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Supporting policies for irrigation adaptation to climate change through distributed agro-hydrological model simulations

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Increasing irrigation efficiency is one of the priority measures in climate change adaptation for vast world areas, where irrigation systems comprising of unlined open-channel networks for water conveyance and distribution and border or furrow irrigation methods for field water application are widespread.

The large-scale conversion from these systems to more hydraulically efficient ones can lead to a reduction in irrigation water requirements but, beyond requiring initial investments and involving higher operating costs, it can produce significant alterations of the rural landscape and impact on the aquifer recharge.

Our research aims at providing to decision-makers knowledge and information that support the selection of the zones where the reconversion of irrigation systems is more effective. The assessment is based on the use of a spatially distributed agro-hydrological model, which simulates on a daily basis all the processes involved, from the flow diversions form surface and groundwater bodies, to the water application on the individual plot of land, till the estimation of the actual crop yield.

A pilot study was carried out on a vast agricultural area in northern Italy irrigated with water diverted from the river Adda, outflowing from lake Como. The area covers a surface of 1,840 km2 that is cultivated almost exclusively with maize and fodder crops, where a dense network of open channels provides the water supply to the individual farms, that mostly use border irrigation. European agricultural policy calls for a reduction of irrigation water use and the local government plans to launch a measure to co-finance farmers who intend to modify their irrigation methods.

Running the agro-hydrological model simulations for the period 1993-2015, both the irrigation volumes supplied to the individual plots and the deficit with respect to the crop water requirements were estimated. A spatially distributed index of irrigation availability was then calculated, given by the ratio between the crop requirement and the actual supply from surface water diversions. The lower the value of the index the more a zone will suffer of production losses unless additional water supply is provided through pumping from groundwater, as more and more often is the case. A criterion for guiding the reconversion of irrigation methods should then give priority to the zones with low values of the index, thus achieving a reduction of both water use and energy consumption. These achievements were tested also for the climate variability for the incoming decade 2020-2030, through the downscaling of regional climate projections provided by the CORDEX project. Starting from a multi-model-ensemble analysis, the model combination ICHEC-EC-EARTH SMHI-RCA4 was then selected for the study. Therefore, the simulation results were summarized in a set of diagrams that, for any threshold value of the index, show: the extent of the total area to be reconverted, the expected water and energy savings, the variation in aquifer recharge and the estimated crop yields. The following step will be to include an evaluation of the reconversion costs and revenues, providing consistent indications to decision-makers, accounting for limitations of available financial resources.