EGU26-10124, updated on 13 Jun 2026
https://doi.org/10.5194/egusphere-egu26-10124
EGU General Assembly 2026

A Pareto-Based Simulation–Optimization Framework for Decision Support in Reservoir Cascades: A Transboundary River Basin Case Study

Matin Rafipour-Langeroudi[1], Ali Moridi[2], and Amir Hatamkhani[3]

[1]University of Oulu, Water, Energy and Environmental Engineering Research Unit, Oulu, Finland (matin.rafipour@oulu.fi)
[2]Civil, Water and Environmental Engineering Faculty, Shahid Beheshti University, Tehran, Iran (a_moridi@sbu.ac.ir)
[3]Civil, Water and Environmental Engineering Faculty, Shahid Beheshti University, Tehran, Iran (amir.hatamkhani@gmail.com)

Transboundary water negotiations are often constrained by limited quantitative understanding of how reservoir operating choices translate into sectoral gains and losses. This study presents a Pareto-based simulation–optimization framework to support negotiation-oriented decision-making by mapping operational and design-related trade-offs in multipurpose reservoir cascades. The framework integrates the WEAP water allocation model with a multi-objective particle swarm optimization (MOPSO) algorithm to explore combinations of reservoir storage targets, release policies, and hydropower capacities that jointly influence winter energy production and downstream irrigation supply reliability. Instead of identifying a single preferred strategy, the approach produces a Pareto front representing feasible compromise solutions between conflicting objectives. This methodology has been applied to the Vakhsh River, a primary tributary of the Amu Darya, where the ongoing development of the Rogun Dam has raised significant concerns about the future of agricultural water security in downstream countries. Application results show that operating strategies maximizing winter energy production reduce downstream irrigation reliability by approximately 40%, while prioritizing downstream supply leads to about a 50% reduction in winter hydropower generation. The shape of the Pareto front further reveals intermediary operating regions where moderate energy reductions yield disproportionately large improvements in downstream reliability, highlighting operational leverage points for negotiated agreements. By identifying compromise operating regions and quantifying system sensitivities, the proposed framework supports cooperative planning and evaluation of operational flexibility in regulated transboundary river systems.