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## Environmental effects of irrigation modernization in The Violada District (Spain)

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The comparative environmental studies on the modernization of irrigation systems are generally based on different areas with different characteristics (soil, dominant crops, crop management, or even weather conditions), not allowing for comparing the environmental effects in the same pre- and post-modernized irrigation district. Thus, there is a need to analyze the effect of the modernization process through the use of actual, detailed data from the same irrigation district.

The Violada Irrigation District (VID; 5234 ha, widely studied since the 1980s), with 92% of the surface modernized in 2008-09 from gravity to pressurized irrigation, offers an ideal scenario to evaluate the environmental implications of irrigation modernization.

The main tools for this evaluation have been (i) the water balance in the VID, to characterize the main irrigation water flows and their concentrations in salts and N, (ii) the soil water balance, to determine the main crops consumption [corn, alfalfa and cereal actual evapotranspiration (ET<sub>a</sub>)]; and (iii) the farmers surveys to establish fertilization and cropping practices. With all this information under both systems, the differences between the water and nitrogen use efficiencies for the main crops have been established for surface and sprinkler irrigation.

Comparing periods with similar crop patterns, dominated by corn, the modernization reduced the water abstraction for irrigation, decreased irrigation return flows and increased the consumptive use by the crops. Altogether, the modernization left more high-quality water available for other uses in the basin.

The irrigation and fertilization management also changed considerably with the modernization, allowing for lower doses with higher frequencies, and increasing the crop yields. Corn (the main crop in VID) showed the highest decrease in nitrogen fertilization. Nevertheless, the total nitrogen inputs to the system slightly increased due to the introduction of double crops. Thus, the corn increased water use efficiency and the nitrogen use efficiency.

The salt and nitrogen loads exported decreased after modernization, due to the reduced irrigation return flows. Under surface irrigation, the salts leaching was mainly produced during the irrigation season while under sprinkler irrigation, it took place all the year-round, avoiding the higher salt loads to the water bodies during the period of lower flow, when their environmental impact would

be higher.

On the basis of the results obtained, it can be concluded that the modernization of the irrigation system caused a decrease in the flow restored to the basin, reduced the irrigation water depletion and preserved water quality globally. In this way, modernization leaves more water available for further uses and reduces the irrigation return flows and the pollutant loads associated with them. Finally, it was inferred that the salt and nitrogen loads emitted from the VID depend mainly on the irrigation system, and secondly, in regard to nitrogen only, on the prevailing crops.