

Water sharing policies for drought conditions to inform Grand Ethiopian Renaissance Dam operations

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Abstract

Water resources infrastructure is critical for energy and food security, however, the development of large-scale infrastructure, such as hydropower dams, may significantly alter downstream flows, potentially leading to water resources management conflicts and disputes, especially in transboundary river basins. Mutually agreed upon water sharing policies for the operation of existing or new reservoirs is one of the most effective strategies to mitigate conflict, yet this is a complex task involving the estimation of available water, identification of users and demands, procedures for water sharing, etc. We propose a water-sharing policy framework that incorporates streamflow forecasts and reservoir operating rules optimization based on user demand estimation. Specifically, we first establish the trade-off between downstream and upstream water availability utilizing multi-objective optimization of reservoir operating rules. Next, we simulate reservoir operation with the candidate (optimal) rules, evaluate their performance, and select the most suitable rules for balancing water uses. Finally, we build a relationship between the reservoir operations simulated from the selected rules and the available hydroclimatic forecast to derive water-sharing policies. We apply this framework to reservoir operation of the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River and validate the performance of the water sharing policy by using perfect and actual GERD inflow forecasts. We find that the derived water sharing policy can balance GERD power generation and downstream water uses, especially in dry conditions, effectively sharing the hydrologic risk in inflow variability among riparian countries. The proposed framework offers a robust approach to inform water sharing contingent on streamflow forecasts for sustainable management of transboundary water resources.

Keywords: GERD, Transboundary rivers, Water-sharing-policy, Reservoir operating rules, Blue Nile River