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Assessment of climate change impacts on the Water-Energy-Food-Ecosystems (WEFE) nexus in the Jucar River Basin (Spain) using hydroeconomic and ecological modelling, and continental-scale economic projections

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In spite of the well-known interconnections found between water, energy, food and ecosystems, an integrated management of such components is seldom employed. On the contrary, several institutions at different levels (national, regional, local) take care of each component, which implies the existence of different (sometimes even opposite) interests that hinder a proper management of the WEFE nexus. Furthermore, drivers at multiple scales (e.g., energy prices, ecosystem protection standards) must be considered to enable a thorough WEFE evaluation. Hydroeconomic modelling can accommodate multi-level economic information while doing justice to the modelling detail required at the river basin scale.

This contribution combines hydroeconomic modelling, ecological (native fish habitat) modelling and continental economic projections to enable a comprehensive WEFE evaluation in the Jucar River Basin (Spain). This basin is characterized by intensive water use in agriculture, the existence of multiannual droughts, and a strong influence of European markets on agricultural goods. The Jucar river system is represented by a hydroeconomic simulation model that considers reservoirs and aquifers, urban and agricultural demands, hydropower plants, native fish habitat in selected fish streams and the water balance of the Albufera wetland, one of the most iconic water-dependent ecosystems in Spain. Climate projections from CMIP6 are used. These climate scenarios are transformed into hydrological projections using the fully distributed 250-m resolution TETIS eco-hydrological model. Urban demands are modelled using demand curves derived employing the point expansion method. Agricultural demands are addressed through the FAO33 methodology using the current crop mosaic and future crop water needs estimated using the AQUACROP model (herbaceous) and the FAO56 method combined with soil water balance modelling (citrus), both forced by the CMIP6 climate projections but assuming fixed CO2 concentrations. Native fish habitat is estimated using hydraulic models and fish preference curves, transformed into streamflow – habitat (WUA) curves for selected streams. Crop and energy prices were obtained from the continental CAPRI and PRIMES models, respectively.

Our results show that surface water resources would decrease in the future, while crop water

needs will increase. Nonetheless, the Jucar river system would hold a satisfactory performance level for climate projections referred to the SSP1_2.6 scenario. However, challenges in agricultural benefits and surface water use could arise in the SSP3_7.0 scenario, while the most pessimistic SSP5_8.5 scenario depicts a situation in which the system is heavily challenged and shows negative impacts for the whole WEFE nexus components. It can be concluded that the system's sustainability would only be likely if the 2^{o}C degree limit set by the Paris Agreement holds (SSP1_2.6). Otherwise, adaptation options would be required to guarantee sustainable WEFE management.

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