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HUMAN IMPACTS ON HYDROLOGICAL CHANGES IN THE MEKONG BASIN IN THAILAND AND VIETNAM

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ABSTRACT

The Mekong River basin comprises the most significant rivers in Southeast Asia, including China, Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. The cascade of hydropower dams drastically affects the river's natural hydrology, limiting downstream flow and trapping crucial nutrients. Mega-dams (since 2010-2020), including those in China, Lao PDR, and Cambodia, have been constructed along the river. Thailand and Vietnam in the Mekong River basin, on the other hand, provide a fascinating case study due to the lack of dam development. The objective of this review study was, therefore, to explore socio-hydrological impacts on the Mekong River basin in Thailand and Vietnam. Monthly river discharge and water level changes in the Mekong River basin were obtained from the Mekong River Commission's readings from 1960 to 2020, which were analyzed for the link among population density, poverty level, and the drought of 2019-2020. The reports indicated that the dams, including Xiaowan and Nuozhadu, significantly impacted water levels and river discharge, with data from 1960 to 2020 showing an increase in river discharge of up to 98% during the dry season and a decrease of up to -35% during the wet season. In addition, Chinese interests planned to extend navigation beyond Chiang Saen to Luang Prabang by removing the Khon Pi Luang rapids. This change in hydrology has destroyed fish habitats and migration patterns in the Mekong River, negatively affecting the productivity of fisheries for people living along the riverbanks, and is also linked to poverty levels; specifically, low population density correlates with low poverty levels, while high population density is associated with high poverty levels. The construction of mega-dams along the Mekong River may signal an alternative to the river's natural flow,

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influencing seasonal patterns and downstream ecosystems in Thailand and Vietnam.
Keywords: Hydrology, Mekong River, People

INTRODUCTION

The Mekong River represents a critical transboundary watercourse, beginning its journey in the remote Qinghai–Tibet Plateau in China, where it is known as the Lancang River. From these high-altitude origins, it carves a path through Myanmar, Lao PDR, Thailand, and Cambodia before fanning out into the fertile Mekong Delta in Vietnam, historically called the Nine Dragons River as it meets the sea. This vast river basin is the lifeblood for approximately 65 million people across two distinct regions: the Upper Mekong Basin in China and the Lower Mekong Basin (LMB), which encompasses the downstream nations. The river's immense geographical and cultural scope underscores its importance as a shared, yet increasingly contested, natural resource (Pokhrel et al., 2018; Liu et al., 2022; Ham-Kucharski, 2022; Manohar et al., 2022; Mekong River Commission, 2024a). The ecological integrity and hydrological cycle of this entire system are intrinsically linked, from the glacial meltwaters of the Himalayas to the sediment deposits that nourish the delta thousands of kilometers away.

In the Lower Mekong Basin alone, over 52 million people are directly reliant on the river’s bounty for their survival and economic well-being. The annual flood pulse of the Mekong historically governed the rhythms of life, creating one of the world's most productive inland fisheries, particularly centered around Cambodia's Tonle Sap lake, and supporting extensive agricultural and horticultural activities along its banks and across its floodplains. This natural cycle deposits nutrient-rich sediment that replenishes soil fertility, enabling robust rice cultivation and diverse crop production that are fundamental to regional food security. The river is not merely an economic asset but a cornerstone of cultural identity, shaping traditions, diets, and settlement patterns for communities that have coexisted with its seasonal ebbs and flows for centuries. This profound dependence makes the population of the LMB exceptionally vulnerable to any alterations in the river's natural state. The contemporary era in the Mekong Basin is increasingly defined by the widespread construction of hydropower dams (Figure 1), with a significant concentration

of these projects located in China, Lao PDR, and Cambodia. While framed as essential for national economic development and energy independence, this infrastructure boom has introduced severe ecological and socio-economic disruptions. The cascade of dams fundamentally alters the river's natural hydrology, significantly reducing downstream river flow and trapping vital sediment flux, which starves the delta of the materials needed to counteract natural subsidence and sea-level rise (Osborne, 2019). Consequently, communities in the LMB are experiencing profound negative impacts, including damage to fisheries from altered flow regimes, degraded water quality, and an alarming increase in the frequency and intensity of extreme weather events such as devastating floods and prolonged droughts (Sridhar et al., 2021; Zhang et al., 2022).

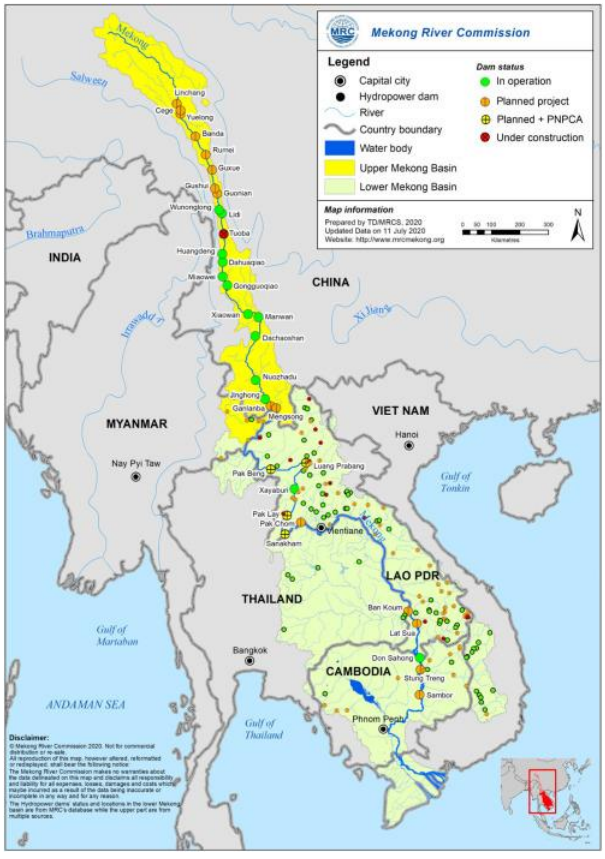


Figure 1 Hydropower in the Mekong River Basin (Mekong River Commission, 2024b)

The Mekong River's dams have altered its streamflow pattern, affecting the fish stocks, agricultural production, and local community in LMB. An agreement among

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Thailand, Myanmar, China, and Laos in 2000 permitted, for instance, vessels of up to 150 Dead Weight Tons to operate between Guan Lei and Chiang Saen. Most vessels operating over this stretch are Chinese, and local people complain that the navigation has negatively affected fish catches. Such activity would result in high costs in terms of disturbance of fish migration and breeding patterns. Dams also restrict sediment flow down the river, with up to 90% of the total sediment flow generated within China. China's dams, without sediment flushing mechanisms, are retaining significant amounts of sediment, which is essential for agricultural and horticultural activities along the river, particularly in Vietnam's Mekong Delta. Dams may, however, have a positive effect on the groundwater system since the high water level caused by damming in the dry season could be beneficial for irrigation (Figure 2) (Ziegler et al., 2013; Osborne, 2019; Liu et al., 2022). Thailand and Vietnam in the Mekong basin are, therefore, an interesting case study because of no dam construction. The objective of this review article was to discuss socio-hydrological impacts on the Mekong River basin in Thailand and Vietnam. The Mekong River Commission studies analyzed the relationship between population density and poverty levels in 2019-2020. Another study examined the impact of mega-dams on the 2019-2020 drought in the Lower Mekong Basin, analyzing hydrological data from 1960 to 2020.

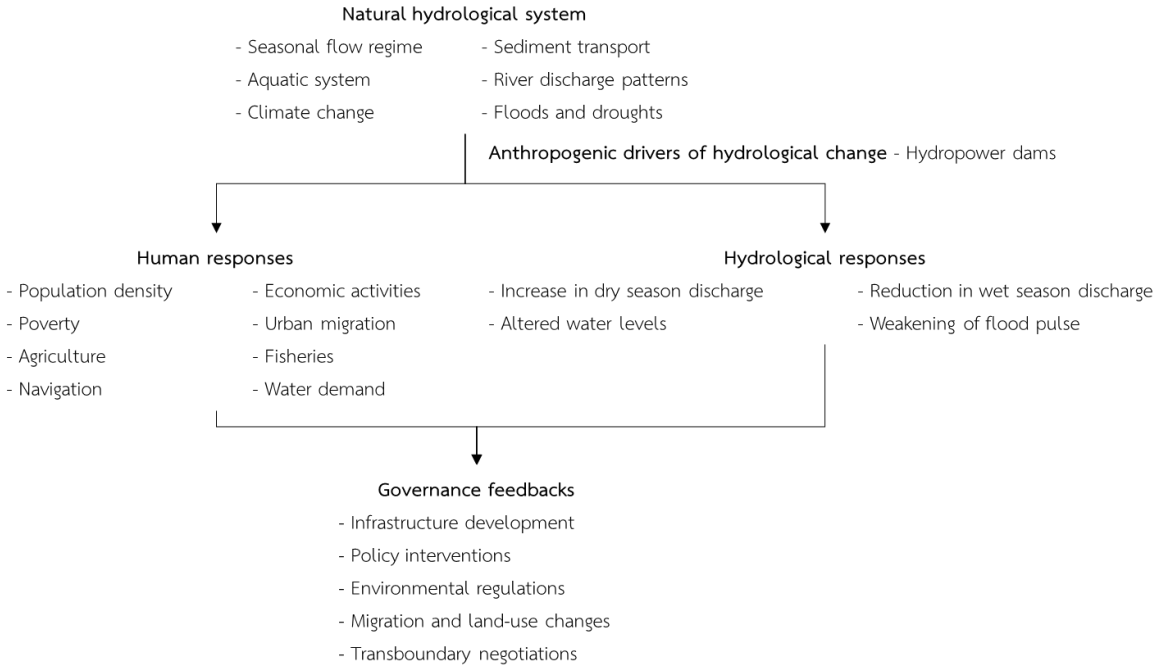


Figure 2 Socio-hydrological framework in the Lower Mekong Basin (Thailand and Vietnam).

Hydrological changes affecting humans and ecosystems in the Lower Mekong Basin

The Mekong River Commission (MRC) study found that low population density was associated with low poverty levels, while high population density was associated with high poverty levels (Figure 3). Climate change-driven extreme weather is causing people to move from their homes to cities, potentially offering better living conditions (Ahmadinejad, 2022; World Economic Forum, 2022).

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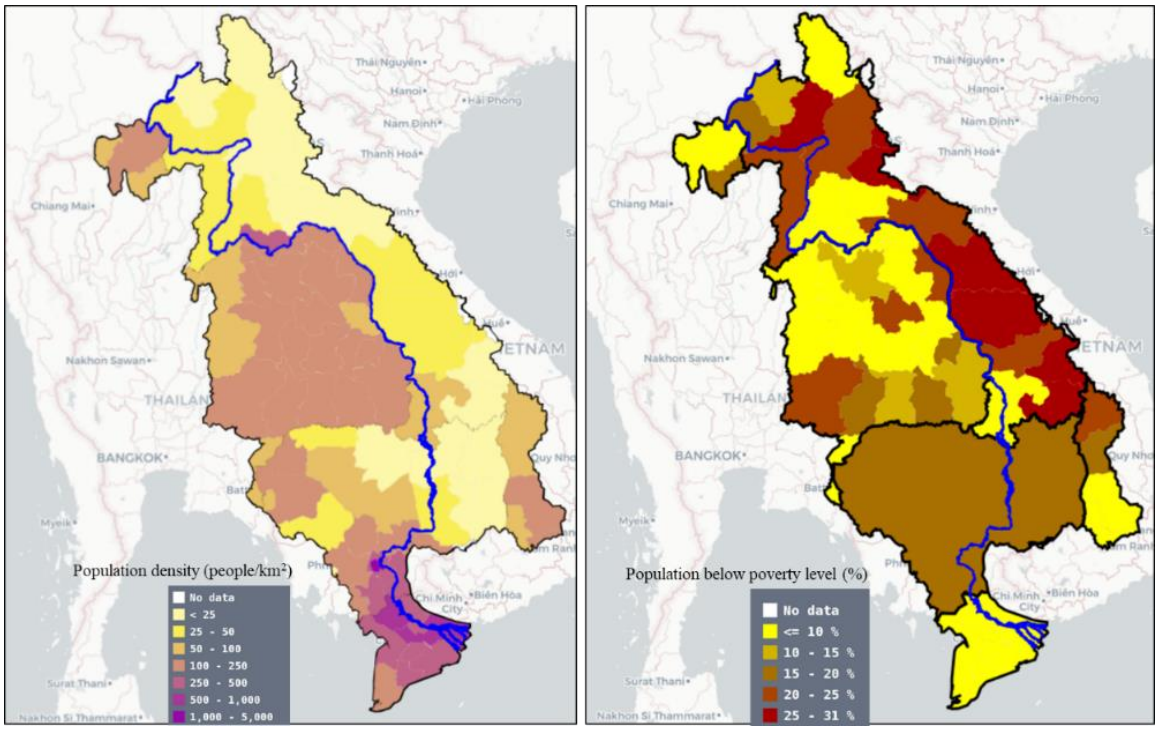


Figure 3 Population density (people/km^2) and population below poverty level (%) in the LMB (Mekong River Commission, 2024c)

An agreement between Thailand, Myanmar, China, and Laos in 2000 allowed vessels of up to 150 Dead Weight Tons to operate between Guan Lei and Chiang Saen. This has had a negative effect on fish productivity. Chinese interests planned to extend navigation beyond Chiang Saen to Luang Prabang by removing the Khon Pi Luang rapids, which are considered vital for fish breeding (Osborne, 2019). Changes in hydrology have disrupted fish habitats and migration patterns in the Mekong River, impacting the productivity of fisheries vital for communities along the riverbanks in Thailand. Similarly, another study examined the impact of mega dams on the Mekong River, specifically the 2019-2020 drought in the LMB. The dams, including Xiaowan and Nuozhadu, have significantly impacted water levels and river discharge. The data obtained from Chiang Saen station from 1960 to 2020 showed, for example, an increase in river discharge of up to 98% during the dry season and a decrease of up to -35% during the wet season. Additionally, monthly water levels obtained from Chiang Saen station rose by up to +1.16

m. during the dry season and dropped by up to -1.55 m. (Table 1) during the wet season (Mekong River Commission, 2020; Lu and Chua, 2021).

Table 1 Median monthly discharge and water level changes in the mega-dam period (2010–2020) versus the pre-dam period (1960–1991) (Lu and Chua, 2021).

Station	Dry Season (Month)		Wet Season (Month)	
	Discharge	Water level	Discharge	Water level
Chiang Saen	+97.6% (March)	+1.16 m. (March)	-34.5% (July)	-1.55 m. (August)
Luang Prabang	+109.8% (March)	+2.09 m. (March)	-28.5% (October)	-1.25 m. (October)
Mukdahan	+150.6% (April)	+1.08 m. (April)	-15.0% (October)	-1.16 m. (October)
Pakse	+113.8% (April)	+0.92 m. (April)	-15.1% (June)	-0.83 m. (July)
Stung Treng	+127.6% (April)	+0.81 m. (April)	-18.4% (June)	-0.73 m. (September)

The study suggests that the mega-dam may signal the start of a new normal of wet-season droughts. Continuously, the LMB is now in drought in the rainy season of 2023 (May to October) (Figure 4). The study also emphasizes the considerable ecological and hydrological effects of these dams on the river extending from the Upper Mekong Basin to the Vietnam Delta (Lu and Chua, 2021). The construction of dams along the Mekong River may signal an alternative to the river's natural flow, influencing seasonal patterns and impacting downstream ecosystems in both Thailand and Vietnam.

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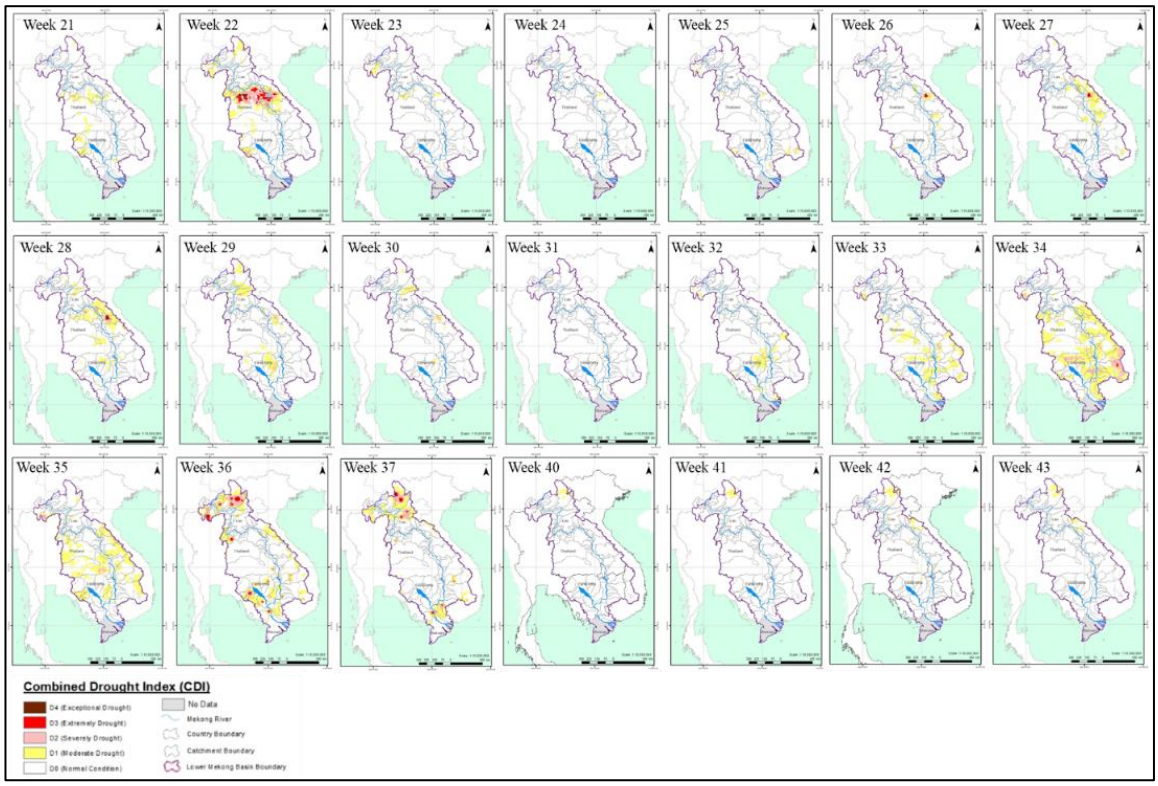


Figure 4 Drought forecast in 2023 (May to October) in LMB

(Mekong River Commission, 2023)

Policy and management recommendations

Transboundary cooperation, involving policy interventions from various governmental concerns, is crucial for strengthening stakeholder collaborations and aligning their agenda towards achieving Sustainable Development Goals (SDGs) in the basin. In addition, a comprehensive understanding of the impact of ENSO on the Mekong basin's hydroclimate could aid in the creation of a regional drought and flood prediction system. These could help regional governments and multinational institutions consider regional vulnerabilities in the planning and design phase of large infrastructure projects (Ruiz-Barradas and Nigam, 2018; Liu et al., 2022).

Conclusion

The Mekong River basin is crucial for the food security and livelihoods of millions of people, but there is a lack of changing management about rivers as dynamic food

environments. Recognizing the complex relationship between human activities and hydrological changes, there is an urgent need for Thailand and Vietnam to adopt sustainable water management practices to ensure human development and the ecological health of the Mekong River. LMB management needs to be multilevel, multisectoral, and interdisciplinary to protect biodiversity, improve food security, and identify policy interventions.

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Declaration of Generative AI and AI-assisted technologies in the writing process

I would like to declare that generative AI (Gemini 2.5 Pro and QuillBot premium) was used solely for assistance in checking and refining the English language in this manuscript. The author entirely generated the content, ideas, and findings presented in the manuscript without AI assistance. After language editing, the author reviewed and validated the final version to ensure its accuracy and integrity.

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