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An integrated modeling approach to support management decisions of coupled bio-physical and socio-economic processes under multiple uncertainties

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The water resources management complexity increase when decisions about environmental and social issues are considered in addition to economic efficiency. Such complexities are further compounded by multiple uncertainties about the consequences of potential management decisions. In this paper, a new fuzzy-stochastic multiple criteria decision-making approach is proposed for water resources management in which a variety of criteria in terms of economic, environmental and social dimensions are identified and taken into account. The goal is to evaluate multiple conflicting criteria under uncertainties and to rank a set of management alternatives. The methodology uses a simulation-optimization water management model of a strongly interacting groundwater-agriculture system to enumerate criteria based on these bio-physical process interactions. Fuzzy and/or qualitative information regarding the decision-making process for which quantitative data is not available are evaluated in linguistic terms. Afterwards, Monte Carlo simulation is applied to combine these information and to generate a probabilistic decision matrix of management alternatives versus criteria in an uncertain environment. Based on this outcome, total performance values of the management alternatives are calculated using ordered weighted averaging. The proposed approach is applied to real world example, where excessive groundwater withdrawal from the coastal aquifer for irrigated agriculture has resulted in saltwater intrusion, threatening the economical basis of farmers and associated societal impacts. The analysis has provided potential decision alternatives which can serve as a platform for negotiation and further exploration. Furthermore, sensitivity of different inputs to resulting rankings is investigated. It is found that decision makers' risk aversion and risk taking attitude may yield different rankings. The presented approach suits to systematically quantify both probabilistic and fuzzy uncertainties associated with complex hydrosystems management.