EU WATER INNOVATION conference 2019

MARSoluT Managed Aquifer Recharge ITN

EIP Water Conference

Accelerating action to tackle water pollution and enhance EU preparedness to water-related climate change impacts. #EUWIC

Wed December 11, 2019, 9:00-13:00

MANAGED AQUIFER RECHARGE AS A REAL CLIMATE CHANGE ADAPTATION MECHANISM. EXAMPLES AND INDICATORS FROM FIVE CONTINENTS

Managed Aquifer Recharge (MAR) has been considered for a long time as an important technology to combat the adverse effects of Climate Change (CC). This is not a gratuitous claim. In this workshop organizers will support this statement on the basis of real sites, indicators and cases located all around the world. MAR is being used in the world in combination with other Integrated Water Resources Management (IWRM) measures to reduce climate change adverse impacts as an adaptation and even mitigation strategy to face up CC challenges. Clear examples will be exposed by the workshop participants. If you are interested in joining the meeting or in more information about the project please contact Enrique Fernández-Escalante or visit the project websites: https://www.marsolut-itn.eu, www.dina-mar.es, https://recharge.iah.org, https://www.ismar10.net/

Meeting language: English.

GrupoTragsa

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Schedule: 9:00 – 13:00 h

Table 1 (9:00 -11:00): Managed Aquifer Recharge as a real Climate Change adaptation mechanism

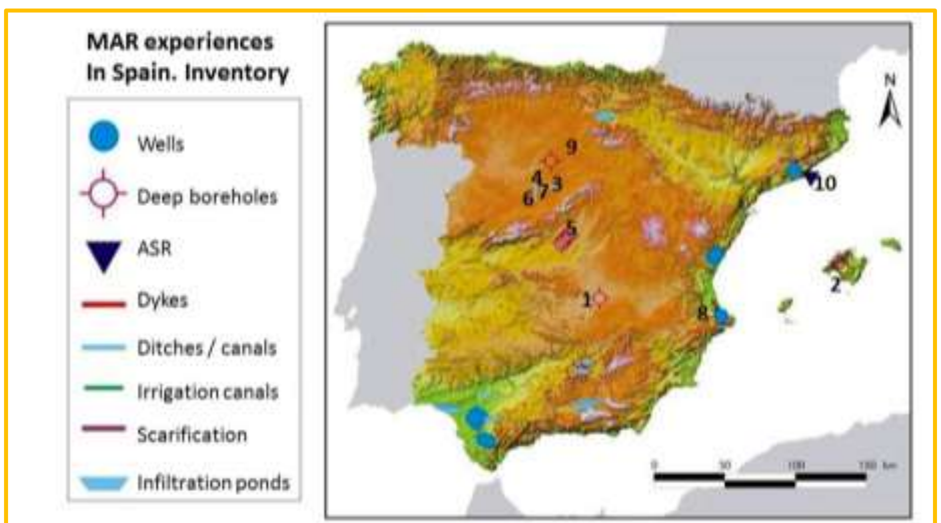
09:00 – 09:20	**Welcome. Introduction round**
09:20 – 09:35	1. **Why Managed Aquifer Recharge is a successful tool to Climate Change adverse effects adaptation? International examples and indicators.** Dr. Enrique Fernández-Escalante. Tragsa Group; IAH MAR Commission, PTEA, MARSOLut.
09:35 – 09:50	2. **Sand river recharge and storage.** Dr. Tibor Stigter (video). Senior Lecturer in Hydrogeology and Groundwater Resources. The Netherlands. IAH Climate Change Commission.
09:50 – 10:05	3. **Web-based real-time monitoring and modeling of managed aquifer recharge applications**. Dr. Catalin Stefan. Technische Universität Dresden Germany – IAH MAR Commission.
10:05 – 10:20	4. **Academic training in climate change adaptation - example of the international Master's Programme "Groundwater and Global Change - Impacts and Adaptation (GroundwatCh)".** (TBC). Technische Universität Dresden.
10:20 – 10:35	5. **Methodology for developing Managed Aquifer Recharge. An example of implementation in Chile**. Dr. Ester Vilanova & Dr. Jordi Guimerà. Amphos 21 Consulting, Barcelona, Spain.
10:35 – 10:50	6. **How to control groundwater quality degradation in coastal zones using MAR optimized by GALDIT** Vulnerability Assessment to Saltwater Intrusion and GABA-IFI models. Dr. João Paulo Lobo-Ferreira. LNEC, MARSOLut, Portugal.
10:50 – 11:20	**Networking coffee break**

Table 2 (11:20 -13:00): Climate change mitigation strategies related to IWRM

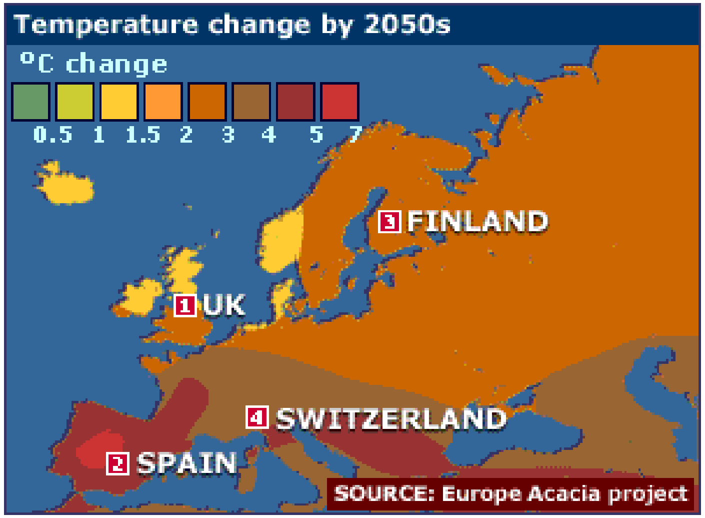
11:20 – 11:35	7. ***Sites and Indicators of MAR as a Successful Tool to Mitigate Climate Change Effects in Spain.*** Dr. Jon San Sebastián / ESR3. Tragsa Group, MARSOLut. Spain
11:35 – 11:50	8. ***Ensuring safe MAR to address water scarcity under the EU Water Framework Directive.*** Dr. Manuel Sapiano. The Energy & Water Agency, MARSOLut. Malta.
11:50 – 12:05	9. ***Nature Based Solution on MAR and climate change alleviation.*** Dr. Elena López Gunn and Marta Rica. iCatalist. Spain.
12:05 – 12:20	***10. From managed to controlled aquifer recharge: the LIFE REWAT Suvereto MAR scheme (Italy).*** Dr. Rudy Rossetto (TBC). Scuola Superiore Sant'Anna, MARSOLut, Freewat, Italy.
12:20 – 12:50	**Debate.** Chaired by Elena López Gunn & Enrique Fernández Escalante

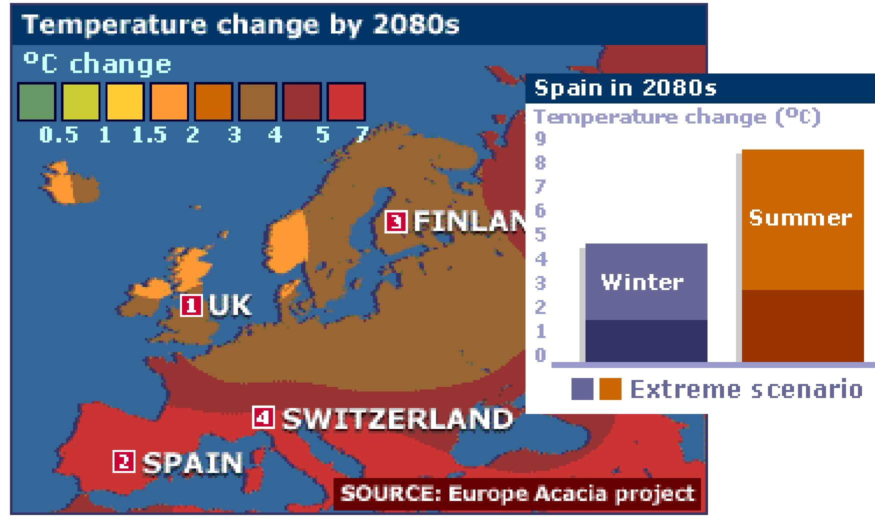
SITES AND INDICATORS OF MAR AS A SUCCESSFUL TOOL TO MITIGATE CLIMATE CHANGE EFFECTS IN SPAIN

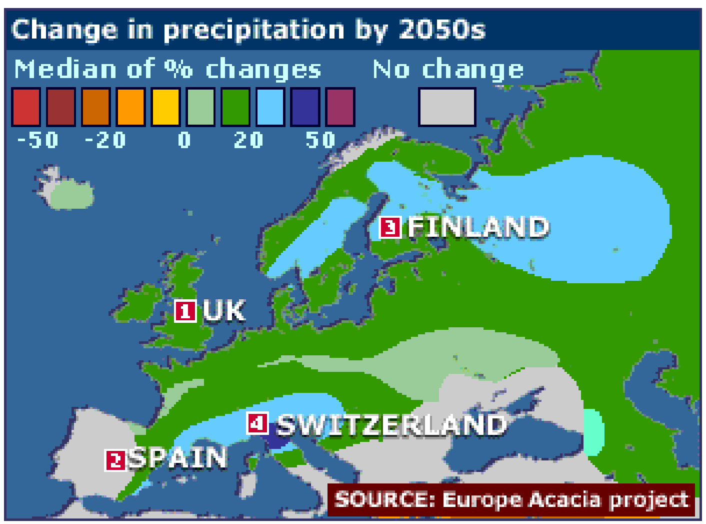
Dr. Jon San Sebastián Sauto, Tragsatec
Dr. Enrique Fernández Escalante, Tragsa

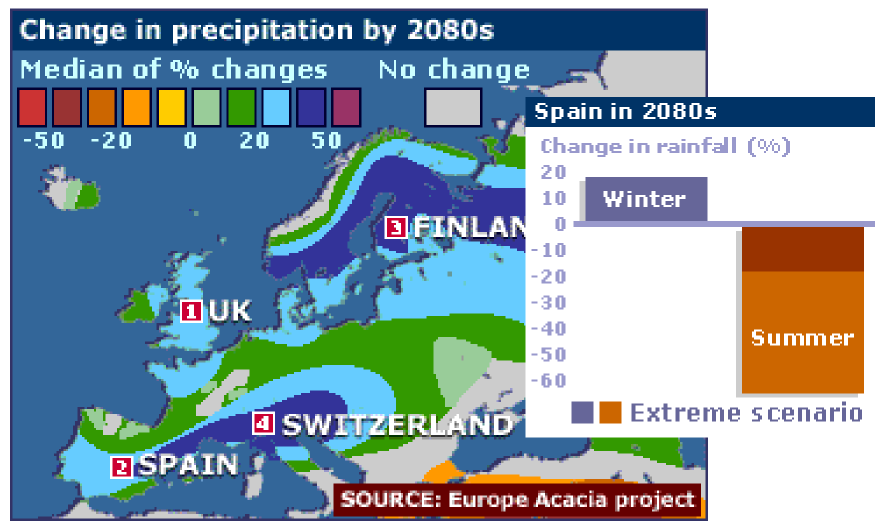


Introduction









Materials and methods

EFFECTS OF CLIMATE CHANGE	PROBLEMS/ REAL IMPACTS DUE TO CLIMATE CHANGE	MAR SOLUTIONS (PREVENTION / MITIGATION)
↑ AVERAGE TEMPERATURE	↑ Evaporation	Underground storage
	↑ Evapotranspiration	Higher humidity
	↑ Water demand	Reclaimed water infiltration
		Punctual /directed infiltration
↓ ANNUAL PRECIPITATION (but stronger storms and flood episodes in rainy season)	↓ Water availability	Self-purification / Re-infiltration
	↓ Runoff	Off-river storage
	↓ Wetlands	Restoration / Establishment
	↓ Hydro-electrical power production	Gravity flow water distribution / Power saving
↑ EXTREME WEATHER	↑ Floods	Eventual infiltration of extreme flows
	↑ Droughts	Multi-annual management / Reserves
↑ SEA LEVEL RISE	↑ Saltwater intrusion	Intrusion barrier wells

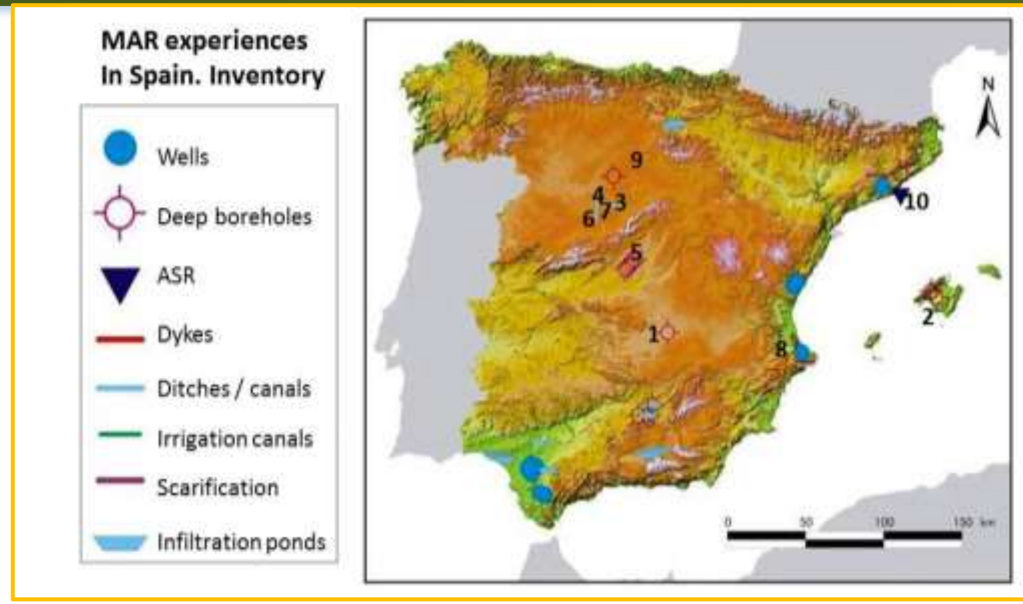
Results

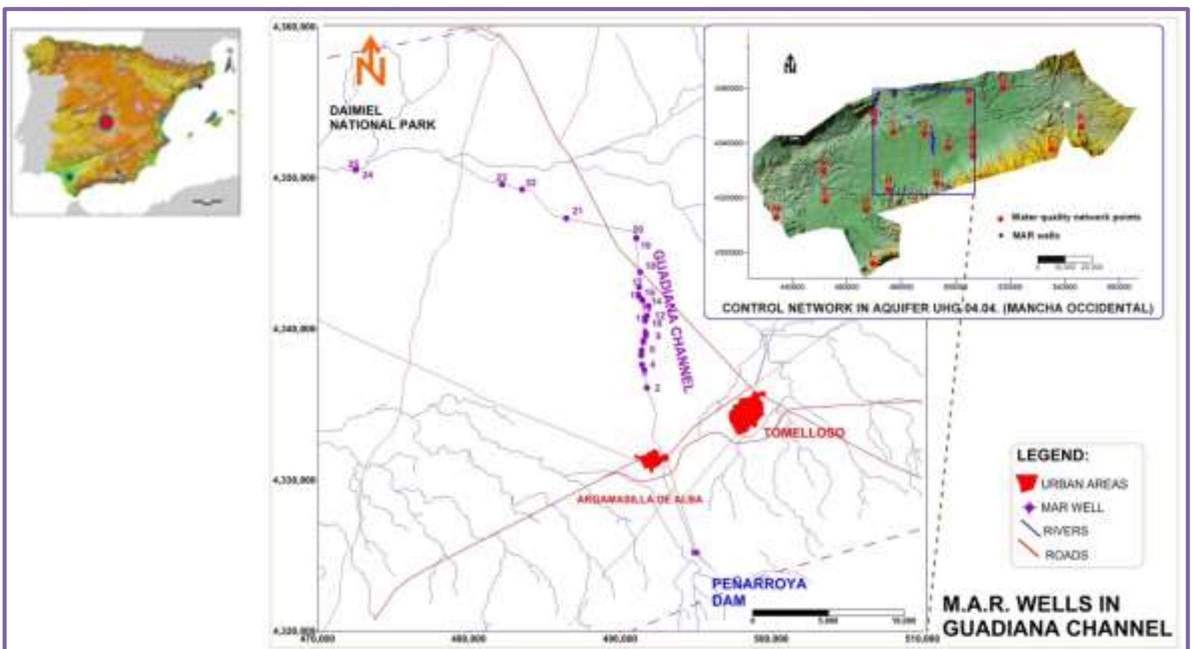
CC ISSUES	MAR SOLUTIONS	SITES	INDICATORS
Evaporation ↑	Underground water storage	*Canal del Guadiana (CLM)*	+48 hm^3/year
	Temperature decrease	*P. de Mallorca (I. Baleares)*	-1.5-6ºC of air temperature
Evapotranspiration ↑	Soil humidity increase	*Gomezserracín (CyL)*	+15-20% soil moisture
Water demand ↑	Reclaimed water infiltration	*Alcazarén (CyL)*	+0.4 hm^3
	Punctual infiltration	*Canal Isabel II (Madrid)*	+5 hm^3/year
Water availability ↓	Self-purification	*Santiuste (CyL)*	+/-12-53% in water q parameters
Run-off ↓	Off-river storage	*Santiuste (CyL)*	+2.62 hm^3/year out of Voltoya River
Wetlands ↓	Restoration	*Santiuste (CyL)*	-5% recharge vol. (Alkaline lake)
Hydro Electric Power ↓	Gravity flow water distribution	*El Carracillo (CyL))*	+40.7 km of canals and pipes
	E savings / Lower emissions	*El Carracillo (CyL)*	-36% E costs (-10,780 kg CO_2)
Floods ↑	Infiltration of extreme flows	*Losa del Obispo (Valencia)*	+0.05 hm^3 in 14 hours
	Forested Watersheds	*Neila (CyL)*	-15-40% of diverted flood volume
Droughts ↑	Multiannual management	*Santiuste (CyL)*	Supply for 3 years with no rain
Saltwater intrusion ↑	Intrusion barrier wells	*Llobregat (Cataluña)*	30 years to regain water table

Examples for Spain

Canal del Guadiana, Castilla-La Mancha (1)

This MAR system can increase the total storage volume by means of intentional recharge in about **48 supplementary hm³ per year**



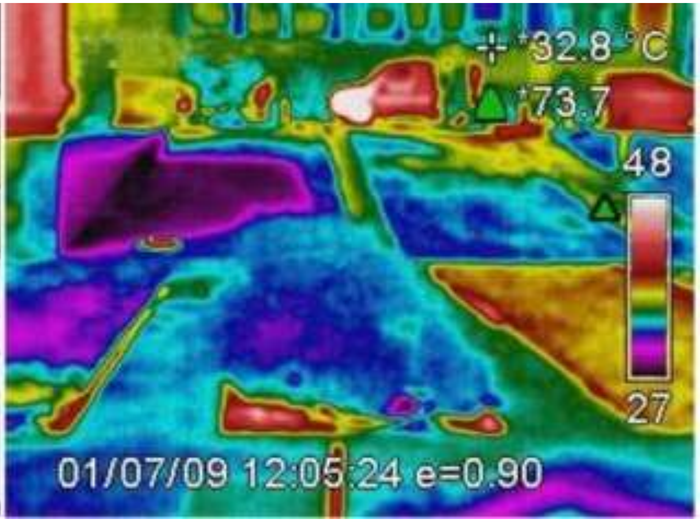


General sketch of the MAR system of wells near Canal del Guadiana for irrigation and environmental purposes

Examples for Spain

Temperature Reduction. Parc Bit, Palma de Mallorca, I. Balears (2)

A good example of this practice can be found in Parc Bit (Palma de Mallorca, Figure 4), where the vegetated roofs, fed by rain collection, were able to reduce the air temperature in the range of 1.5 to 6 °C

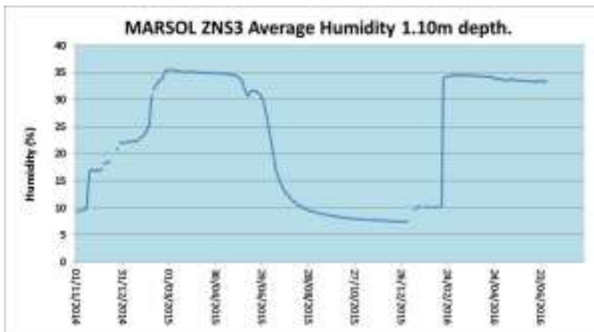


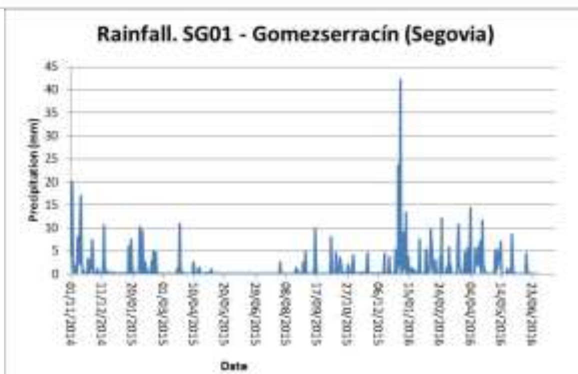
Sustainable drainage urban systems (SUDS) to reduce the urban heat island (UHI). Model and development of green roof on the Parc Bit building, Palma de Mallorca, Spain. Example of thermography to track the UHI evolution

Examples for Spain

Increase in Soil Humidity. Gomezserracín, Castilla y León (3)

additional storage in the unsaturated zone increased soil moisture by 15%–20% according to datasets obtained from the MARSOL ZNS-3 station





Infiltration ponds in the Los Arenales aquifer: Gomezserracín, soil humidity evolution from the so called MARSOL ZNS-3 station datasets (02/11/2014–30/06/2016) and natural precipitation evolution

Examples for Spain

Infiltration of Extreme Flows. Lliria, Valencia (8)

In 2014, it was used twice to reduce the peak-flow in a flood and to recharge the karstified aquifer with an infiltration rate of almost 1000 L/s for a period of 14 h (0.0504 hm^3), a significant amount of water that otherwise would have worsened the devastation caused by the flooding.

Deep borehole “Arnachos” at Balsa del Campo, Valencia (UTM 685,744/4,391,256) located in the margin of an irrigation pond and used as both, a safety and recharge element

Discussion

MAR SOLUTIONS	ADVANTAGES	DISADVANTAGES
Underground water storage	Water recharge can help to restore wetlands associated to overexploited aquifers, especially when winter extraordinary flows are used as recharging source	Run-off abstraction can change recharge into negative impact, considering downstream ecosystems
Temperature reduction	Broad array of possibilities in SDUS, from parking lots to roofs, from rain storage to high evaporation systems	Risk of accidental pollution through run off on contaminated areas.
Soil humidity increase	Maintenance of micro-flora and fauna in the soil, Fertility increase, Low infiltration with low investment and good purification.	High soil humidity can facilitate flooding by water table rising or freezing in cold climates. Balance between unsaturated and saturated area should be searched.
Reclaimed water Infiltration	Decreasing offer of primary sources (precipitation and run-off) and increasing offer of secondary ones (WWTP, desalination, storm reservoirs). Chance to change a split into a resource.	Reclaimed water involves unbalance between recharging water quality and receptor aquifer quality, clogging during infiltration, and legal limits to recharge (EIA) or to use (authorization).
Punctual infiltration	High potential to manage peak flows in constrained areas with filtering systems and possibility of deep recharge as a safety measure in open aquifers.	Decantation processes can get clogged. Forced refilling can reduce the availability of extreme flows from unexpected storms.
Self-purification	Design adapted to spill parameters combining water depths and flora growth that let the development of physical, chemical and biological depending on light, flow or speed of water. Habitats can be supported depending on management	Poor quality could decrease the infiltration rate due to clogging or could compromise the authorization if thresholds are surpassed after mixture. Roots and biofilms play opposite roles in infiltration
Off-river storage	Despite dams, MAR avoid building permanent dykes that can become biological barriers for fauna and flora and critical changes in morphology that impulse eutrophication or anoxic processes when water stay stored in the river.	Abstractions for recharge must be assessed under EIA criteria as any other project. Impacts on coastal and transitional waters should not be forgotten. Sedimentation changes are as important as water reduction when considering downstream effects.
Restoration	Slow infiltration in unlimited areas for recharging ponds simultaneously support temporary wetlands with a low volume share expense and a huge role as wild fauna and flora or leisure	Public Health can be threatened when unsatisfactory quality reclaimed waters are involved in infiltration pools.
Gravity flow water distribution	Lateral transmissivity and specific design for the local geomorphology can be combined to arrange an equative share of the recharge for any user. Stop devices or the distinctive permeability are means to manage a successful transportation.	Detailed hydrological and geotechnical studies play a main role to take advantage of the aquifer features for recharge. Transportation and recharge can be compromised if benefits are not adequately shared by the final users.
E savings / Lower emissions	New alternatives are considered to improve energy efficiency as the replacement of diesel engines by electric engines fed by solar or wind energy to reduce the pumping cost	The fall of the electric fare can trigger the rise of farmers' water demand, so it is indispensable to arrange a Basin Plan to moderate consumption
Infiltration of extreme flows	High capacity to manage floods and peak flows in reduced spaces with measures of sedimentation. Optional diversion to deep or confined aquifers to combat flooding when groundwater level gets too high in unconfined aquifers.	Decantation processes can get clogged and peak flows reduced before injection. Forced recharge can also damage the natural porosity of the soil
Forested watersheds	Basin erosion control and reforestation promotion are fostered by MAR devices that retain soil and reduce the slope. Deep roots species help to stabilise the terrain and even lengthen the life cycle of dams.	Recharge in the higher part of the basin makes downstream run-off conditional to the increased rate so soils and wetlands can be severely affected.
Multiannual management	Being out of the riverbed, preventive measures against floods as winter or spring releases are not required. Deep aquifers storage can be used as emergency resources.	Multi annual management involves a well planned with a social supportive spirit among stakeholders. Despite the advantages with respect to dams, extreme groundwater levels must be also prevented.
Intrusion barrier wells	Acceptable use of low-quality sources (high NaCl or NO_3 concentration)	Collateral effects of pollutants in the recharged volumes on the potential storage of the ground

Conclusions

- CC effects and their associated problems have been related to 15 successful MAR solutions in 10 sites Spain.
- A series of indicators have been established to value the efficacy and efficiency of MAR related to CC.
- MAR technique can be used as a tool that can simultaneously achieve several purposes.
- Management can help to lead MAR systems to balance different simultaneous goals *(f. i. reducing filtration rate while improving water purification)* or different seasonal purposes *(storage vs. transportation).*
- Adaptation and mitigation of CC can be/are aims of MAR systems.

water

https://www.mdpi.com/2073-4441/11/9/1943

https://www.mdpi.com/journal/water/special_issues/ISMAR10_2019