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Many-Objective de Novo Water Supply Portfolio Planning Under Deep Uncertainty

Joseph Kasprzyk (1), Patrick Reed (1), Gregory Characklis (2), and Brian Kirsch (2)

(1) Department of Civil and Environmental Engineering, Pennsylvania State University, State College, USA (preed@engr.psu.edu), (2) Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill, Chapel Hill, USA (charack@email.unc.edu)

This paper proposes and demonstrates a new interactive framework for sensitivity-informed de Novo programming, in which a learning approach to formulating decision problems can confront the deep uncertainty within water management problems. The framework couples global sensitivity analysis using Sobol' variance decomposition with multiobjective evolutionary algorithms (MOEAs) to generate planning alternatives and test their robustness to new modeling assumptions and scenarios. We explore these issues within the context of a risk-based water supply management problem, where a city seeks the most efficient use of a water market. The case study examines a single city's water supply in the Lower Rio Grande Valley (LRGV) in Texas, USA, using both a 10-year planning horizon and an extreme single-year drought scenario. The city's water supply portfolio comprises a volume of permanent rights to reservoir inflows and use of a water market through anticipatory thresholds for acquiring transfers of water through optioning and spot leases. Diagnostic information from the Sobol' variance decomposition is used to create a sensitivity-informed problem formulation testing different decision variable configurations, with tradeoffs for the formulation solved using a MOEA. Subsequent analysis uses the drought scenario to expose tradeoffs between long-term and short-term planning and illustrate the impact of deeply uncertain assumptions on water availability in droughts. The results demonstrate water supply portfolios' efficiency, reliability, and utilization of transfers in the water supply market and show how to adaptively improve the value and robustness of our problem formulations by evolving our definition of optimality to discover key tradeoffs.