

# Review the Effectiveness and Limitations of Modelling Downstream Impacts on Nile Hydropower Dams

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**Abstract:** Conflicts frequently arise between countries over shared transboundary river resources, especially in developing regions where water is crucial for agriculture, energy production, and drinking water. Hydropower dams, in particular, present challenges for downstream water availability on these rivers. The Eastern Nile River Basin, which supports a rapidly expanding population of 300 million, is grappling with a shortage of water and energy that fails to satisfy its increasing needs. The urgent requirement to address the rising energy demands upstream and the downstream issues of water scarcity, exacerbated by the Nile's unpredictable hydroclimatic conditions, have hindered the creation of a cooperative framework for managing the Grand Ethiopian Renaissance Dam (GERD) despite over thirteen years of negotiations. The key to resolving the ongoing water dispute in the Eastern Nile River Basin lies in maximizing hydropower generation from the upstream mega-dams on the Nile during prolonged droughts while also reducing the water shortage downstream. Numerous modeling initiatives have advocated for a comprehensive agreement that considers the interests of all three Riparian nations. Despite these calls being echoed in prominent publications over recent years, such an agreement has yet to be realized. In this study, we reproduce these hydraulic simulations and emphasize the limitations and effectiveness of the various methods employed. Specifically, we illustrate the replication of recent modeling efforts and the variation in outcomes when evaluating the downstream effects during extended drought periods, highlighting how incorrect assumptions can lead to flawed conclusions. We pinpoint the underlying cause of these numerical inconsistencies and stress the importance of transparent data sharing in modeling endeavours to make them feasible for both downstream and upstream water and hydropower research communities. Our hydraulic replication for water-energy trade-off studies underscores the necessity for increased data sharing and input transparency in these modeling efforts to effectively mitigate disputes among the river basin riparian.

**Keywords:** Nile; GERD; Hydropower dam; Water Management.