Water Security and Integrated Water Resources Management improvements due to Managed Aquifer Recharge (MAR). Selection of case studies, characterization, benchmarking and practical recommendations

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ABSTRACT
Water security (WS) is a SDG defined as "*The capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability".* Managed Aquifer Recharge (MAR) is a water management method that allows water to be introduced into underground aquifers. Once stored in these, it can be extracted for different uses (urban supply, irrigation, reduce marine water intrusion, reduce pollution, regenerate ecosystems, etc.) (DINA-MAR, 2011).

The relation between both concepts is a usually integrated water management (IWRM) resource, and there are plenty of examples related to the WS-MAR binomial. Some of them have been selected and studied, characterizing the systems and conducting some benchmarks so as to compare relevant elements regarding collaborative governance, the creation of spaces of collaboration, co-management of groundwater resources including MAR (Co-MAR), the establishment of indicators of pressure, state, response, and achievement of the target, and finally, an open set of practical recommendations has been proposed. The selected demo sites include MAR and have been grouped into five sets:

A- Water security in urban supply. The selected examples are Managed recharge to increase the guarantee of urban supply in Madrid and Barcelona cities (Spain). The water supply guarantee has been increased in both cases according to water availability indicators, but requires permanent monitoring activities and an important investment. In any case, a 100% water supply guarantee has not been reached.

B- Industrial water security. Some examples of conflicts of interest among end-users of (ground)water and benefits for the agroindustry and the timber industry in Spain (Los Arenales aquifer) and Peru (I-V-L aquifer) are described. Some of the most important lessons learned are related to heavy investment by private developers, the extension of the activity is subject to judicial resolution, the importance of pretreatment for Water Security, the temporary storage for decanting MAR water, and the need for new detailed studies to allocate MAR systems in appropriate areas.

C- Environmental water security and public use. Reporting the consequences of rapid implementation in which the design and location could be improved, the low water security guarantee for intermittent MAR systems and impacts that are difficult to foresee related to public use, with potential conflicts of interest, increased costs due to the necessity of deterrent measures and permitting difficulties such as fencing, signage, etc. and the participation of the local community interpreted as an opportunity for site enhancement and ongoing operation as part of the follow-on main implementation projects on MAR.

D- Extreme events and climate change. In the fourth group are described and tested some examples for the reduction of the peak flow rate and to enlarge the time of concentration by means of percolation boreholes and the drainage of an irrigable area with detraction of volumes used for MAR in an adjacent aquifer in Spain.

E- Combinations of the previous examples. Selected examples from South America and Mediterranean countries share the common feature of legislative barriers, conflicts of interest, and unclear financing mechanisms jeopardizing their long-term permanence.

In short, the use of the MAR technique in IWRM systems should prioritize the supply to the population as the main objective of water security; water security and its components are generally dependent on budgetary allocations and economic interests; legislative barriers and conflicts of interest occasionally represent major drawbacks for the implementation of the MAR technique and the water security rise, improved governance through the implementation of bottom-up systems, the new concepts of Co-Managed Aquifer Recharge (Co-MAR) and Public Private People Partnerships (PPPP) improve integrated management and water security, etc.