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Many-objective reservoir policy identification and refinement to reduce institutional myopia in water management

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Current water reservoir operating policies are facing growing water demands as well as increasing uncertainties associated with a changing climate. However, policy inertia and myopia strongly limit the possibility of adapting current water reservoir operations to the undergoing change. Historical agreements and regulatory constraints limit the rate that reservoir operations are innovated and creates policy inertia, where water institutions are unlikely to change their current practices in absence of dramatic failures. Yet, no guarantee exists that historical management policies will not fail in coming years. In reference to policy myopia, although it has long been recognized that water reservoir systems are generally framed in heterogeneous socio-economic contexts involving a myriad of conflicting, non-commensurable operating objectives, the broader understanding of the multi-objective consequences of current operating rules as well as their vulnerability to hydroclimatic uncertainties is severely limited.

This study proposes a decision analytic framework to overcome both policy inertia and myopia in complex river basin management contexts. The framework combines reservoir policy identification, many-objective optimization under uncertainty, and visual analytics to characterize current operations and discover key tradeoffs between alternative policies for balancing evolving demands and system uncertainties. The approach is demonstrated on the Conowingo Dam, located within the Lower Susquehanna River, USA. The Lower Susquehanna River is an interstate water body that has been subject to intensive water management efforts due to the system's competing demands from urban water supply, atomic power plant cooling, hydropower production, and federally regulated environmental flows. The proposed framework initially uses available streamflow observations to implicitly identify the current but unknown operating policy of Conowingo Dam. The quality of the identified baseline policy was validated by its ability to replicate historical release dynamics. Starting from this baseline policy, we then combine evolutionary many-objective optimization with visual analytics to discover new operating policies that better balance the tradeoffs within the Lower Susquehanna. Results confirm that the baseline operating policy, which only considers deterministic historical inflows, significantly overestimates the reliability of the reservoir's competing demands. The proposed framework removes this bias by successfully identifying alternative reservoir policies that are more robust to hydroclimatic uncertainties, while also better addressing the tradeoffs across the Conowingo Dam's multi-sector services.