EGU2020-19492
https://doi.org/10.5194/egusphere-egu2020-19492
EGU General Assembly 2020

Endogenous and Exogenous Uncertainty in Adaptive Water Resource Planning

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Water security can be susceptible to demand increases and climate change impacts. In this case interventions (new infrastructure and/or policies) must be made to meet future demands despite the timing and extent of supply-demand changes are unknown in advance. Given the potential large economic costs of water infrastructure, and the uncertainties in both future supplies and demands, formal planning under uncertainty techniques aiming for robustness and/or adaptability are warranted.

Staged water infrastructure capacity expansion optimization models help create flexible plans under uncertainty. In these models two types of uncertainties are realized. The first category is the exogenous uncertainty that can be incorporated into the optimization using an a priori scenario ensemble. The second category is the endogenous uncertainty for which the optimized timing and selection of interventions determines when and which uncertainties must be considered. Endogenous uncertainty is therefore 'decision-dependent' and cannot be considered as a priori set of scenarios.

This work describes an extension to an adaptive multistage real options water infrastructure planning optimization problem formulation to incorporate endogenous uncertainty and describe its effect on cost and option selection. We show how endogenous uncertainty propagates when making planning decisions over time on a synthetic case study. The results are contrasted with the deterministic formulation in terms of option activations and the expected present value of the cost.