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Effect of reservoir zones and hedging factor dynamism on reservoir adaptive capacity for climate change impacts

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Hedging is universally recognised as a useful surface water operational practice for temporally redistributing water shortages and thereby avoiding occasions of large, crippling water shortages. However, when based on the zones of available water in storage, hedging has traditionally used a single hedged zone (below the unhedged zone) and a constant rationing ratio that limits the amount of water supplied in the hedged zone. Given the usual seasonality of reservoir inflows, it is also possible that hedging could feature multiple hedged zones and dynamic (i.e. temporally (seasonally, monthly) varying) rationing ratios but very few studies addressing this have been reported especially in relation to adaptation to climate change impacts. This study has developed Genetic Algorithms (GA) optimised zone-based operating policies of various configurations using data for the Pong reservoir, Himachal Pradesh, India. The derived policies were alternatively used to drive behaviour simulations of the reservoir for the purpose of assessing the effect of multiple hedging zones as well as dynamic rationing ratios on the performance of the reservoir during climate change. The results show that without hedging, the reservoir vulnerability was unacceptably high ($\geq$ 60%); this further deteriorates as the catchment becomes drier due to projected climate change. The reliability indices, volume-based and time-based, were generally greater than 80% throughout. The introduction of a single hedged zone with constant (or static) rationing ratio drastically reduced the vulnerability to less than 25%, although the hedging reduction in water supplied was a mere 17%. Further simulations employing either the multi-zone hedging policies or dynamic rationing ratios produced only modest improvements in the vulnerability situation. The significance of this study is its demonstration of the effectiveness of hedging in offsetting the water shortage vulnerability caused by climate change and the fact that hedging does not have to be over-complex to be effective, since simple, single zone hedging with a constant rationing ratio has been shown to be as effective as much more complex multi-zone, multi- rationing-ratios hedging schemes.