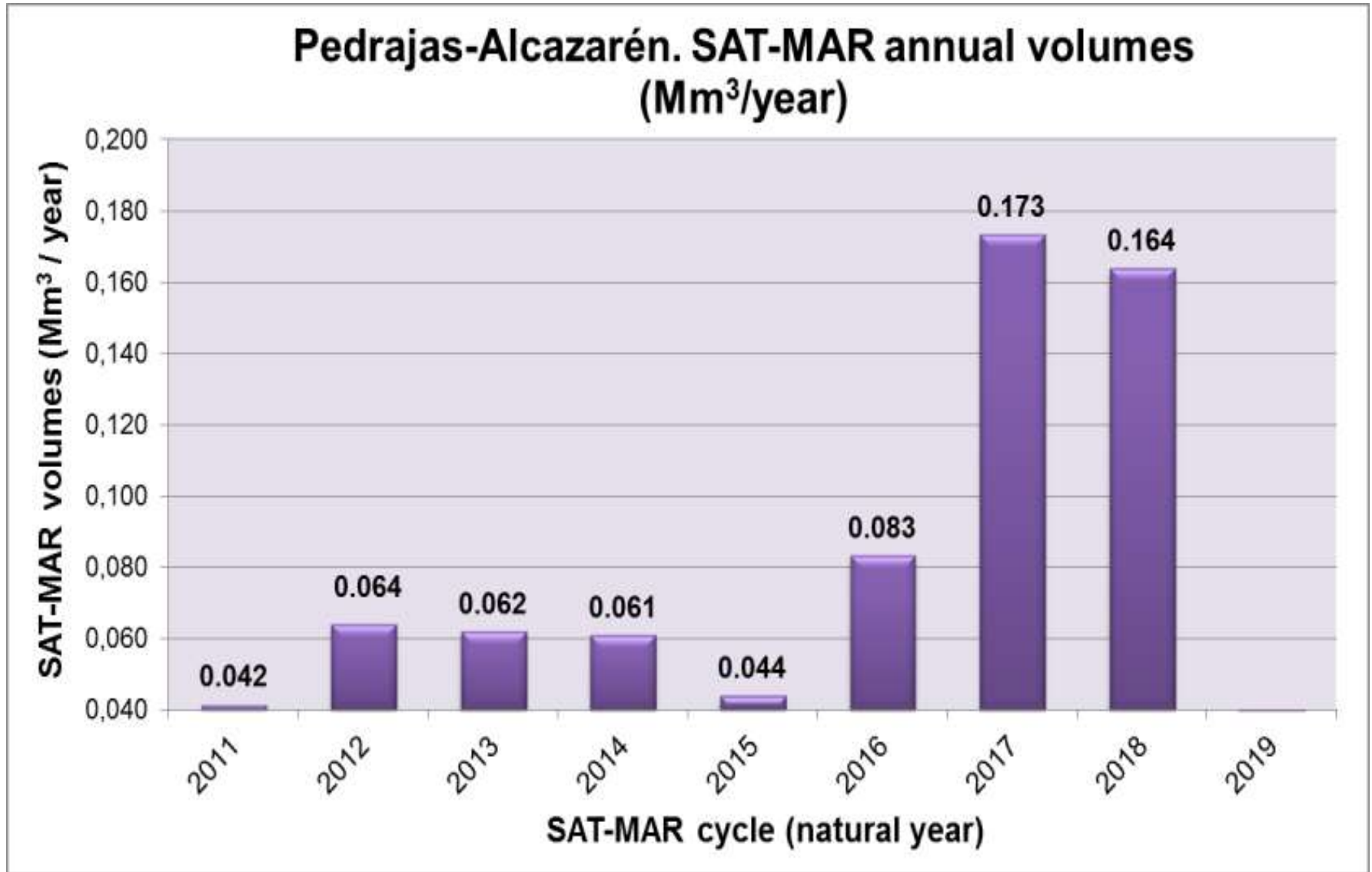


Cubeta de Santiuste. Contribution of MAR to the water balance (2002-2020)

# PEDRAJAS-ALCAZARÉN GENERAL SKETCH

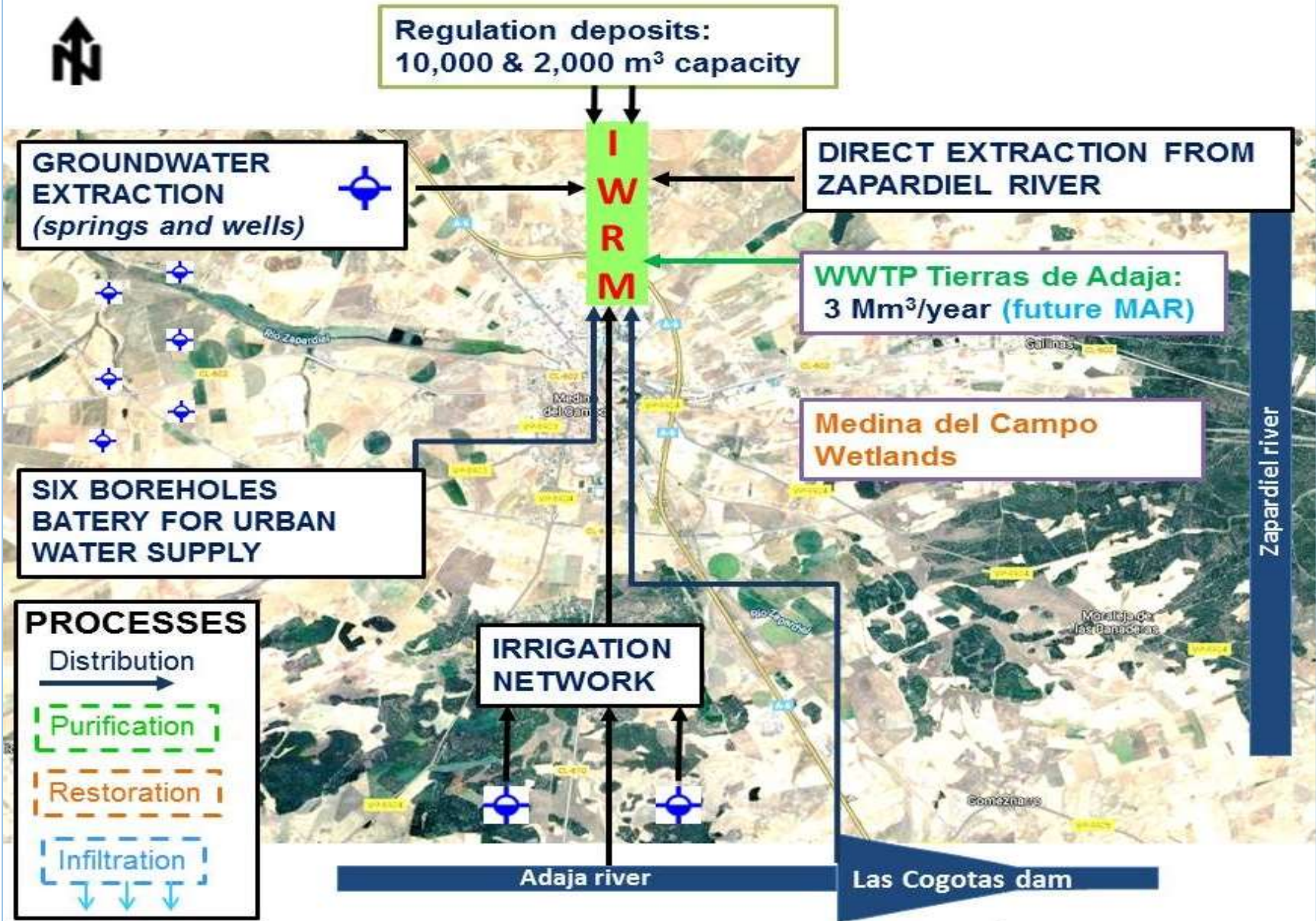


Pedrajas-Alcazarén IWRM scheme



Pedrajas-Alcazarén. contribution of the SAT-MAR system to the water balance (2011-2020)

# MEDINA DEL CAMPO IWRM SKETCH



# Background (10)

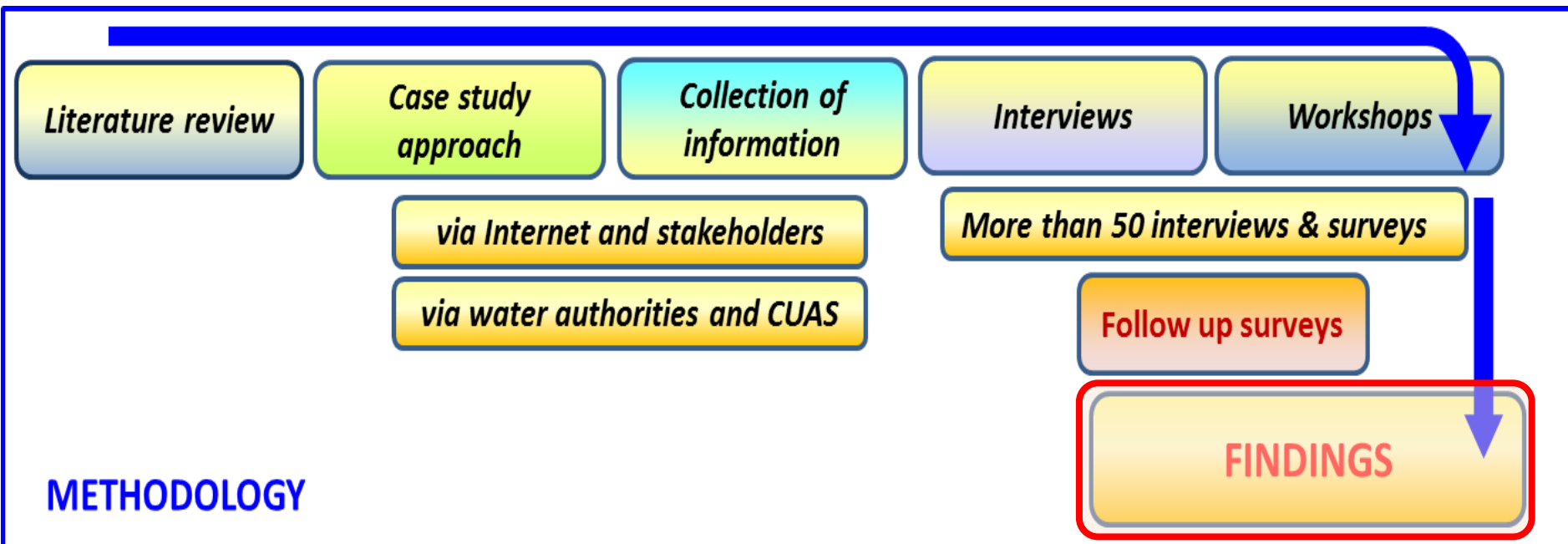


# Methodology (1/2)

- ✓ **MAR and CUAs serve as entry points** to understand the full system, including other IWRM measures
- ✓ The authors used combined a 4-stage method, consisting on literature review, case-study analyses, data treatment from more than 50 interviews/surveys, and five workshops in rural areas.



## Co-MAR methodological approach



# Methodology (2/2)

## Roles that stakeholders play in the decision-making process

Stakeholder management scheme:

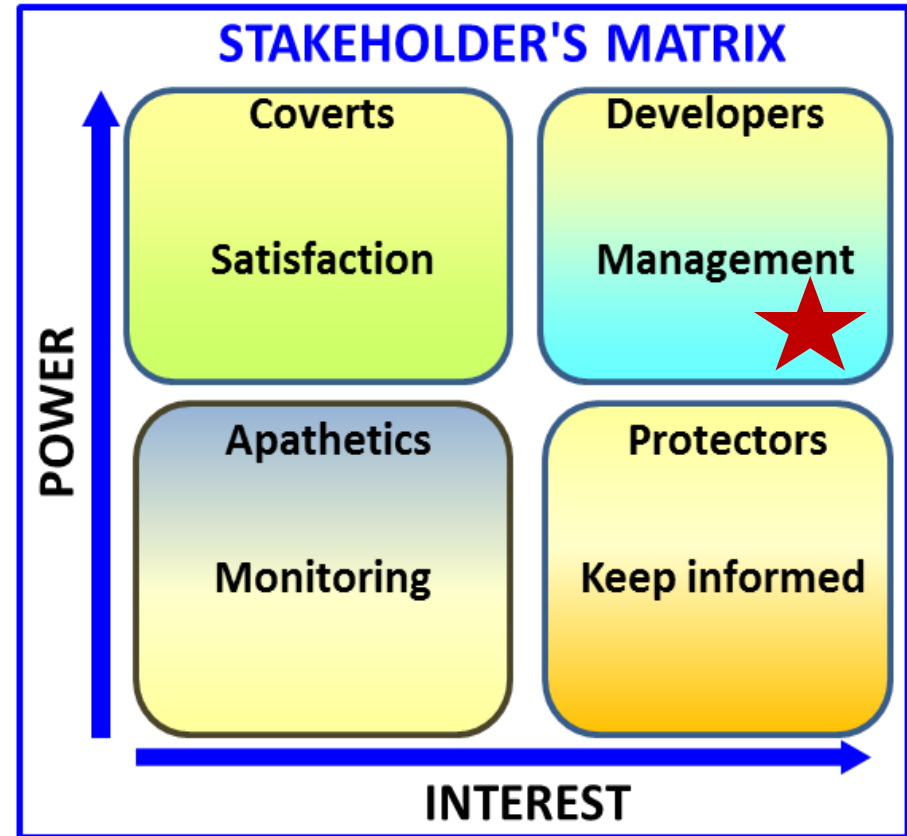
*Roles are shown at the top of each quadrant, and management approaches at each quadrant's center.*

-“Developers” are secondary stakeholders (e.g., CUAS) > decision support system > decision-making process.

-“Protectors”, have high interest but low individual power (farmers)

-“Apathetics”. Monitoring

-“Coverts”, e.g. farming trade unions, should be kept satisfied.



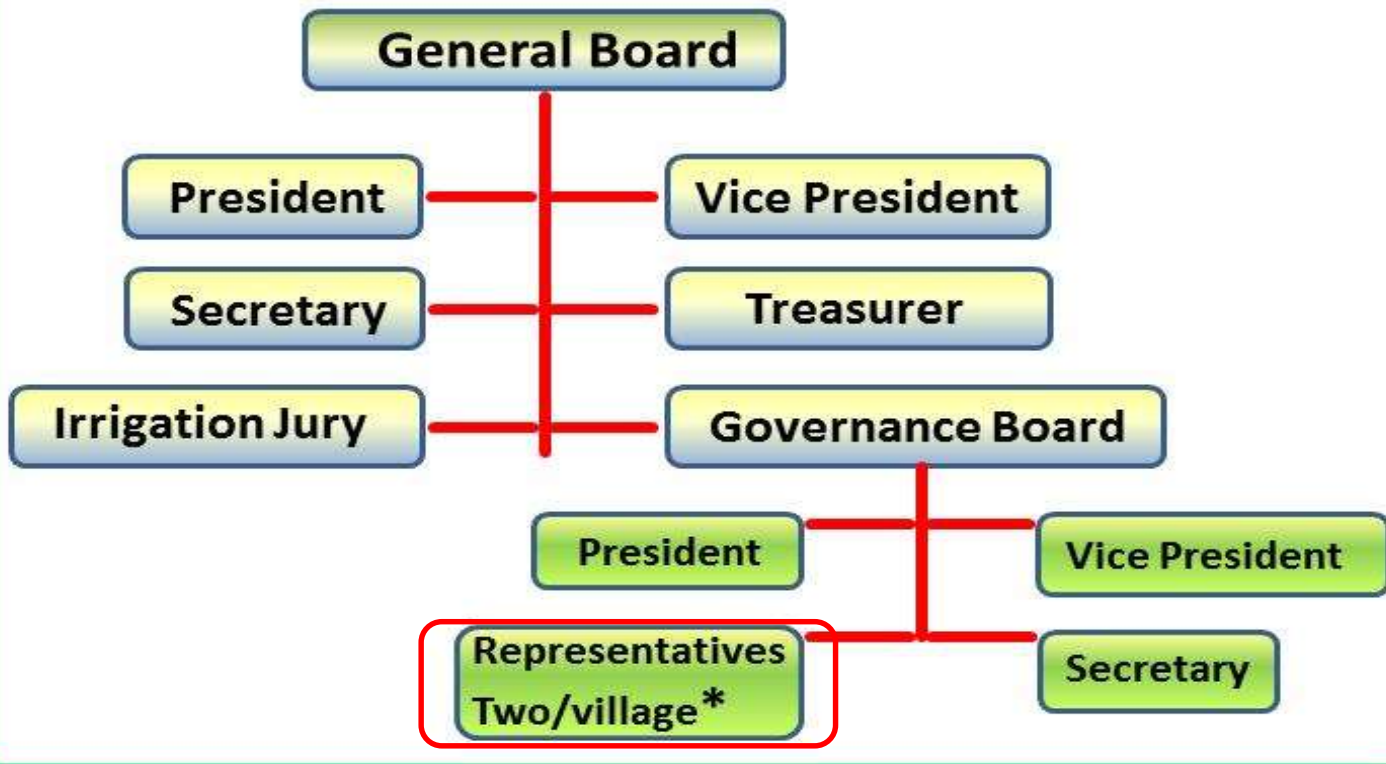
**CONSEQUENTLY, CUAS become a fundamental instrument for water planning, control, and for the rational use of groundwater.**



# Results (1/4)

-Both groundwater bodies, Los Arenales & Medina del Campo, count on **4 groundwater users' communities** (El Carracillo, Medina del Campo, Cubeta de Santiuste de San Juan Bautista and Alcazarén\*), places in which **MAR takes place since 2002 and provides about 24% of the total water used for irrigation** in the area.

## STAKEHOLDERS ORGANIZATIONAL SCHEME. EXAMPLE FOR AN IRRIGATION COMMUNITY

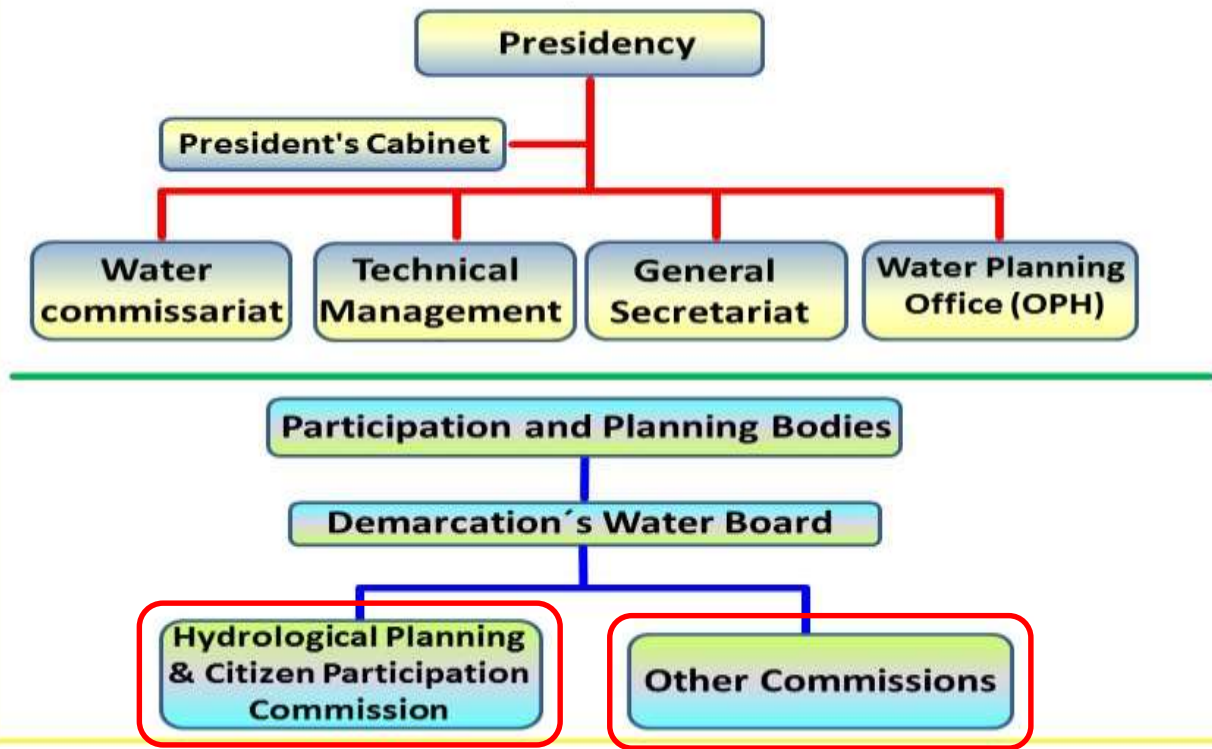


-End users' participation in DM

# Results (2/4)

- Hard structural measures to address intensive groundwater use:  
Managed Aquifer Recharge schemes
- Soft non-structural measures:  
CUAS and wider stakeholder engagement
- “Space for collaboration” in socio-technical systems
- Stakeholders are a group of agents that represent the local population, researchers...

## C.H.D. STRUCTURE: BRANCHES, ADVISORY BODIES AND COUNCILS



### CHD structure, advisory bodies, and councils

[Duero River Basin Plan, or PHD (CHD, 2016)]

-End users' participation in DM

# Results (3/4)

The Duero River Basin Plan, or PHD (CHD, 2016) establishing rules for performing MAR operations and promoting the creation of *Groundwater User Communities* (=CUAS)

**Hard (structural measures)** to address intensive groundwater use:

Managed Aquifer Recharge schemes

**Soft (non-structural measures):**

CUAS and wider stakeholder engagement



*The “space for collaboration” in socio-technical systems* combines new **hard** structural measures, like managed aquifer recharge, and collective management institutions, like the CUAS (**soft**), making up a **socio-technical complex system** that follows a **collaborative model**.

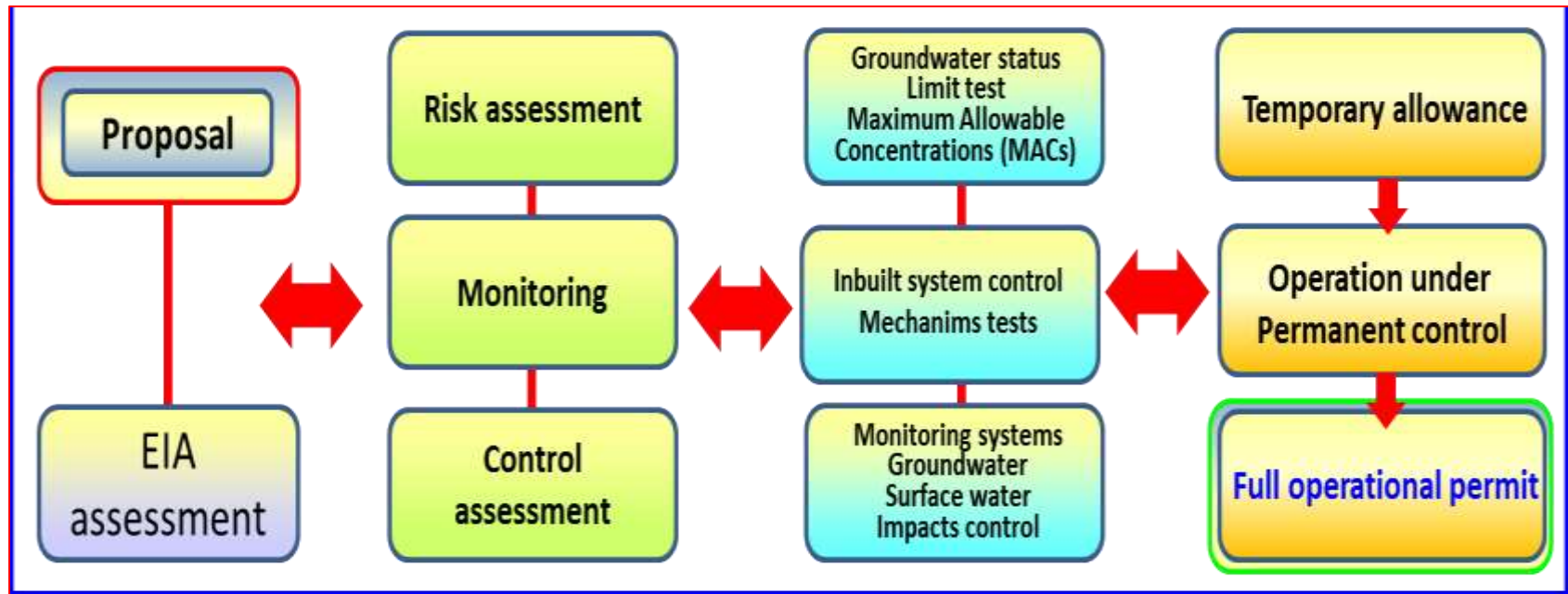
This is a **bottom-up, non-hierarchical network model of governance** very effective in comparison to the usual **top-down one**, where water management decisions are, traditionally, imposed by Water Authorities.

**Stakeholders** are a group of agents that represent the local population, researchers and people involved in the development of the system (not in the management), who participate occasionally through legal public consultation or communication channels, even social networks. This group can include, e.g. technicians, external consultants, influencers, local leaders, students, etc.

*Their participation is aligned with the Water Framework Directive (WFD, Art. 14), which promotes new water policy tools, including public information and citizen participation.*

# Results (4/4)

## Stages to implement a Co-MAR system



## Some indicators for Co-MAR outcomes (benchmarking)

	Region of Castilla y León	Municipalities in the case study areas
Density of working age population (unit: inhabitants between 20 and 64 years old per km <sup>2</sup> )	7.4 inhabitants./km <sup>2</sup>	17 inhabitants/km <sup>2</sup>
agroindustry (unit: related jobs workers per km <sup>2</sup> )	3.73 w/km <sup>2</sup>	11.29 w/km <sup>2</sup>
Number of companies in the area (Unit: n <sup>o</sup> of companies per km <sup>2</sup> )	0.46	1.28
Population growth	-6% decrease in the region	+28% since MAR began

# Conclusions

1. **Co-MAR at Los Arenales** is an example of **PPPP** as collaboration for the management of the water resource among **public authorities and private landowners**. It is **key to improve the IWRM mechanisms**.
2. **The bottom-up approach** involves end-users..., *stakeholders* and even the general population in decision making processes, resulting **more social and effective**.
3. **Co-MAR has permitted higher values for economic indicators** in the studied areas where MAR activities are taking place.
4. **The spaces of collaboration are becoming the basis for new governance schemes** that aim more sensibility at the **collective interest of all users**.
5. Despite MAR and co-MAR, the extraction of groundwater is still very intensive with an exploitation index greater than one. **New aquifer recharge experiences could be conducted in Los Arenales and Medina areas to bring WEI down**.
6. A "**shift in paradigm**" is necessary in the water sector, from **traditional patterns** of water consumption to a circular economy approach, considering **wastewater resources and MAR important assets** in a water scarcity context.
7. **Regulation changes** are needed, as well as **modernization** of the irrigation systems, measures to improve **water and energy efficiency** backed by the nature (NBSs), leading to **better economic results and resource savings**.

# Recommendations

## ✓ **Shift in paradigm**

*The actors play an important role in this new governance for future water security (technology is only part of the solution).*

*+Changes to the current organizational structures are essential to incorporate more intense and deeper end-user and public participation.*

## ✓ **Deepening the Space for collaboration**

*It is critical that these elements of oversight and strong collaboration are strengthened and deepened, creating venues for fluent communication with users involving all actors on future decisions on the management of the system, particularly water rights, monitoring and evaluation.*

## ✓ **MAR with added post treatment processes for better water quality**

*Develop schemes that increase the self-purification capacity of the system and biofilter effectiveness, e.g. artificial wetlands and infiltration ponds equipped with reactive layers of interactive filters.*

## ✓ **Decision support systems that combine the technical and the social aspects**

*Study the economic aspects to avoid potential conflicts of interest in ranking the different uses of water, as well as the selection of MAR zones and their prioritization.*

# Multilevel participation to improve aquifer management (Co-MAR) In Ica aquifer (Peru)



**Hidr-ICA Committee constitution. Ica, 2022 March**

## MAR. Public use and human security



Fotos: cortesía de Roberto Navarro



*Engineer Navarro also reported a disastrous incident in mid-April 2018, when a child from Ica drowned while bathing in an artificial recharge pond. The infiltration ponds must include informative signs and certain safety measures to avoid further incidents (ANA, 2019).*

- **Public use eventually crashes into water security and MAR**
- **Dissuasive measures**
- **Increased costs and difficulty in obtaining permits (fencing, signage...).**
- **Additional element of water (in)security.**



## MAR. Public use vs human security



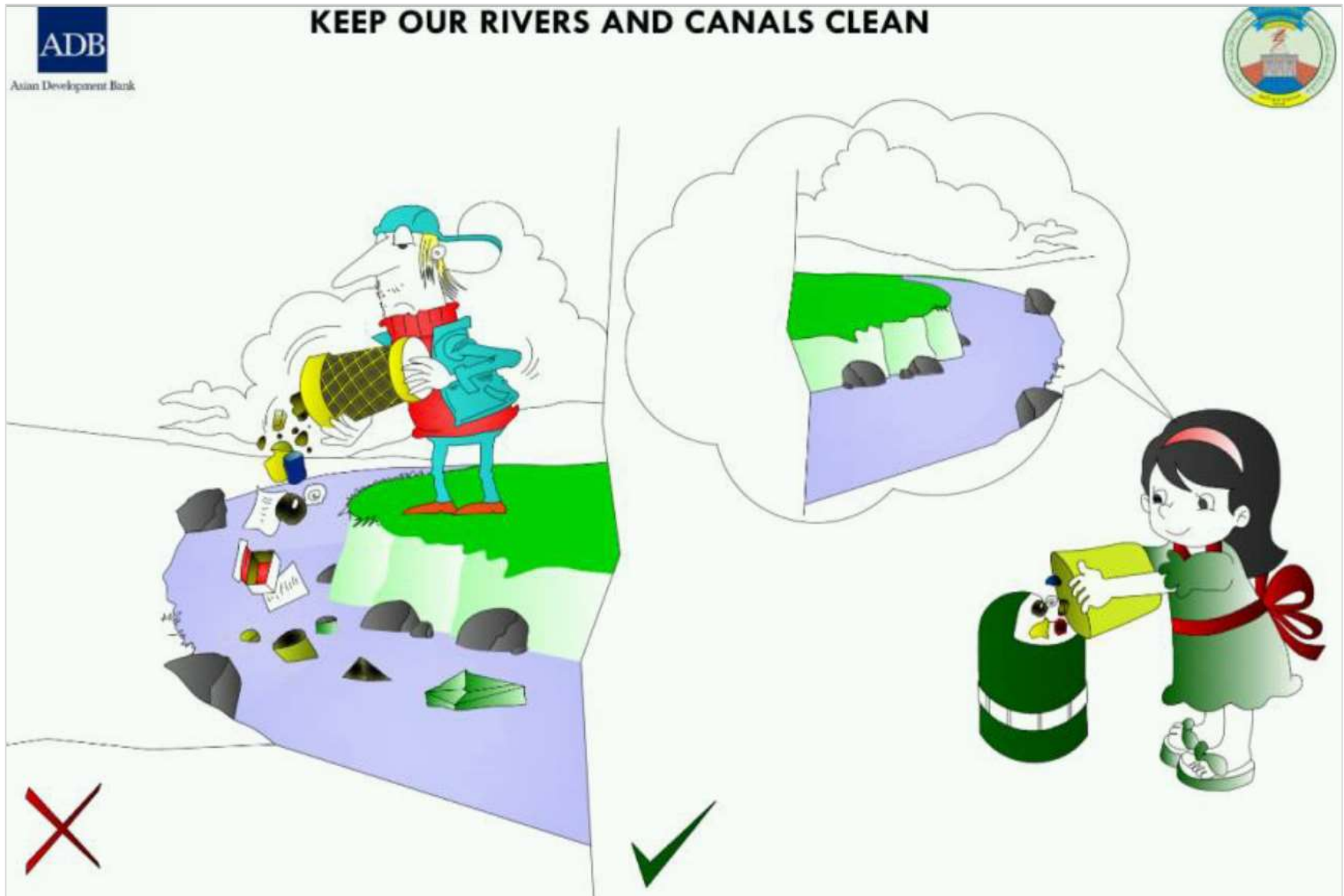
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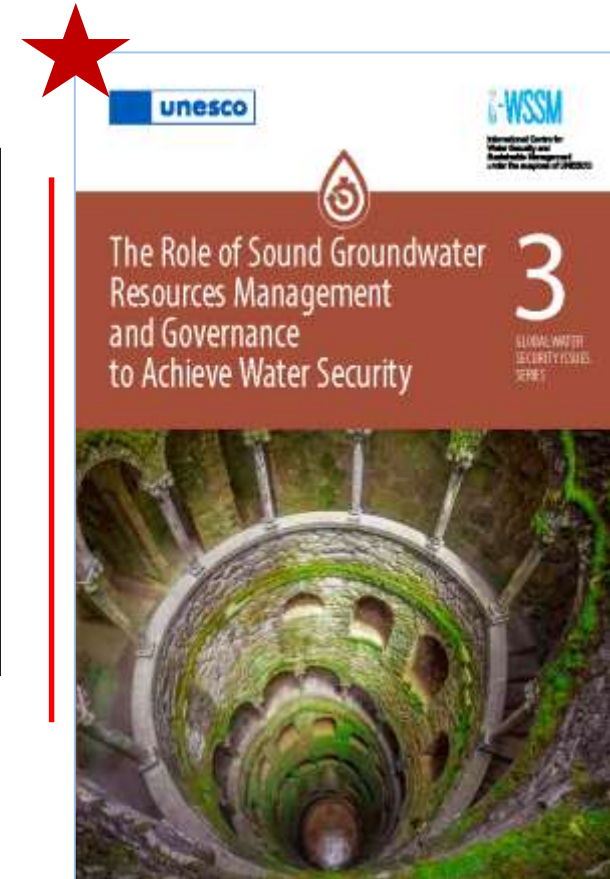
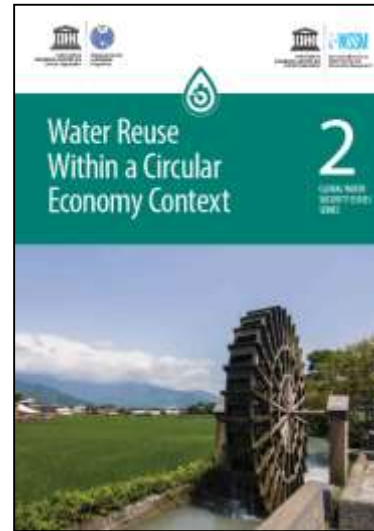
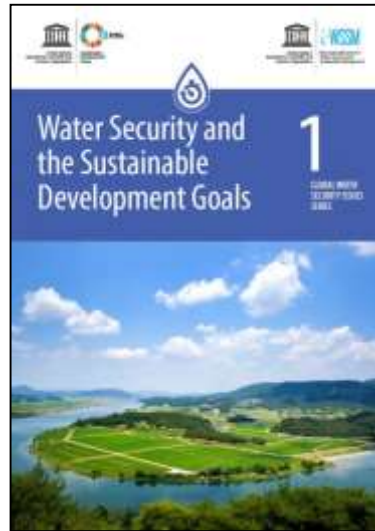
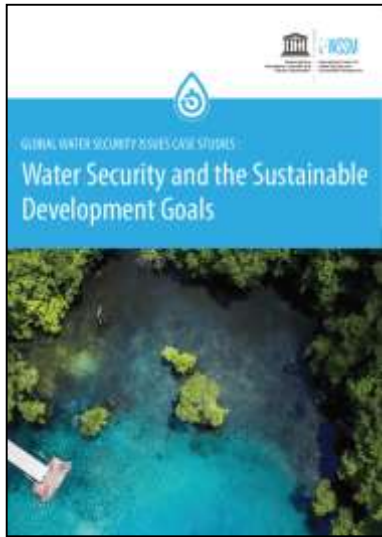
- Since implementation and finalization of the basin in early 2020, in hot weather, **MAR Site 3 has attracted several (male) youth who swim in the main basin and socialize on the off-take weir, as illustrated (...)**
- Whilst the project team's guard at the site has tried to **discourage** this activity, it has proved **impossible due to the numbers of swimmers.**
- **No swim related accidents reported.**
- **Having observed the way the local community has interacted with the MAR infrastructure, we propose to see this as an opportunity for site enhancement and ongoing operation, as part of the follow-on main implementation project.** (L&M-ADB, 2020)

# MAR Consignments. Public participation, public use, and human security



# To broaden this info...

## WSSM\_GWSI 2019-2021



[https://reliefweb.int/sites/reliefweb.int/files/resources/i-WSSM\\_GWSI\\_Case\\_Studies\\_%28small\\_size%29\\_final.pdf](https://reliefweb.int/sites/reliefweb.int/files/resources/i-WSSM_GWSI_Case_Studies_%28small_size%29_final.pdf)

**Fernández-Escalante, E. and López Gunn, E. (2021).**


***Co-managed aquifer recharge: Case studies from Castilla y León (Spain).***

UNESCO and UNESCO i-WSSM. 2021. *The Role of Sound Groundwater Resources Management and Governance to Achieve Water Security (Series III)*. Global Water Security Issues (GWSI) Series – No.3, UNESCO Publishing, Paris.

<https://unesdoc.unesco.org/ark:/48223/pf0000379093?posInSet=1&queryId=c7371bd0-59dd-4d1b-a4d5-6b6e21e87129>

# Managing Aquifer Recharge Commission (IAH-MAR)


## IAH Commission on Managing Aquifer Recharge



International Association of Hydrogeologists

WELCOME
ABOUT THE COMMISSION
SYMPOSIA AND WORKSHOPS
WORKING GROUPS
COMMUNITIES
COLLABORATIONS
RESOURCES

## Welcome




*Attendees at ISMAR10, Madrid, May 2019 – the latest triennial symposium of IAH-MAR, UNESCO and ASCE.*

Welcome to the website of the International Association of Hydrogeologists Commission on Managing Aquifer Recharge (IAH-MAR). Here you can discover what our working groups are doing and contribute to their current projects, you can download resources on MAR, connect with people, get information on symposia coming up, and join our email list to stay informed of latest news. We also have sister sites in Spanish and Chinese.

### Managed Aquifer Recharge

Managed aquifer recharge, also called groundwater replenishment, water banking and artificial recharge, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. It embraces methods such as riverbank filtration, stream bed weirs, infiltration ponds and injection wells, and uses natural water sources and appropriately treated urban stormwater, sewage and other waste waters to increase groundwater storage, protect and improve water quality, and secure drought and emergency supplies. Its growing scientific base supports its rapidly increasing use as a vital management tool in the sustainable use of the world's water resources.

### Latest News



National Seminar on “Resilience of Groundwater Resources for Accommodating Changing Climate Scenarios” – 7 November 2020 in New Delhi,

### CURRENT PROJECTS THAT YOU CAN JOIN

- New working group: MAR in Conferences. Coordinator: Daniela Benedicto van Dalen
- New working group: Urban MAR. Coordinator: Niels Hartog
- LatinMAR Community of Practice – a new initiative to advance MAR in Latin America. Coordinator: Adriana Palma
- MAR Suitability Mapping Working Group. Coordinator: Jose Bonilla
- Contributions to a second monograph on clogging-focussing on its management – Clogging Working Group. Coordinator: Russell Martin
- Groundwater Solutions Initiative for Policy and Practice (GRIPP) – a Collaborative International Project, Coordinator: Karen Villholth

#### JOIN OUR MAILING LIST

Register with our large email group to share information, ideas and news concerning recharge enhancement.

Join IAH-MAR email community

WhatsApp group on:  
**Aquifer Recharge Management**

<https://chat.whatsapp.com/J8jKMuCXrTr83d1SI9vDBe>

**>170 technicians discuss about MAR**

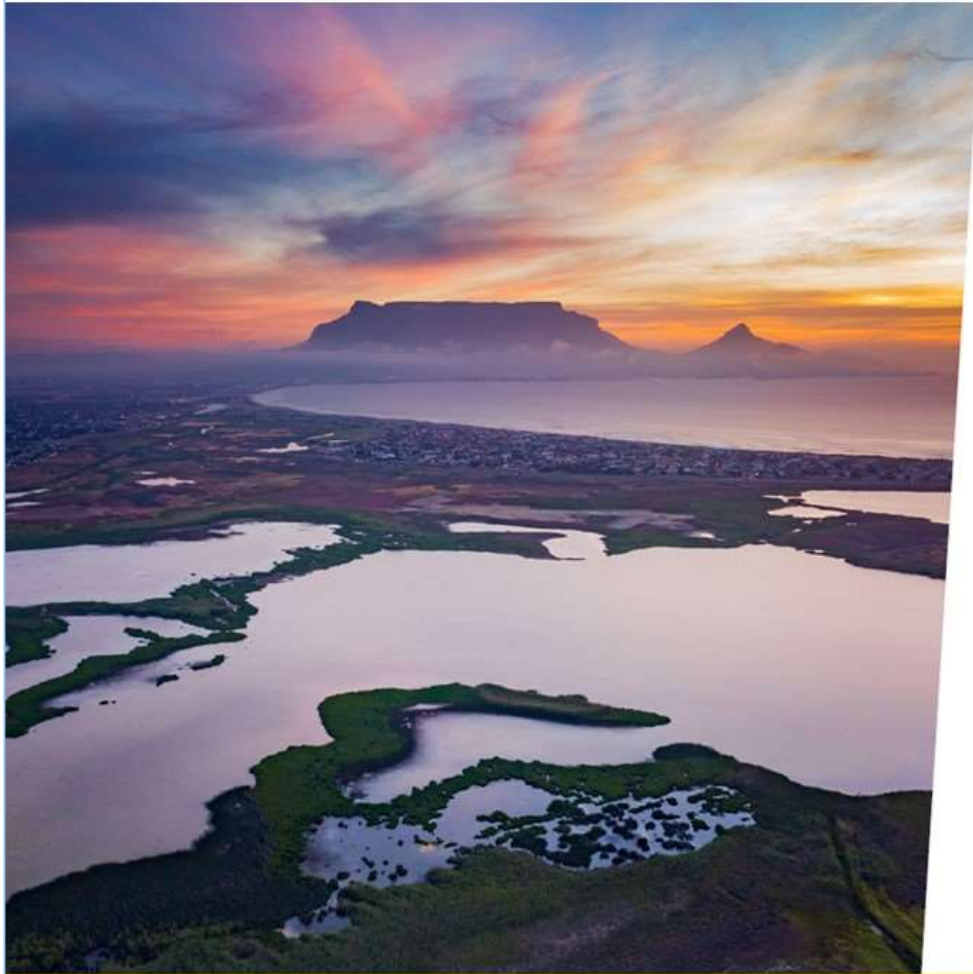
**Tehran, 2024 April 23<sup>th</sup>-24<sup>th</sup>**

**Thank you**

**efernan6@tragsa.es**

<https://recharge.iah.org/>

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Managing Aquifer Recharge

**ISMAR12**

## **International Symposium on Managed Aquifer Recharge**

**28 April – 2 May 2025**

**Cape Town**

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For more information please visit <https://iah.org.za/>