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Integration of operational and infrastructure decisions into long-term planning and management of water resources systems under deep uncertainty

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Abstract: Long-term planning and management of water resources systems is increasingly complicated by deep uncertainty. Deep uncertainty, driven by long-term climate, technology and socioeconomic changes, affects how water resources systems perform in the long run, as water availability and demand patterns can shift in unpredictable ways over time. In addition, water resources systems are required to meet multiple and often competing management objectives, such as providing reliable water supply, controlling floods during extreme events, maintaining environmental flow requirements, and generating hydropower to support energy needs.

To address these challenges, several planning strategies have been developed to assist decision-making under deep uncertainty. For example, the adaptation of operation policy can be used to delay expensive infrastructure upgrades until they are absolutely necessary (Huang et al., 2024). This can be achieved through the re-optimisation of operation policies under a wide range of plausible future conditions, so that adequate performance can be maintained for a longer period of time no matter how the future unfolds. As the adaptation of the operation policy itself may be insufficient to maintain system performance, decisions on when and how to implement infrastructure upgrades must also be taken into account in long-term planning and management of water resources systems. However, there is limited understanding of how to best incorporate both operational and infrastructure decisions into long-term planning and management, so that water resources systems can be planned and managed in a fully coordinated manner to maintain satisfactory system performance under deep uncertainty.

In order to address this shortcoming, in this study, a comprehensive framework based on multi-objective optimisation has been developed to jointly optimise the adaptation of operation policy and the timing and scale of infrastructure upgrades under deep uncertainty. A reservoir planning and management problem in Northern Australia has been used as the case study. The application of the framework to the case study system demonstrates benefits, as the integration of operational and infrastructure decisions leads to cost-effective solutions. Results show that hundreds of millions of Australian dollars can be saved without compromising system performance. The framework contributes to advancing the decision-making process under uncertainty and supports more integrated and forward-looking planning and management of water resources systems.

REFERENCES

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