Short Abstract

The recent increase in human activities, such as the construction of dams along rivers, has led to significant hydrological changes in downstream regions. A significant effect of dam construction is the disruption of natural flow patterns leading to erratic water levels, seasonal fluctuations, and sporadic sediment transport. This study introduces a modelling framework to analyze the downstream flow impact of hydropower dams. The framework comprises both a reservoir operation model and a hydrodynamic model. A comprehensive investigation was undertaken to assess the hydropower dams' influence across the entire water year. Moreover, a detailed examination was conducted to characterize the outflow hydrographs from Inter Basin Water Transfer (IBWT) and Non Inter Basin Water Transfer (NIBWT) hydropower dams. For NIBWT hydropower, Lower Subansiri Hydropower Project is considered for the analysis. Results showed that with the presence of the dam, the flashy characteristic of the outflow hydrograph increases. Thus, dam-induced flood is a combination of regional flood as well as flash flood. Based on the statement ranking of the dam-induced flood was provided among the global hazards considering the factors suggested by Bryant. To assess the flow contribution by the ungauged tributaries downstream of the dam, a streamflow generation module was developed using the Drainage Area Ratio (DAR) incorporated into the developed model and applied in the operational IBWT hydropower project.

The impact of the operational IBWT hydropower dam in downstream areas during the flood period was investigated by coupling the reservoir operation and hydrodynamic models. An inflow forecast-based adaptive flood moderation model was developed using simulation optimization of the coupled reservoir operation and hydrodynamic model. The Ranganadi Hydropower Project (RHEP) which is an IBWT hydropower project was considered in the analysis. The analysis quantifies of advanced-release assuming perfect forecasts over diverse inflow forecast horizons (FH) before the arrival of the flood. The framework also incorporated a Monte Carlo Simulation (MCS) based generated inflow into the coupled model. The analysis stated that the Effective Forecast Horizon (EFH) is more sensitive to the magnitude of the inflow peak than the inflow volume. The EFH for RHEP was found to be 12 hours A sensitivity analysis was performed on the adjusted operating policy, considering inflow peak flow and variable peak flow arrival times to assess the system performance. The analysis stated that the risk associated with the flood peak arriving early is more than the peak arriving later than the expected time of arrival of flood peak.For the lean period, the study also investigated the impact of IBWT hydropower dams on the downstream habitat of the IUCN red-listed endangered species, Tor Putitora. Additionally, the research evaluated the feasibility of releasing different environmental flows (EFs) from the reservoir to fulfil downstream EFR requirements while maintaining acceptable power production efficiency.

Keywords: Reservoir Operation Model, Hydrodynamic Model, Dam Induced Flood, Effective Forecast Horizon, Environmental Flow