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Using scenario analysis to investigate uncertainty in water resource management

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Abstract:
Water resource management is a challenging task due to the complexity and uncertainty of the environmental systems and challenges of addressing multiple stakeholder perspectives. A crucial issue is therefore in specifically understanding if and how we can make decisions under such deep uncertainty.

We examined this issue in a case study which estimates groundwater sustainability, farm profit and ecological outcomes of many drivers (e.g. climate change, water policy, farm practices). An integrated model was developed for this purpose. It encompasses a surface and groundwater model, water allocation rules, a farm decision and crop model and an ecology model. Scenarios were generated to assess uncertainty in model assumptions (e.g. climate, crop price, water requirements of the ecosystem) and opportunities for interventions (e.g. water allocation rules, adoption of efficient irrigation techniques), accounting for stakeholder values in assessing the trade-offs between three outcomes/entities - environment, farm profit and groundwater sustainability. In general we selected upper and lower bounds for the uncertainty variables.

We found that the dominant uncertainties affecting outcomes are climate and market conditions, and four climate-market clusters were identified. Robust interventions could not be identified given the climate and market uncertainties, although analysis of scenarios within each climate-market cluster helped identify vulnerabilities and opportunities for joint interventions by surface water managers, groundwater managers and farmers. For example, under dry climate conditions and high crop prices, combinations of water allocation and flood irrigation efficiency measures are most effective in achieving multiple outcomes under uncertainty. This study demonstrates how analysis of scenarios can be used to identify patterns (here with clustering), diagnose the effect of state of knowledge and interventions on outcomes (e.g. using meta-modelling) and hence feed into deliberation processes (e.g. with iterative discovery).

Keywords: uncertainty, water management, trade-offs, climate, agriculture, water allocation