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Levelised cost distribution curves and global sensitivity analysis for assessing managed aquifer recharge scheme viability under uncertainty

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Abstract: Managed aquifer recharge (MAR) operated for long-term storage and strategic supply through 'water banking' has proven to increase drought resilience in the United States (Megdal and Dillon, 2015). Uncertainty around the economic viability of MAR, however, has been a barrier to implementation. This study presents a framework using a probabilistic approach with global sensitivity analysis to account for uncertainty and identify critical factors that influence costs. The approach considers time-varying and volume dependent operating conditions and costs. The framework is applied across a plausible range of operating scales and conditions to produce translatable cost curves to indicate viability and prioritise investigations to reduce assessment uncertainty for a variety of cases.

Levelised cost (LC) (or cost effectiveness) of water supplied using MAR is a readily comparable metric that accounts for amortised capital and operating expenses over the life of a project per unit produced (e.g. water volume of water supplied). LC avoids assumptions about potential benefits and externalities, enables direct comparison with alternatives, and is transferable across system types, scales and applications (Ross and Hasnain, 2018). Models that simulated MAR scheme operations and estimated costs used a water balance function to handle volumes in and out of the aquifer, and a net present value function for financial assessment. Models were driven by a hydrological series and a series of stochastic inputs. Water balance functions generated the volumetric time series for calculation of volume-dependent operating costs that were variably discounted over the project life. Outputs included volumes recharged and recovered, LC of recharged and recovered water, and disaggregated capital and operating costs. Global sensitivity analyses explored the full parameter space to assess relationships between distributions of input variables and model outputs.

Resulting LC curves for MAR systems revealed that the cost of recovered water could be expected to be three to four times the cost of recharge for equivalent scheme types, scales and conditions. LC estimates were generally within the range of costs for similar schemes reported internationally. Proportional errors around mean estimates of LC of recovered water were up to two times higher for smaller (<1 GL/y) compared to higher (5 GL/y) capacity infiltration basin schemes. Cost curves revealed efficiencies of scale were subject to diminishing returns beyond a certain size. Disaggregated cost analyses showed the dominance of different capital and operating expenses are likely to change according to scheme size and type. Global sensitivity analyses conducted for best- and worst-case scenarios revealed that the most sensitive variables that influence costs can change under different operating scales and conditions. This form of meta-sensitivity analysis examines how sensitivities change if parameters or inputs change and can indicate where there are non-linearities and tipping points. Ultimately, this approach was able to identify the most important factors influencing scheme costs for different scenarios to prioritise investigations for reducing uncertainty in viability assessments. The framework is broadly applicable for assessments of other types of projects, especially those with time-varying operation and significant uncertainty.

REFERENCES

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