Climate change adaptation in a Mediterranean river basin based on Eco-Engineering Decision Scaling

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The Iberian Peninsula is considered a global change hot spot, where increases in agricultural demands and reductions in water resources availability are expected. In Spain, basin-scale tools for water resources planning have a long-term experience, but predicting simultaneously the impact of global change on agriculture and instream habitats is still challenging. This work adapted the methodology of Eco-Engineering Decision Scaling to evaluate the vulnerability of the Serpis River Basin to satisfy the water needs of freshwater habitats and agricultural uses under future climatic conditions.

Relevant performance indicators were selected for agriculture and fish habitat: reliability of supply for irrigation (%), and suitable area of habitat for one native and one invasive fish species (m2). Standard thresholds of reliability for irrigation and minimum environmental flows are well established in Spain, determining legal intolerable conditions on the managed river system. Consequently, a water resource system model of the Serpis River was implemented and calibrated in GAMS (General Algebraic Modeling System), to estimate these indicators.

Flow-habitat relation curves were developed upon habitat suitability models for the target fish species and a 2D hydraulic simulation covering the most habitual discharges. Multiple hydrological scenarios were built based on a weather generator, which creates synthetic precipitation (P) and temperature (T) annual time series, to carry out the vulnerability analysis. These series were modified (between ±30% on the mean and coefficient of variation for P and up to +3ºC on T) to create 60 climate change scenarios (for each the short, mid and long term). A total of 434 generation runs per scenario were developed in MATLAB® to explore model uncertainty. Each hydrological scenario was used to force a lumped hydrological model of the Serpis River and obtain the associated water yields, which were fed into the water resource system model to estimate performance indicators. System vulnerability was assessed upon maps of the performance indicators across the range of climate variables (P and T), which help understand the trade-offs among indicators and the overlapping domain of mutually acceptable performance.

The results of this methodological approach will be useful to define water management alternatives and adaptation measures by stakeholders. Under the current dam operation rules, the vulnerability analysis indicated increasingly reductions of reliability for agriculture in mid-term and long-term scenarios, as well as the habitat for native fish species. In addition, the implementation of additional components of the environmental flow regime (e.g., limitation of maximum flow in regular operation) suggests the need for further adaptation measures (e.g. dam re-operation) where the dialogues and equitability among the stakeholders will be fundamental to meet the multiple contrasting interests.

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