Can on-farm irrigation reservoirs enhance long-term sustainability of large irrigated systems?

The case of Riegos del Alto Aragón (Spain)

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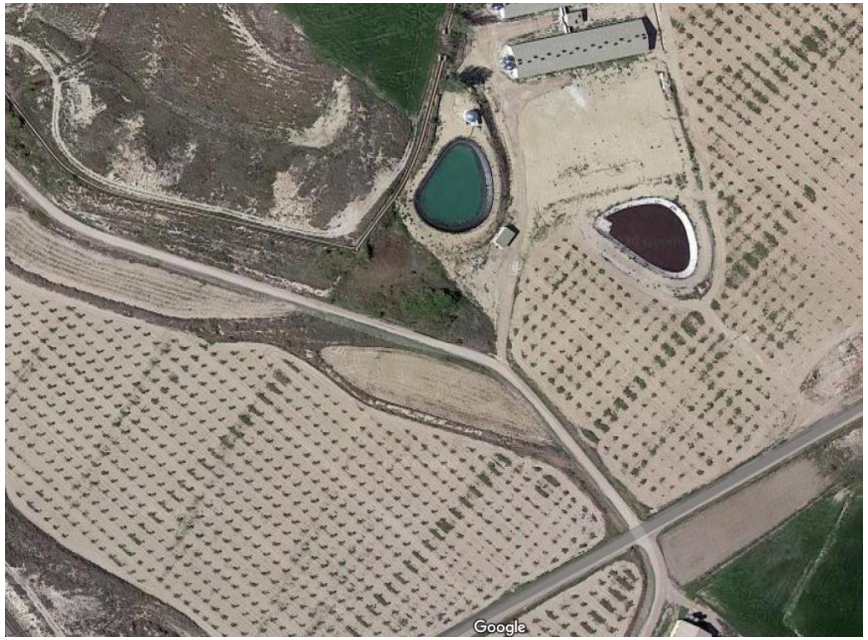
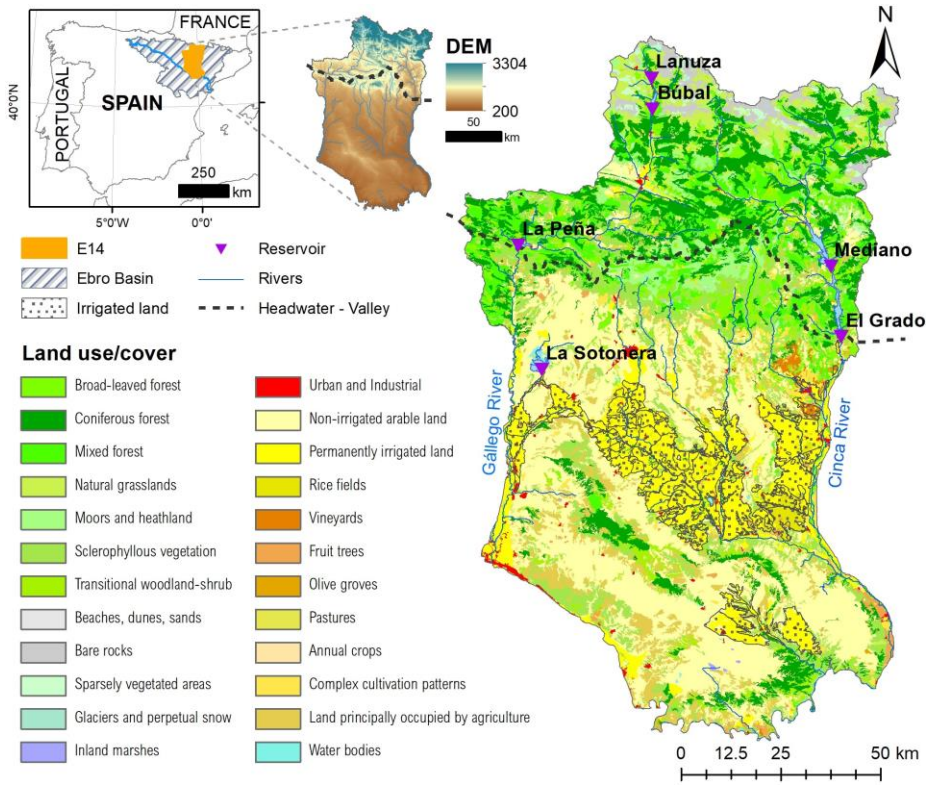


STUDY AREA

The **Riegos del Alto Aragón** is the largest irrigated system in Spain and in the European Union, with an irrigated area that currently exceeds 140,000 ha over a territory of 2,500 km^2 within the Gallego and Cinca Rivers system in the Ebro River basin.

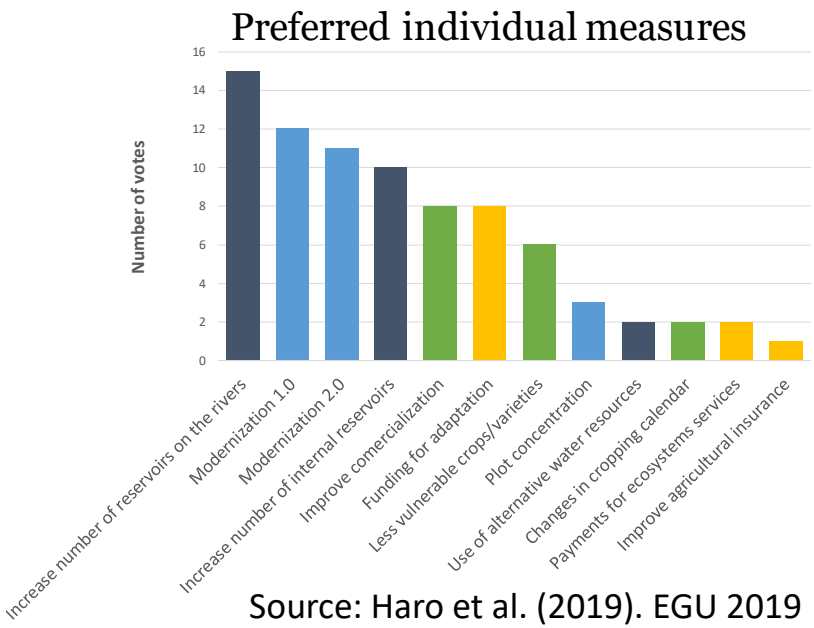


Water resources system facts

Surface (km^2)	12.235
Surface water resources (hm^3/year)	2.561,75
Groundwater resources (hm^3/year)	826,00
Urban Demand (hm^3/year)	19,49
Irrigation Demand (hm^3/year)	1.557,37
Industrial Demand (hm^3/year)	6,17
Environmental Demand (hm^3/year)	15,3
Installed Hydropower Capacity(MW)	510,74
Storage Capacity (hm^3)	1.218,14

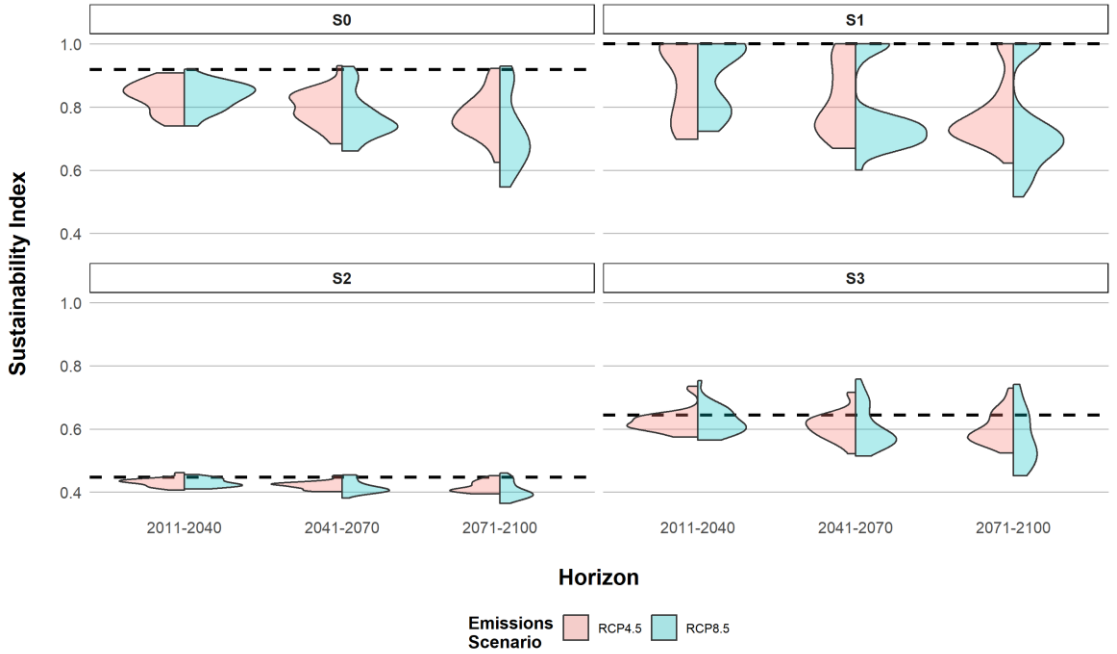
PREVIOUS WORK

Stakeholders would like that **more large reservoirs** were built in the system (Haro et al. (2019))



Source: Haro et al. (2019). EGU 2019

Palazon et al. (2019) and Haro et al. (2020) showed that new large reservoirs **would not allow maintaining current operating levels in the long-term**.



Sources: Palazon et al. (2019). EGU 2019
Haro et al. (2020). J Hydrol

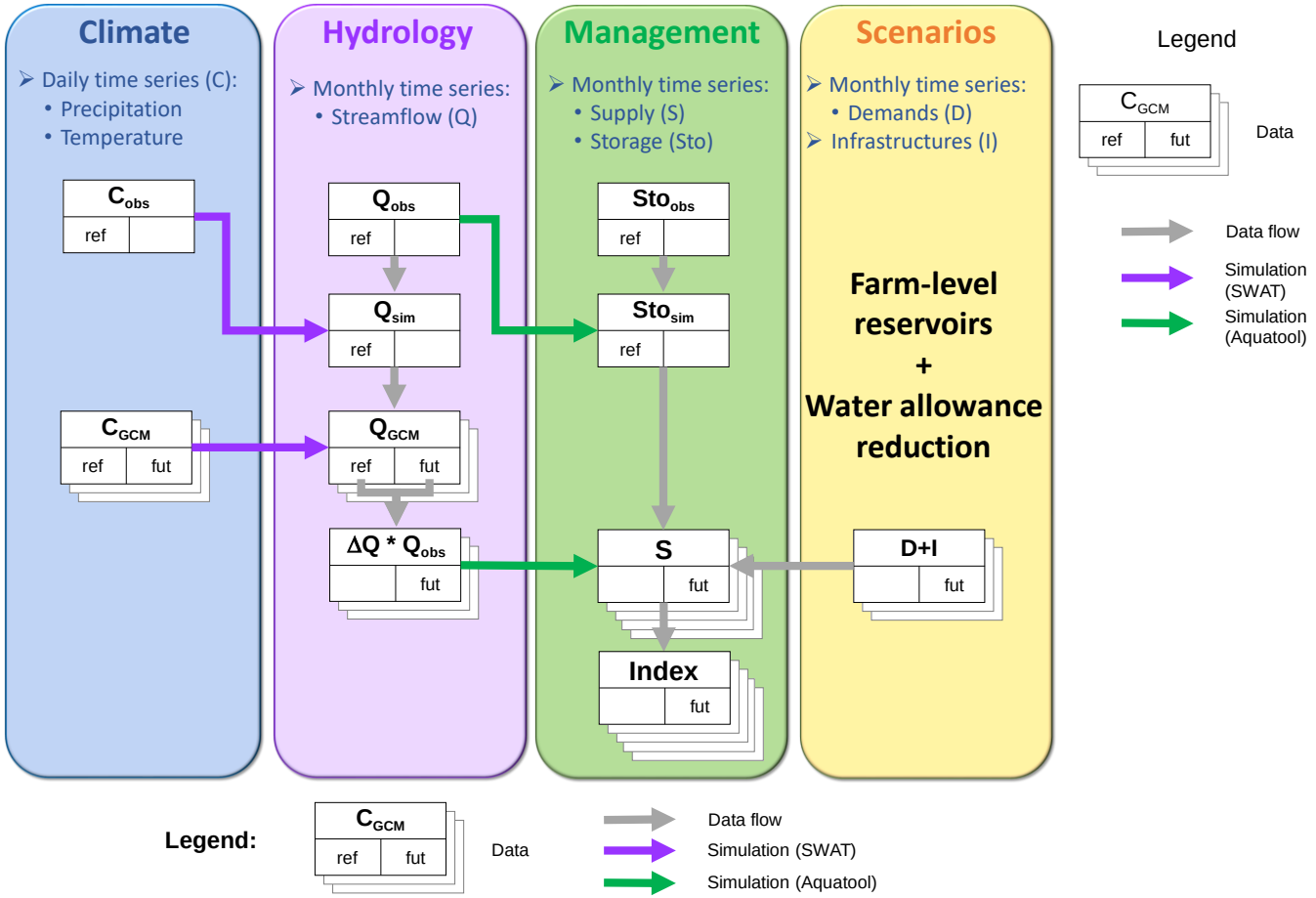
OBJECTIVES

1. Study the **effect of the construction of farm level irrigation farms** on the long-term performance of the system by means of various indicators
2. Assess the need to introduce further adaptation measures that **reduce irrigation water demand** for a more robust performance under climatic change

METHODOLOGY

Based on the multi-model and multi-scenario cascade modelling approach used to evaluate long/term sustainability of water resource systems proposed in Haro et al. (2020), a new set of scenarios was tested: construction of new irrigation reservoirs and water allowance reductions.

The construction of new irrigation reservoirs was represented as an irrigation water demand shift towards the winter (Dec, Jan, Feb).



RESULTS (I)

The construction of new irrigation reservoirs has a limited capacity to enhance performance indicators under current climate, even reducing notably the performance of some of them, and it is further shadowed by the effect of climatic change.

It must be noted that a reservoir size equivalent to a 10% of the demand already equals the size of a large on-river reservoir (155 hm^3), although spread across the territory.

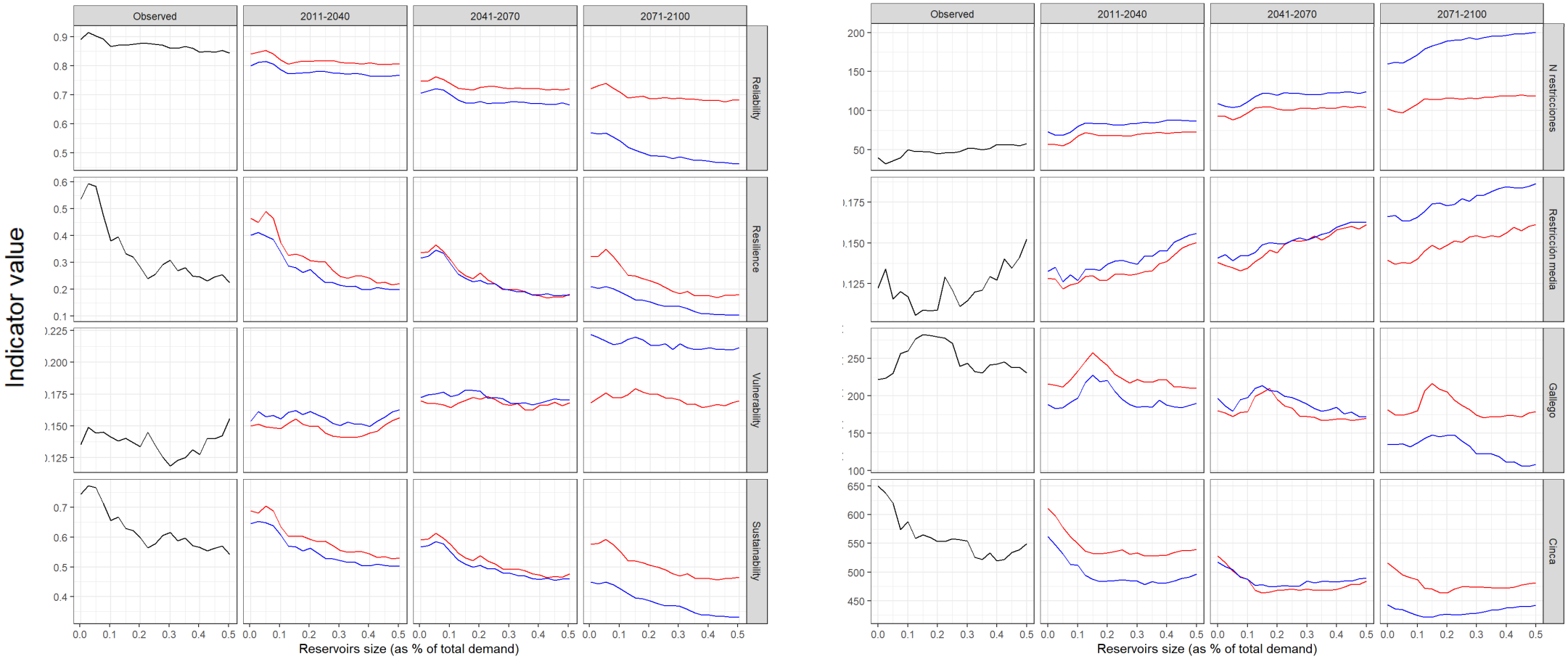


Figure: Evolution of performance indicators for the whole RAA system with the size of new irrigation reservoirs

RESULTS (II)

Maintaining current levels of operation will only be possible in combination with other measures that allow reducing irrigation water demand. Currently, farmers consider modernization measures (also of high preference as per Haro et al. (2019)), as means to improve their efficiency and thus being able to irrigate more, instead of a way to reduce irrigation water demand.

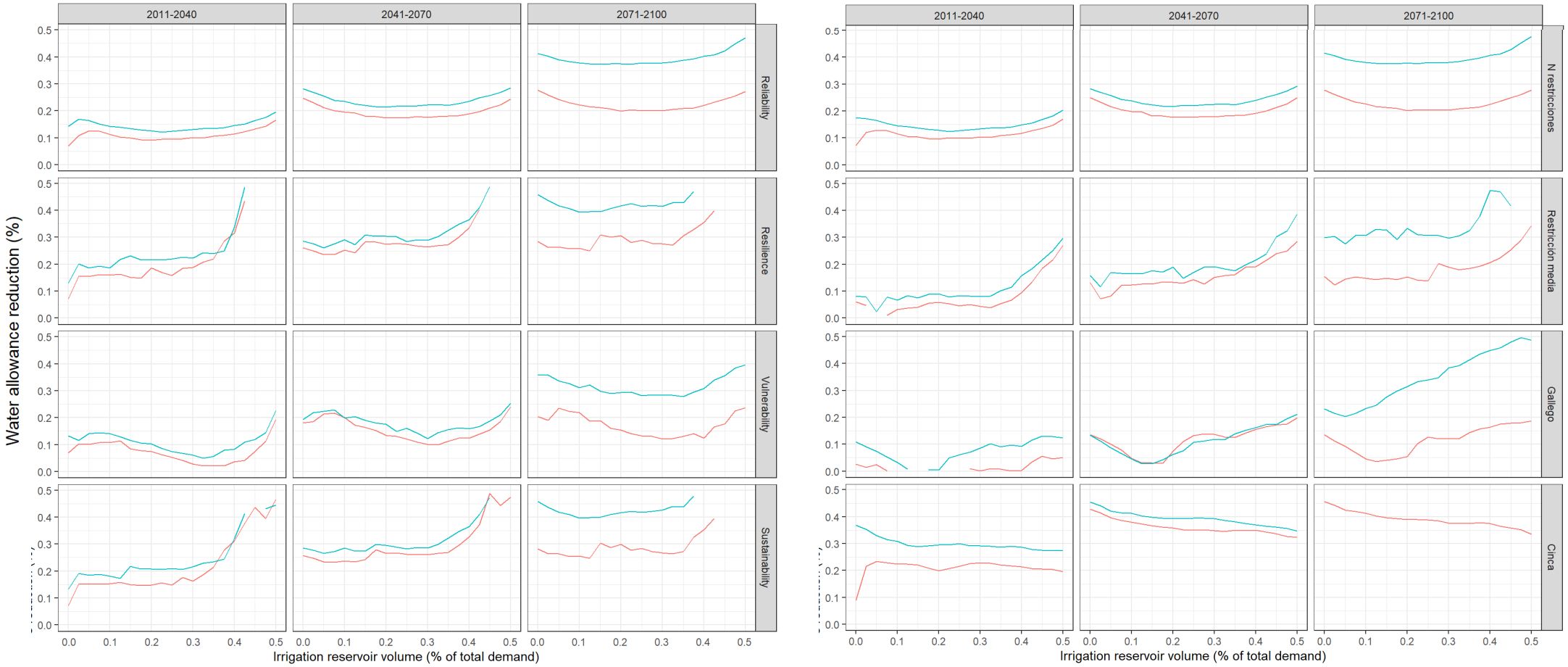


Figure: Water allowance reduction necessary to return to current performance levels for each indicator, future horizon, and irrigation reservoir size

CONCLUSIONS AND FURTHER WORK

- So far the modelling considers that irrigation reservoirs are built at a similar rate everywhere in the system. In the coming weeks, we will test if variable reservoir construction rates at each demand unit improves current results.

- Also, it is necessary to explore the solutions for irrigation reservoir sizes that do not exceed the equivalent size of an already large on-river reservoir

- Farmers will be informed about these results in a forthcoming meeting where new adaptation measures will be proposed (especially demand-oriented ones).

- Construction and operational costs will be considered together with the costs of demand-oriented measures in future work.

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Abstract

With a total irrigated area above 127,000 ha divided in 58 sectors, the Riegos del Alto Aragón (RAA) irrigation district is currently the largest irrigated area in Spain and in the European Union. Also, it is the largest water user within the Gallego-Cinca subsystem within the Ebro River Basin, which also supplies water to 588 livestock operations, 10 industrial polygons, and 110 populated areas. Although there are plans to increase the irrigated area by another additional 47,000 ha, the system is currently close to its resource limit and several supply restrictions took place in the last years with consequent impacts on agricultural productivity. Moreover, this expansion of the irrigated area collides with environmental objectives in the region, mostly due to water quality and nature conservancy aspects, as well as with other uses of water downstream.

The forecasted effects of climate change on future water resources produced in the Pyrenees (the major source of water in the system), as well as market prices, national and international trade and agricultural policies, among other variables, are surrounded by a high level of uncertainty that difficult investment decision-making. Some of the adaptation measures initially devised for the system, e.g. construction of new large reservoirs in the Gallego and Cinca rivers, require either confronting further environmental conflicts or large energy expenses, when not both. With the end of the era of large public works there is a need to identify new and robust strategies for climate change adaptation. One of these strategies is the construction of private on-farm reservoirs within the RAA system that started in recent years.

The present work evaluates the contribution of on-farm reservoirs to enhancing the long-term sustainability of the RAA system using a multi-model and multi-scenario approach. The Soil and Water Assessment Tool (SWAT) was used to simulate water provisions from the Gallego-Cinca headwater system under an ensemble of downscaled climate models. Afterwards, SWAT outputs were fed into a water allocation model built with AQUATOOL to simulate the management of the system's reservoirs, including on-farm reservoirs, and the water supply to the different demands. The performance of agricultural demands and compliance with environmental flow requirements in the system was evaluated for different on-farm reservoir sizes and combined with construction and operational costs to develop sustainability/investment curves. The outcomes have the potential to better inform decision-making from farmers in RAA as well as from managers in the Ebro River Basin Agency, providing further understanding of the system's dynamics under climatic change.