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An integrated modeling approach to support management decisions of coupled groundwater-agricultural systems under multiple uncertainties

Yohannes Hagos Subagadis, Niels Schütze, and Jens Grundmann
Institute of Hydrology and Meteorology, TU Dresden, Dresden, Germany (yohannes.subagadis@mailbox.tu-dresden.de)

The planning and implementation of effective water resources management strategies need an assessment of multiple (physical, environmental, and socio-economic) issues, and often requires new research in which knowledge of diverse disciplines are combined in a unified methodological and operational frameworks. Such integrative research to link different knowledge domains faces several practical challenges. Such complexities are further compounded by multiple actors frequently with conflicting interests and multiple uncertainties about the consequences of potential management decisions. A fuzzy-stochastic multiple criteria decision analysis tool was developed in this study to systematically quantify both probabilistic and fuzzy uncertainties associated with complex hydrosystems management. It integrated physical process-based models, fuzzy logic, expert involvement and stochastic simulation within a general framework. Subsequently, the proposed new approach is applied to a water-scarce coastal arid region water management problem in northern Oman, where saltwater intrusion into a coastal aquifer due to excessive groundwater extraction for irrigated agriculture has affected the aquifer sustainability, endangering associated socio-economic conditions as well as traditional social structure. Results from the developed method have provided key decision alternatives which can serve as a platform for negotiation and further exploration. In addition, this approach has enabled to systematically quantify both probabilistic and fuzzy uncertainties associated with the decision problem. Sensitivity analysis applied within the developed tool has shown that the decision makers' risk aversion and risk taking attitude may yield in different ranking of decision alternatives. The developed approach can be applied to address the complexities and uncertainties inherent in water resources systems to support management decisions, while serving as a platform for stakeholder participation.