Spatiotemporal Evolution of Water Bodies in the Tarbela Dam Region: Drought Impact and Propagation Mechanisms Using Google Earth Engine

Muhammad Shahab[1,2*], Liaqat Ali[2], Fahad Alshehri[1], Izaz Aziz[2], Manzoor Ilahi[2]

[1] *Abdullah Alrushaid Chair for Earth Science Remote Sensing Research, Geology and Geophysics Department, College of Science, King Saud University, P.O. Box 2455, Riyadh 11451, Saudi Arabia.*

[2] *GIS and Space Application in Geosciences Lab, National Centre of Excellence in Geology, University of Peshawar*

**Email: shahabgeo07@gmail.com*

This study examines the spatiotemporal dynamics of water bodies in the Tarbela Dam region, leveraging transition mapping and pixel-level analysis to identify key hydrological changes and their potential drivers. Using remote sensing data, water bodies were classified into nine distinct transition classes, including permanent, seasonal, and ephemeral categories, as well as their respective transformations. Results reveal significant losses of permanent water bodies, the emergence of new seasonal and permanent features, and transitions from seasonal to stable regimes, indicating both hydrological variability and human-induced changes. Quantitative pixel-based analysis further corroborates these findings, showing high recurrence and stability in permanent water bodies, alongside marked reductions in occurrence and seasonality in areas categorized as "lost permanent" or "lost seasonal." The observed changes are attributed to a combination of climate change, sedimentation, and anthropogenic factors such as upstream water management and land-use changes. For instance, the emergence of new seasonal water bodies may reflect extreme rainfall events linked to climatic variability, while the stabilization of seasonal bodies into permanent water features could result from reservoir operations and increased groundwater inflows. These transitions have profound implications for regional water availability, biodiversity, and ecosystem services, highlighting the need for sustainable water resource management. This research underscores the importance of integrated watershed management strategies to address the loss of critical water resources and mitigate the impacts of climate change. Policymakers must prioritize interventions such as afforestation, optimized irrigation practices, and rainwater harvesting to safeguard water bodies and ensure sustainable development in the Indus River basin. Future research should focus on combining remote sensing data with hydrological and socio-economic models to further unravel the complex drivers of water body changes and enhance regional water resilience. By providing a detailed assessment of water body dynamics in a key hydrological region, this study contributes valuable insights into the challenges and opportunities for water management under changing climatic and anthropogenic conditions.

Keywords: Water body dynamics; Spatiotemporal analysis; Hydrological transitions; Google Earth Engine; Climate change impacts