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Definition of scarcity-based water pricing policies through hydro-economic stochastic programming

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One of the greatest current issues in integrated water resources management is to find and apply efficient and flexible management policies. Efficient management is needed to deal with increased water scarcity and river basin closure. Flexible policies are required to handle the stochastic nature of the water cycle. Scarcity-based pricing policies are one of the most promising alternatives, which deal not only with the supply costs, but also consider the opportunity costs associated with the allocation of water. The opportunity cost of water, which varies dynamically with space and time according to the imbalances between supply and demand, can be assessed using hydro-economic models. This contribution presents a procedure to design a pricing policy based on hydro-economic modelling and on the assessment of the Marginal Resource Opportunity Cost (MROC). Firstly, MROC time series associated to the optimal operation of the system are derived from a stochastic hydro-economic model. Secondly, these MROC time series must be post-processed in order to combine the different space-and-time MROC values into a single generalized indicator of the marginal opportunity cost of water. Finally, step scarcity-based pricing policies are determined after establishing a relationship between the MROC and the corresponding state of the system at the beginning of the time period (month).

The case study of the Mijares river basin (Spain) is used to illustrate the method. It consists in two reservoirs in series and four agricultural demand sites currently managed using historical (XIVth century) rights. A hydro-economic model of the system has been built using stochastic dynamic programming. A reoptimization procedure is then implemented using SDP-derived benefit-to-go functions and historical flows to produce the time series of MROC values. MROC values are then aggregated and a statistical analysis is carried out to define (i) pricing policies and (ii) the relationship between MROC and status of the system. Finally, the effectiveness and flexibility of those pricing policies are analyzed using a hydro-economic simulation model. The results show that the use of scarcity-based pricing policies improves the current management practices, yielding almost as much economic benefits as SDP-derived policies. The fluctuations in the system state are quickly reflected in the supplies, giving the pricing policies enough flexibility to adapt to the stochastic nature of water resources. This work demonstrates that the adequate design and use of pricing policies can improve the efficiency and flexibility of water resources systems management.

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