

# **Exploring the Complexities of Dams' Impact on Transboundary Flow: A Meta-Analysis of Climate and Basin Factors**

Abubaker Omer\*, Hyungjun Kim\*\*

.....

## **Abstract**

The impacts of dams on transboundary flow are complex and challenging to project and manage, given the potential moderating influence of a broad range of anthropogenic and natural factors.

This study presents a global meta-analysis of 168 studies that examines the effect magnitude of dams on downstream seasonal, annual flow, and hydrological extremes risk on 39 hotspot transboundary river basins. The study also evaluates the impact of 13 factors, such as climate, basin characteristics, dams' design and types, level of transboundary cooperation, and socioeconomic indicators, on the heterogeneity of outcomes. The findings reveal that moderators significantly influence the impact of dams on downstream flow, leading to considerable heterogeneity in outcomes. Transboundary cooperation emerges as the key factor that determines the severity of dams' effect on both dry and wet season's flows at a significance level of 0.01 to 0.05, respectively. Specifically, the presence of water-supply and irrigation dams has a significant (0.01) moderating effect on dry-season flow across basins with high transboundary cooperation. In contrast, for wet-season flow, the basin's vulnerability to climate extremes is associated with a large negative effect size. The various moderators have varying degrees of influence on the heterogeneity of outcomes, with the aridity index, population density, GDP, and risk level of hydro-political tension being the most significant factors for dry-season flow, and the risk level of hydro-political tension and basin vulnerability to climate extremes being the most significant for wet-season flow.

The results suggest that transboundary cooperation is crucial for managing the impacts of dams on downstream flow, and that various other factors, such as climate, basin characteristics, and socioeconomic indicators, have significant moderating effects on the outcomes. Thus, context-specific approaches are necessary when predicting and managing the impacts of dams on transboundary flow.

**Keywords:** Dams, Transboundary-flow, Hydrological-extremes, Transboundary-cooperation, socioeconomic indicators

### **Acknowledgment**

**This study is supported by Brain Pool (BP) program initiated by the Ministry of Science and ICT (MSIT) and National Research Foundation of Korea (NRF)**

---

\* Member · Post-Doc Dept. of Applied Science Research Institute, KAIST · E-mail: a\_omer@kaist.ac.kr

\*\* Associate Professor, Dept. of Moon Soul Graduate School of Future Strategy, KAIST