Research article

The Stream Flow and Water Level Change on Mekong Mainstream from the Hydropower Development Projects at Nakhon Panom, Thailand

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Abstract Mekong, a major trans-boundary river, is one of the main source of hydropower for many Southeast Asian countries. Sources of the hydropower come from many mega-dams along the river. However, constructing mega-dams for hydropower causes numbers of hydrological effect especially with the change of water flow and water level along the river. Nakhon Panom, a province located by the river bank in Thailand, has been severely affected by the hydropower dam operation. To solve these dilemmas effectively, a set of up-to-date data from all perspectives is need for the analysis, however, the data that reports on a transition of hydrological after dam construction are currently limited. This study aims to respond the needs of data by investigate the change of water flow and water level before and after the dam construction using various indicators under the principle of Indicators of Hydrological Alteration (IHA). Hydropower project timeline was created to analyze the daily discharge and water level from 1964 to 2013. Findings portrayed that the water flow had been significantly changing and may directly affects people along Mekong River in terms of their livelihoods, agriculture and tourism activities (e.g. Songkran Festival). The results of this study also can be used as a reference data for hydrological analysis in the future.

Keywords Mekong mainstream, hydropower, hydrological impact, transboundary impact

INTRODUCTION

Mekong River is a major trans-boundary river in Asia which has a lot of potential for hydropower development. The river can be divided into two parts: the Upper Mekong from Tibetan Plateau and China where it is named *Lancang Jiang* and passing Yunnan province of China and Myanmar, and continues the flow through the Lower-Mekong passing Thailand, Laos, Cambodia and Vietnam (Fig. 1a)

The Upper Basin covers 24 percent of the total area and contributes 15 to 20% of the water that flows into the Mekong River. Most of the total flow volume is delivered to the Mekong from tributaries in the Lower Mekong Basin. These tributaries can be separated into two groups: tributaries on the left bank that drain the high-rainfall areas of Lao PDR to the major wet season flows, and tributaries on the right bank, mainly the Mun and Chi rivers, that drain low relief regions of lower rainfall a large part of Northeast Thailand. The major contribution comes from the two major 'left-bank' (eastern) tributaries between Vientiane–Nakhon Phanom and Pakse-Stung Treng that together contribute more than 40% of the flow (Table 1 and Fig. 1b). These two groups of tributaries are also marked by different levels of resource development i.e. in Thailand there is little

room for further expansion of irrigation development and in Lao PDR, there is a lot of potential for water resources development of all kinds (MRC, 2005; 2007; 2018).

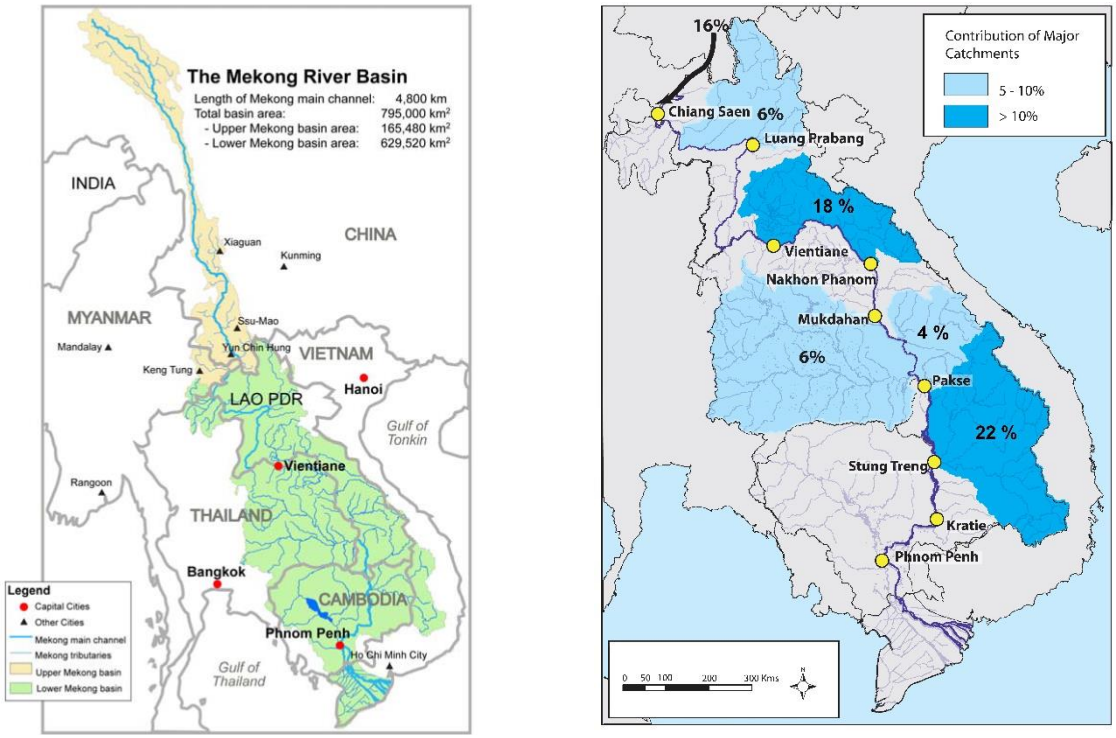
Nakorn Panom, one of eight provinces of Thailand, is directly affected from the operation of hydropower projects in both Mekong mainstream and its branches.

The Upper Basin makes up 31% of the water that flows through Nakhon Panom. While the tributaries during Vientiane – Nakhon Phanom contribute 22% of the flow as shown in Table 1.

Table 1 Proportional contributions to total Mekong River flow

River Reach	Left Bank (%)	Right Bank (%)	Total (%)
China	16		16
China – Chiang Saen	1	3	4
Chiang Saen – Luang Prabang	6	2	8
Luang Prabang – Vientiane	1	2	3
Vientiane – Nakhon Phanom	18	4	22
Nakhon Phanom – Mukdahan	3	1	4
Mukdahan – Pakse	4	6	10
Pakse – Kratie	22	2	24
Tonle Sap	9		9
Total	55	20	100

Source: MRC (2018)



(a) Overview (Rossi et al., 2009) (b) Major contributions to flow (MRC, 2009; 2018)

Fig. 1 Mekong River and its characteristics

Currently, the mainstream in China is dammed by 6 hydropower projects in planned cascade of up to eight storage hydropower projects i.e. Xiaowan Dam, Jinghong Dam, Dachaoshan Dam, Manwan Dam, Nuozhadu Dam and Gongguoqiao Dam. While the first dam of 10 proposed run-of river hydropower projects in Lower Mekong River i.e. Xayaburi Dam is under construction. Moreover, most Mekong River tributaries have cascades of dams in place or planned (MRC, 2010).

Mega-dam structure construction usually results in huge hydrological effect regarding the water flow and water level. This alteration also causes worrisome to people along the river about

the direct and indirect impacts to their livelihoods in terms of their small-scaled fisheries, the economic system and the ecology system of the river.

From the above-mentioned consequences, the monitoring system of transboundary impacts should be established to monitor the impact prior to the construction, during the construction process and after the construction has finished.

OBJECTIVE

The objective of this research is to investigate the result of pre and post constructing the dams using various indicators under the principle of Indicators of Hydrological Alteration (IHA) in Nakhon Panom province, Thailand.

METHODOLOGY

The Indicators of Hydrologic Alteration (IHA) model is used to provide information to understand the hydrologic impacts of human activities as a result of the dam construction. This model can calculate 67 statistical parameters that later are subdivided into 2 groups i.e. 33 IHA Parameters and 34 Environmental Flow Component (EFC) parameters. For IHA parameters, it can be calculated using parametric (mean/standard deviation) or non-parametric (percentile) statistics. (Nature Conservancy, 2009).

Daily time series of discharge and water levels from 1964 to 2013 from provided by Thailand National Mekong Committee were used to investigate the results of pre and post dam construction using various indicators from IHA by Nature Conservancy (2009), and indicators from the studies of Piman (2013) and World Bank (2004).

In this study, the time duration was divided into four phases depending mainly on the operations of the two dams locating on the Upper part of Mekong River: Dachaoshan Dam (2003); Manwan Dam (1996) and two dams on the tributaries: Nam Ngum Dam (1972); and Theun-Hinboun Dam (1998). The water flow status and the water level in the past before dam operation was likely in its natural condition however, natural flow of the mainstream water was changed because of the dam construction (2014) as illustrated in Fig. 2.

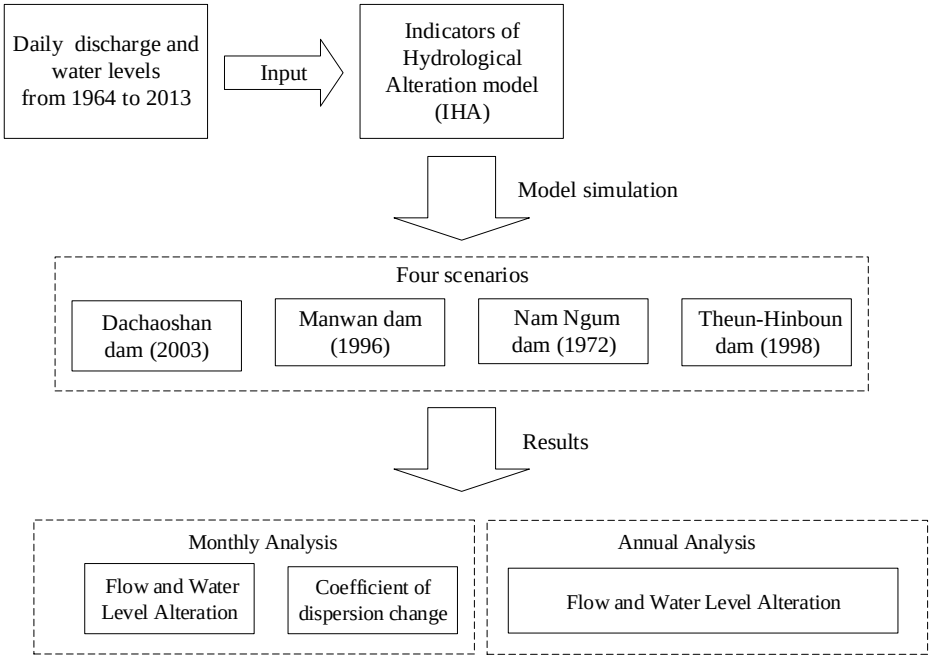


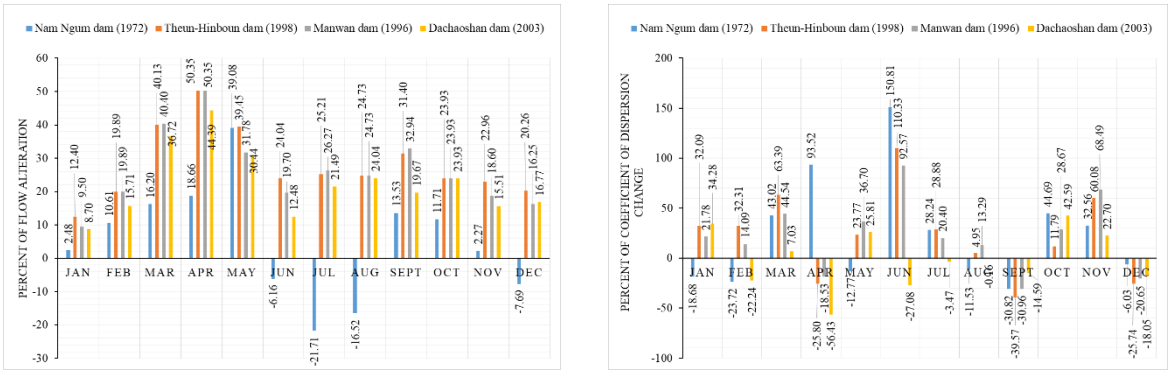
Fig. 2 Study diagram

RESULTS AND DISCUSSION

Monthly Flow and Water Level Analysis

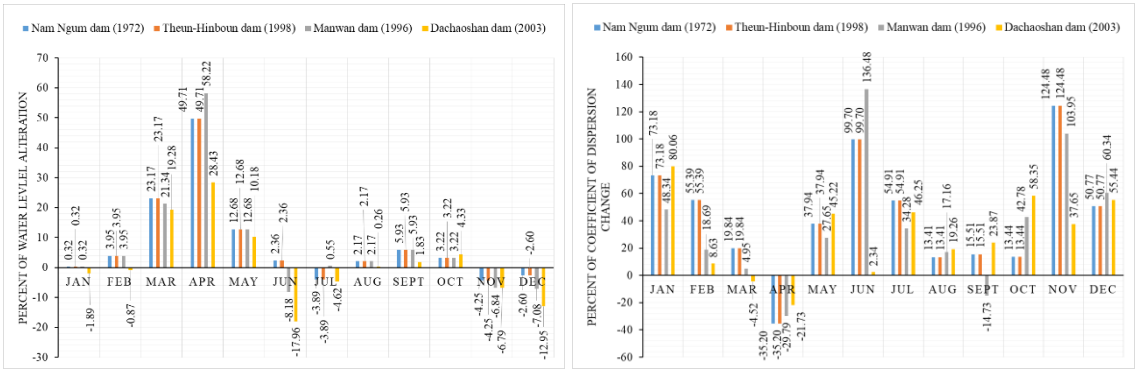
The analysis of mean monthly flow and mean monthly water level illustrated that under the dam construction and operation, most of the dam contribute to increasing the water flow and water level in every month except Nam Ngum Dam in which the flow and the water level are decreased in July, August, and December (Figs. 3 and 4). These might cause from the operation of Nam Ngum dam in Nam Ngum River, Laos PDR which diverse the water to Se Bang Fai River (opposite Nakhon Phanom province). The flow had increased more than 30 percent after the constructions in April and May. This alteration is different from other areas in Thailand which the flow is usually increase during dry season and decrease during wet season. The highest flow alteration is 50.35% in April resulted from the Theun-Hinboun Dam. The highest change of flow variation found in June with the 150.81% change in coefficient of dispersion (CD) resulted from Nam Ngum Dam (Fig. 3).

In terms of water level, the highest water level alterations is 58.22% in April which resulted from Manwan Dam, while Theun-Hinboun Dam contributed 49.71% of the change. The highest change of water level variation is still found in June with the 135.48% of CD change resulted from Nam Ngum Dam (Fig. 4). Moreover, it was found that during March to May and July, the monthly water level was also increased.



(a) Flow alteration (b) Change of coefficient of dispersion

Fig. 3 Monthly flow analysis



(a) Water level alteration (b) Change of coefficient of dispersion

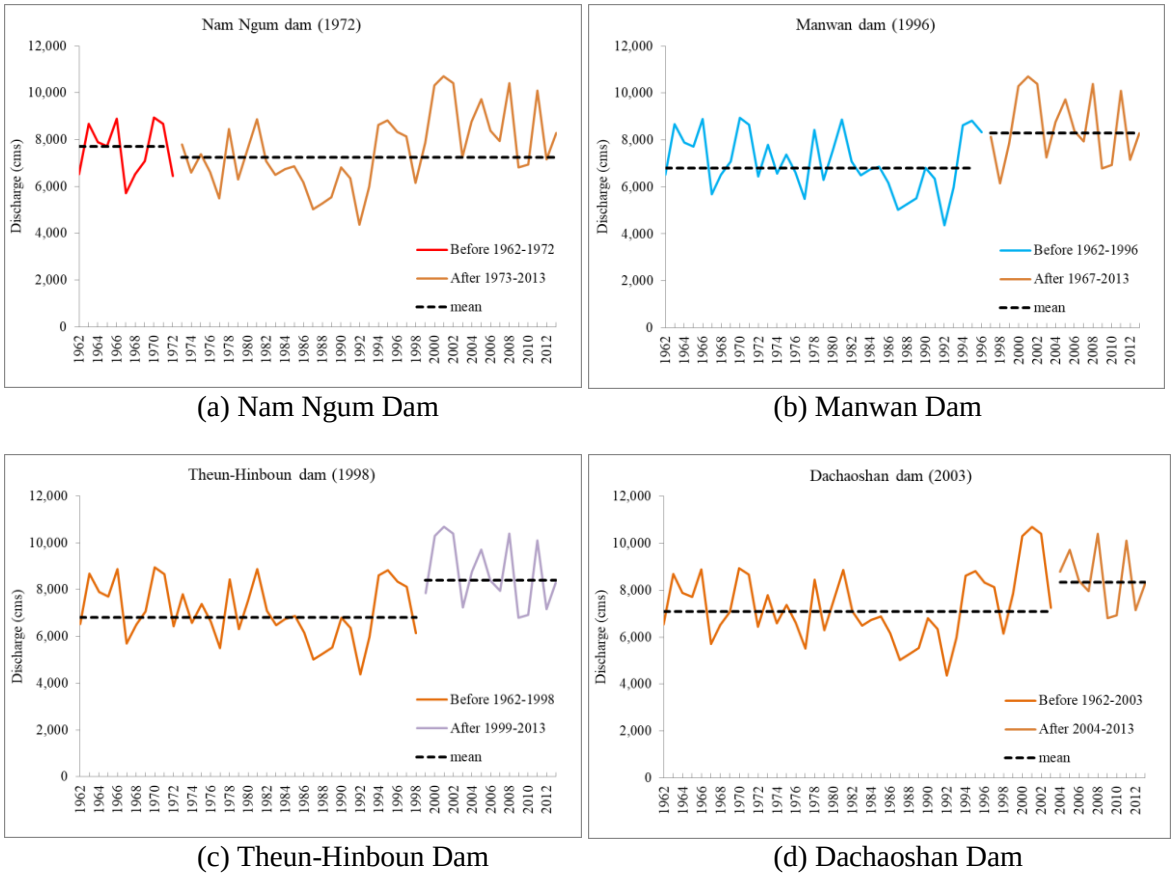
Fig. 4 Monthly water level analysis

However the characteristic of the average monthly flow graphs from Nakhon Phanom was increased every month and showed the differences when comparing to the stations from the upstream (see Piman, 2013; Lu et al, 2014; Rossi et al, 2009) which average monthly flow increased in dry-season and decreased in wet-season.

Annual Flow and Water Levels Analysis

The annual flow analysis indicated that the operation of dams had significantly increased mean annual flow in Mekong mainstream except Nam Ngum dam. Theun-Hinboun dam contributes the most effect to the flow. The mean annual discharge before and after dam operation is 6,810 and 8,390 m^3/s, respectively (Fig. 5). The annual flow after dam operation has 1,580 m^3/s increased.

While the annual water level analysis showed that the operation of dams just slightly increases the water level. The highest increment of water level is 0.04 m resulted from Nam Ngum Dam and Dachaochan Dam.



(a) Nam Ngum Dam (b) Manwan Dam

(c) Theun-Hinboun Dam (d) Dachaoshan Dam

Fig. 5 Annual flow analysis

CONCLUSION

A construction of the mega-dam structure in hydropower project usually results in huge hydrological effect regarding flow and water level. In Nakhon Phanom, the water level was highly increased as a result of the water releasing from hydropower projects from Nam Ngum, and Theun-Hinboun project in Laos.

The monthly flow and water level analysis indicated that most of the dams contribute to increase the flow and water level every month except Nam Ngum dam that the flow and the water level decreases in July, August, and December. The highest flow alteration is 50.35% found in April resulted from Theun-Hinboun Dam. The highest change of flow variation found in June was

150.81% change in coefficient of dispersion (CD) resulted from Nam Ngum Dam whereas the highest water level alteration is 58.22% found in April which resulted from Manwan Dam.

The annual flow and water level analysis indicated that the operation of dams significantly increased mean annual flow in Mekong mainstream except Nam Ngum Dam. Theun-Hinboun Dam influenced the water flow the most. The annual flow after dam operation was increased to 1,580 m^3/s. While the annual water level analysis showed that the dam operations have slightly effect to the increasing of water level. The highest increment of water level is 0.04 m. resulted from Nam Ngum Dam and Dachaochan Dam.

To handle with the occurrences, communities along Mekong River need to adapt themselves to the changes. Additionally, Thailand should be more actively collaborated with other countries especially for their assistance to supply the water when needed. Further studies need to be conducted regarding the hydrodynamic model to calculate the length of time from the releasing points and the preferred destinations.

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