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# Hydro-economic optimization model for selecting least cost programs of measures at the river basin scale. Application to the implementation of the EU Water Framework Directive on the Orb river basin (France).

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This article presents a case study which illustrates how an integrated hydro-economic model can be applied to optimize a program of measures (PoM) at the river basin level. By allowing the integration of hydrological, environmental and economic aspects at a local scale, this model is indeed useful to assist water policy decision making processes. The model identifies the least cost PoM to satisfy the predicted 2030 urban and agricultural water demands while meeting the in-stream flow constraints. The PoM mainly consists of water saving and conservation measures at the different demands. It includes as well some measures mobilizing additional water resources coming from groundwater, inter-basin transfers and improvement in reservoir operating rules. The flow constraints are defined to ensure a good status of the surface water bodies, as defined by the EU Water Framework Directive (WFD).

The case study is conducted in the Orb river basin, a coastal basin in Southern France. It faces a significant population growth, changes in agricultural patterns and limited water resources. It is classified at risk of not meeting the good status by 2015. Urban demand is calculated by type of water users at municipality level in 2006 and projected to 2030 with user specific scenarios. Agricultural water demand is estimated at irrigation district (canton) level in 2000 and projected to 2030 under three agricultural development scenarios. The total annual cost of each measure has been calculated taken into account operation and maintenance costs as well as investment cost.

A first optimization model was developed using GAMS, General Algebraic Modeling System, applying Mixed Integer Linear Programming. The optimization is run to select the set of measures that minimizes the objective function, defined as the total cost of the applied measures, while meeting the demands and environmental constraints (minimum in-stream flows) for the 2030 time horizon. The first result is an optimized PoM on a drought year with a return period of five years, taken as a baseline scenario. A second step takes into account the impact of climate change on water demands and available resources. This allows decision makers to assess how the cost of the PoM evolves when the level of environmental constraints is increased or loosed, and so provides them a valuable input to understand the opportunity costs and trade-offs when defining environmental objectives for the long term, including also climate as a major factor of change. Finally, the model will be used on an extended hydrological time series to study costs and impacts of the PoM on the allocation of water resources. This will also allow the investigation of the uncertainties and the effect of risk aversion of decision makers and users on the system management, as well as the influence of the perfect foresight of deterministic optimization.

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