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A quantitative framework for assisting the development of river basin planning pathways under climate change

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Hydroclimatic nonstationarity due to climate change poses challenges for making water infrastructure planning decisions in river basin systems. While decisions that are flexible or adaptive hold intuitive appeal, identifying sequences of well-performing decisions or planning pathways requires rigorous quantitative analysis that address uncertainties directly while making the best use of scientific information on the expected evolution of future climate. Multi-period stochastic optimization (MSO) offers a potentially effective and efficient technique for addressing this challenge, however the necessity of assigning probabilities to future climate states or scenarios is an obstacle to implementation, given that methods to reliably assign probabilities to future climate states are not well developed. We present a method that overcomes this challenge through a framework that decreases the dependency on probability distributions of future climate and rather evaluates them after optimization to aid selection amongst competing planning alternatives. The framework begins with generating a scenario-tree to represent a wide range of plausible climate futures considering natural climate variability and gradual changes in climate. The MSO model is then solved iteratively, by systematically replacing the probability weights within the scenario-tree. The iterative process yields a vector of 'optimal' planning pathways each under the associated set of probabilistic assumptions. In the final phase, the vector of optimal pathways is evaluated to identify the solutions that are least sensitive to the scenario probabilities and are most-likely conditional on the climate information. The proposed framework is illustrated for the planning of new dam and hydro-agricultural expansion projects in the Niger River Basin in West Africa over a 60-year planning period from 2020 to 2080.