E203

Impacts of Proposed Hydropower Dams on Stream Flow

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1. Introduction

The flow regime plays a significant role in the hydrological process of a river basin. Change in streamflow will have direct impacts on the river ecosystem. The rapid economic development of the Mekong region has led to massive construction of water infrastructures such as hydropower dams and large irrigation schemes. Large hydropower dams have been built in China since the 1990s. While hundreds more are being built and planned throughout the basin, especially the tributaries of the Mekong River Basin[1]. Existing and on-going construction of these dams, mainly the mainstream, will alter the streamflow, flood characteristics, and river ecosystem of the basin. The main objective of this study is to assess the impacts of existing and planned dams on streamflow characteristics using the distributed hydrological model.

2. Study Area

The Mekong River Basin (MRB) is known as the largest basin in Southeast Asia. Originated in the Tibetan highlands, the Mekong River is shared by six riparian countries of China, Myanmar, Laos, Thailand, Cambodia, and Vietnam. It covers a drainage area of 795,000 km^2, with an average annual discharge of 14,500 m^3/s or 475 km^3/year. The hydrological cycle is driven by the Southeast Asian monsoons, with an average precipitation of 1,500 mm/year[2]. In general, the Lancang River in China, about 24% of the total drainage area, is recognized as the upper Mekong Basin (UMB). While the Lower Mekong Basin (LMB) flows across the other five countries. The number of existing and planned hydropower in the MRB is about 145, including 22 on mainstream of MRB.

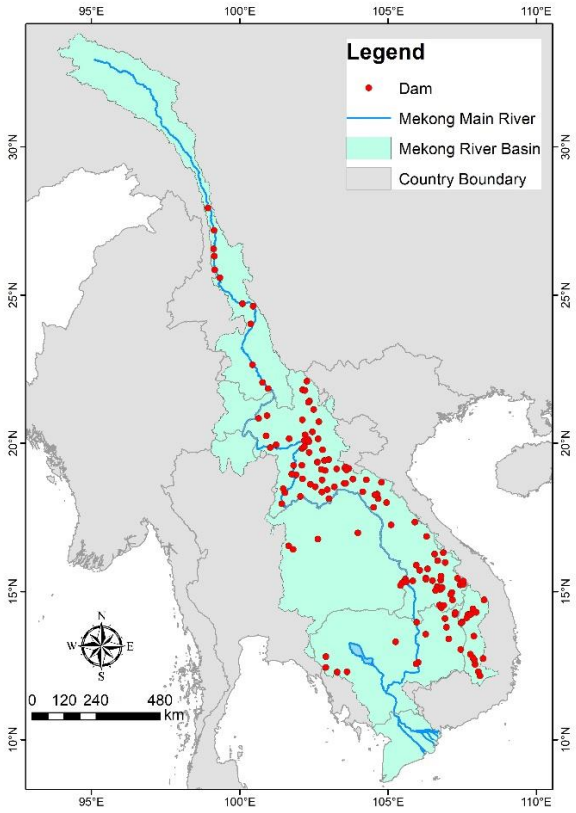

Figure 1. Map of the Mekong River Basin and location of the hydropower dams

3. Methodology

Rainfall-Runoff-Inundation (RRI) Model

RRI model is a two-dimensional model that can simulate rainfall-runoff and flood inundation at the same time[3]. The flow in the slope grid cells is calculated with the two-dimensional diffusive wave model while the channel flow is calculated with one-dimensional diffusive wave model. The model also considers subsurface and vertical infiltration flow governed by the discharge-hydraulic gradient relationship and the Green-Ampt method, respectively. The flow interaction between the river channel and slope is computed at each time-step depending on

water-level and levee-height conditions.

With the built-in dam function of the RRI, the model can simulate the effect of dam reservoirs in the MRB. The objective function of the reservoir operation rule in this study is to maximize the power generation from the hydropower. Hydrologic model RRI is used to simulate the discharge from 1982 to 2016.

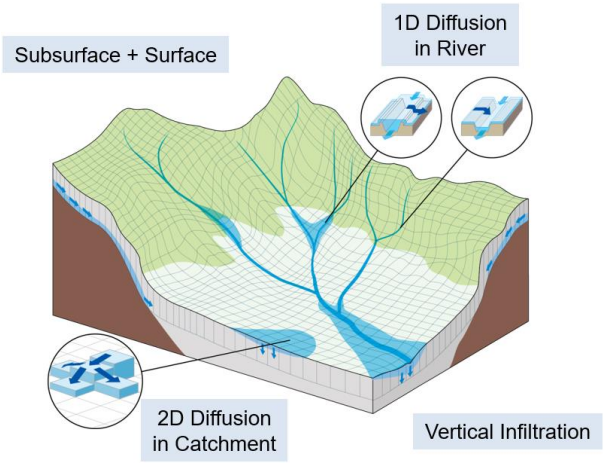

Figure 2. Schematic of RRI model

4. Results and Discussions

Streamflow of the MRB is simulated by the distributed hydrological model RRI. The model simulated the discharge in two conditions, with and without the dams. The flow characteristics such as peak annual discharge, average monthly discharge, low flow, and high flow were assessed. The preliminary result showed that the flow regime in the MRB will be subject to moderate alteration when all the hydropower dams are fully operated. The impacts can be seen clearly at the monthly-scale and seasonal-scale at the downstream of the LMB. When all existing and planned dams are in operation together, a further result at Kratie station (Cambodia) suggested that the discharge in the dry season will increase on average by 38 percent, while in the wet season will decrease by 4 percent compared to the baseline scenario (without dams). On the other hand, the low flow (Q95) will increase by 33 percent and the high flow (Q5) will decrease by 8 percent. Our analysis showed that the operation of hydropower dams is likely to impact the downstream of LMB, particularly during the dry season.

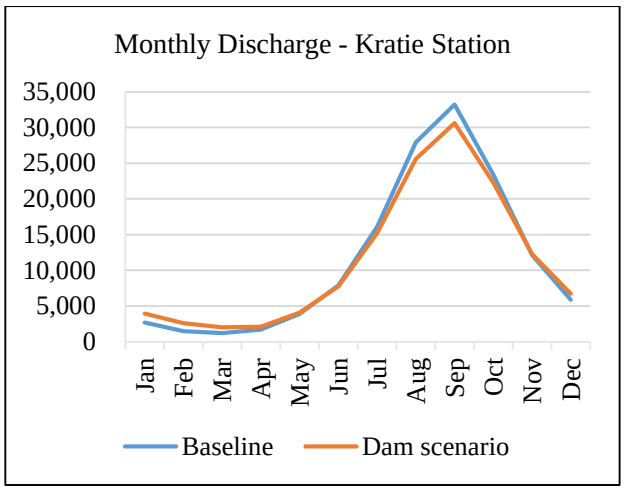

Figure 3. Average monthly discharge at Kratie station

5. Conclusion and Future Work

The water infrastructure development in the Mekong region has altered the flow regime in the basin, particularly the Lower Mekong Basin. This study applied the distributed hydrological model RRI to assess the impact of existing and planned hydropower dams on the flow characteristics. Our key finding shows that the flow regime in the MRB will be altered by the dam operation at monthly-scale and seasonal-scale. Further research including the impact of climate change scenarios will be applied in this study in the next step. The cumulative impact of climate change and dam operation on streamflow will be further investigated. A potential trade-off between the impact of climate change and dam operation is expected.

References

1) Cochrane, T. A., Arias, M. E., & Piman, T. (2014). Historical impact of water infrastructure on water levels of the Mekong River and the Tonle Sap system. Hydrology and Earth System Sciences, 18(11), 4529-4541.

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3) Sayama, T., Ozawa, G., Kawakami, T., Nabesaka, S., & Fukami, K. (2012). Rainfall–runoff–inundation analysis of the 2010 Pakistan flood in the Kabul River basin. Hydrological Sciences Journal, 57(2), 298-312.