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UNDERSTANDING OF HYDROPOWER DEVELOPMENT IN THE GREATER MEKONG: A SUSTAINABLE PATHWAY OR AN UNACCEPTABLE COST?

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Abstract

Since the 1960s, hydropower has been seen as key to poverty reduction, energy security, and economic growth in the Mekong region. However, uncontrolled construction on the river's mainstream and tributaries poses significant risks to safety, economy, human rights, and the environment, prompting concerns about the true "sustainability" of hydropower development. In the scope of this study, the author focuses on the energy development policy of the Greater Mekong Subregion and emphasizes the importance of assessing the long-term impacts on multiple aspects, especially the cross-border environmental impacts of mega-hydropower construction on the Mekong mainstream to ensure the sustainable development goals that this region is aiming for.

Keywords: *hydropower plant project, sustainable energy development, environmental impact assessment, the greater Mekong subregion, MRC, Xayaburi dam*

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The Mekong River, Southeast Asia's largest, flows through China, Myanmar, Thailand, Laos, Cambodia, and Vietnam. Its hydroelectric potential makes water management and energy policies politically sensitive.[1] At the regional level, platforms like Lancang-Mekong Cooperation and the Greater Mekong Subregion (GMS) were launched to promote trust and cooperation among the six Mekong Basin states. However, differences in socio-economic development and national priorities often lead to a "deadlock," preventing unified operations and common agreements on sharing river benefits, including sustainable energy development.

At the beginning of the 21st century, the Mekong River was largely undammed.[2] Due to the precipitous increase in the global population and other energy demands, global energy consumption is expected to grow by nearly 50% in next 20 years.[3] In this context, hydropower generates more than 60% of all global renewable electricity in 2020.[4] Mekong Basin states use geopolitical

1 Jacobs, J. W. (2002). The Mekong River Commission: Transboundary water resources planning and regional security. *The Geographical Journal, 168*(4), 345–364. https://doi.org/10.1111/j.0016-7398.2002.00061.x, p. 355.

2 The ASEAN Post. (2019). Giving a dam about the Mekong. *The ASEAN Post*. https://theaseanpost.com/article/giving-dam-about-mekong

3 Moodley, P., & Trois, C. (2021). Lignocellulosic biorefineries: The path forward. In Sustainable Biofuels Opportunities and Challenges. *Applied Biotechnology Reviews*, 21-42, p. 21.

4 International Energy Agency. (2022). *Hydropower special market report: Analysis and forecast to 2030* (p. 72). https://iea.blob.core.windows.net/assets/4d2d4365-08c6-4171-9ea2-8549fabd1c8d/HydropowerSpecialMarketReport_corr.pdf

advantages to develop their economies and meet energy demands by utilizing water resources. China began building hydropower plants on the upper Mekong in the 1950s, with the first mega-hydropower plant (HPP), Manwan, constructed in 1986. In contrast, no HPPs were built on the Lower Mekong mainstream in the 20th century, though many were installed on its tributaries. Since the 1960s, the Mekong Committee and Interim Mekong Committee have prioritized hydropower to promote socio-economic progress and poverty alleviation in the Mekong subregion, proposing in the 1970 Water Resources Development Plan the construction of seven large-scale multipurpose cascade HPPs for hydropower, irrigation, flood management, and navigation improvement. Lack of financial and technical resources, along with armed conflicts, hindered these projects.[5] However, with support from regional and non-regional entities, Mekong Basin countries reconsidered building HPPs by adopting "The 1987 Revised Water Resources Development Plan".[6]

Recent years have seen a rapid implementation of water-related infrastructure projects in order to meet the region's needs in a timely manner.[7] As of January 2022, HPP construction's statistics throughout the Mekong River Basin show that 805 HPPs have been constructed, 152 HPPs are planned for construction, 44 HPPs are under construction, and 14 HPP projects have been canceled.[8] Along the Mekong River mainstream, only two Mekong Basin countries have constructed mega-HPPs: China has 11 HPPs and Laos has two HPPs. In this study, the author focuses on the energy development policy of the GMS region, highlighting the importance of assessing the long-term impacts, particularly the cross-border environmental effects of mega-hydropower construction on the Mekong mainstream, to ensure the sustainable development goals of the region.

1. Hydropower development in the Greater Mekong Subregion: The Xayaburi case

The Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (1995 Agreement), adopted by the MRC, is the sole regional binding convention regulating transboundary Mekong watercourse sharing. Chapter II of the Agreement defines "proposed use" as any significant water use proposal by a riparian state, excluding domestic and minor uses without substantial impact on mainstream flows. Therefore, projects on tributaries without a proven

5 Jacobs, J. W. (1995). Mekong Committee history and lessons for river basin development. *The Geographical Journal, 161*(2), 135–148. https://doi.org/10.2307/3059971, p. 137.

6 Piper, B. S., Gustard, A., Green, C. S., & Sridurongkatum, P. (1991). Water resource developments and flow regimes on the Mekong River. *Hydrology for the Water Management of Large River Basins*, 201, p. 48.

7 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. https://doi.org/10.5194/hess-18-4529-2014, p. 4531.

8 CGIAR. (n.d.). *Greater Mekong Dams Observatory*. https://wle-mekong.cgiar.org/changes/our-research/greater-mekong-dams-observatory/

significant impact are not regulated by the 1995 Agreement. The term "proposed use" is interpreted broadly, and hydropower projects are considered similarly to other uses of the Mekong River's water resources. The 1995 Agreement does not prohibit, prevent, encourage, or promote hydropower development by any member state.[9] Besides the 1995 Agreement, the construction of the HPPs is also regulated by other internal regulations, such as: Procedures for Data and Information Exchange and Sharing (PDIES, 2001), Procedures for Water Use Monitoring (PWUM, 2003), Procedures for Notification, Prior Consultation and Agreement (PNPCA, 2003), Procedures for Maintenance of Flows on the Mainstream (PMFM, 2006), Procedures for Water Quality (PWQ, 2011). It should be emphasized that these regulations are not legally binding, so in practice, parties often "formally" comply with them.

Up until this point, only China and Laos have constructed HPPs on the Mekong mainstream. While China is not a member of the 1995 Agreement, the Laos government formally submitted 11 planned hydropower projects on the mainstream of the river to the MRC's Secretariat in 2010. After a decade, two of them (HPP Xayaburi and HPP Don Sahong) are already in operation.[10] Since 2010, Laos has applied the Mekong prior consultation procedure six times: Xayaburi (2010), Don Sahong (2014), Pak Beng (2016), Pak Lay (2018), Luang Prabang (2019), and Sanakham (2019), to assess impacts on regional water rights..

The Xayaburi HPP is the first project where all requirements for HPP construction on the Mekong mainstream were applied. Proposed by Laos, it generates power year-round and falls under Article 5(B)(2) of the 1995 Agreement, necessitating prior consultation with the Joint Committee. Launched on 22 October 2010, this process follows the 1995 Agreement and the 2003 PNPCA,[11] promoting sustainable development through equitable water use and cooperation. The 2003 PNPCA principles include sovereign equality, equitable water use, respect for rights, and transparency. However, unclear definitions and criteria lead to case-by-case interpretations and potential disagreements, reducing the principles' legal binding effect.

The Xayaburi HPP pre-consultation ended on 22 April 2011. During this period, the MRC's Joint Committee established a working group for technical checks and reporting, meeting thrice in 2010-2011.[12] Experts participating in the

9 Sithirith, M. (2016). Dams and state security: Damming the 3S rivers as a threat to Cambodian state security. *Asia Pacific Viewpoint, 57*(1), 64. https://doi.org/10.1111/apv.12108, p. 64.

10 Grumbine, E. R., & Xu, J. (2011). Mekong hydropower development. *Science, 332*(6026), 178–179. https://doi.org/10.1126/science.1200990

11 Mekong River Commission. (2003). *Procedures notification, prior consultation, and agreement*. http://www.mrcmekong.org/assets/Publications/policies/Procedures-Notification-Prior-Consultation-Agreement.pdf

12 Mekong River Commission. (2009). *Preliminary design guidance for proposed mainstream dams in the Lower Mekong Basin*. http://www.mrcmekong.org/assets/Publications/Consultations/SEA-Hydropower/Preliminary-DG-of-LMB-Mainstream-dams-FinalVersion-Sept09.pdf

consultation meetings in Cambodia expressed concerns that the six-month period allotted to the international consultations was insufficient for a comprehensive study and comprehensive evaluation of the project.[13] The situation was exacerbated by the fact that: (i) the environmental and population impact assessment reports revealed gaps in the study and lack of necessary information; (ii) potential transboundary impacts on Cambodia (social, economic, and environmental) were not adequately studied; and (iii) impacts on ecotourism, local culture, pollution, and hydropower plant safety and other issues were not adequately investigated.[14] The consultation meeting in Thailand, which reviewed the environmental impact assessment and the Mekong River Commission's Technical Review Report on the Xayaburi HPP proposed by the Laos Government, again highlighted the general lack of information.[15] Specifically, it emphasized the absence of a comprehensive study on the impacts of the hydropower plant on fisheries, sediment and nutrient flow, water quality, and water transport. In the first report of the national consultation meeting in January 2011,[16] the government of Vietnam, as the most downstream state, expressed strong concerns about the potential impacts of Xayaburi HPP. According to this report, these concerns were particularly focused on the Mekong Delta, which is often referred to as the "rice bowl" of Vietnam and is crucial for sustaining rice productivity and the livelihoods of millions of local inhabitants. The hydropower plant threatened downstream states by reducing water quality and flow, impacting fisheries and local livelihoods. In the second report presented in February 2011, Vietnam reiterated the necessity for a comprehensive study of the potential transboundary impacts on the environment, ecosystem, biodiversity, and flow regime. Vietnam also advocated for extending the study timeframe to 5-10 years to adequately address these concerns.[17]

As the Xayaburi HPP project progressed, stark differences emerged between upstream and downstream nations, reflecting varied priorities. Cambodia and Vietnam sought to extend the consultation due to irreversible ecosystem impacts, while Laos and Thailand prioritized immediate energy needs. In March 2011, the MRC Secretariat's "Preliminary Consultation Project Report" analyzed technical aspects but did not address social impacts, recommending further consideration of

13 Mekong River Commission. (2010a). *Report of the National Consultation Meetings on "Prior Consultation for the Proposed Xayaburi Dam Project" in Cambodia*. http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/Report-National-Cons-on-XayaburiCambodia.pdf

14 Mekong River Commission. (2010b). *Report on National Consultation Meeting on Prior Consultation for the Proposed Xayaburi Hydroelectric Power Dam Project*. http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/Report-National-Cons-on-XayaburiThailand.pdf

15 *Ibid*.

16 Mekong River Commission. (2011a). *Brief results of the first national consultation workshop on Xayaburi Hydropower Project proposed on the Mekong mainstream of Lao PDR (14 January 2011, Can Tho City, Vietnam)*. http://www.mrcmekong.org/assets/Consultations/2010-Xayaburi/Report-National-Cons-on-XayaburiCanTho.pdf.

17 *Ibid*.

transboundary effects and mitigation measures.[18] The report concluded that the Xayaburi HPP did not meet 2011 PWQ standards for water quality and ecosystem impact management, emphasizing the need for further assessments. However, the final advisory report under the 2003 PNPCA lacks binding enforcement, necessitating further study of potential transboundary impacts per international water law principles.

It is worth noting that since 2007, i.e., long before the Preliminary Consultation procedure began, the Thai Ch. Karnchang Public Company Limited and the Laos Government had *de facto* started the process of preparing for the Xayaburi HPP.[19] In November 2012, after the formal end of the prior consultation procedure, Laos unilaterally proceeded with the Xayaburi HPP's construction despite the claims of other Mekong Basin states and the lack of a joint agreement. Thus, Laos practically declared Xayaburi HPP's design to the MRC Secretariat, and the Laos Government implemented the proposed project without approval from the MRC. As a result, the consultations with other Mekong Basin states were merely procedural and had no impact on the Laos Government's decision.

International environmental law establishes principles for shared water management, including the 1967 Helsinki Rules, which introduced equitable utilization and state responsibility. These principles were further codified in the 1997 UN Watercourses Convention and the 1992 Water Convention, emphasizing equity, harm prevention, cooperation, and ecological protection. In the Mekong region, the 1995 Agreement outlines cooperation principles such as environmental protection (Article 3), equitable utilization (Article 5), and flow maintenance (Article 6). Laos breached these obligations with the Xayaburi HPP by neglecting additional assessments despite warnings in 2011, potentially violating Articles 3 and 6. EarthRights International highlighted these issues in a 2010 SIA.[20] The final report estimated that dam construction will likely block nutrient-rich sediment and annual water flow on flood season, which negatively impact agriculture and fishery of the Mekong subregion. Moreover, the report pointed out that land clearance for reservoir construction directly affect 4,000 households, that could lead to massive internal resettlement.

The construction of the Xayaburi HPP poses potential "harmful effects" to the environment and other Mekong Basin states. Under Articles 7 and 8 of the 1995 Agreement, the Laos Government must prevent and immediately cease actions causing harm and is responsible for damages if notified with valid evidence. However, Article 8 lacks specific criteria for "cause", "extent of damage", and

18 Mekong River Commission. (2011b). *Prior Consultation Project Review Report*. http://www.mrcmekong.org/assets/Publications/Reports/PC-Proj-Review-Report-Xaiyaburi-24-3-11.pdf

19 Grunwald, R., Wang, W., & Feng, Y. (2020). Modified transboundary water interaction nexus (TWINS): Xayaburi dam case study. *Water, 12*(710). https://doi.org/10.3390/w12030710.

20 EarthRights International. (n.d.). *Xayaburi Dam*. https://earthrights.org/what-we-do/mega-projects/xayaburi-dam

"responsibility for damages", making it challenging to link the HPP to immediate effects. This ambiguity could lead to a "deadlock" in implementing Article 8. The 1995 Agreement's flexible mechanism allows varied interpretations, risking non-compliance. While the Xayaburi HPP's commissioning on 29 October 2019 marked a significant step in Laos' dam construction on the Mekong, the Laos Government has not adequately fulfilled its international obligations, setting a controversial precedent for future projects.

The Don Sahong HPP faced procedural and legal challenges under the Mekong Agreement. Although Laos began preparatory work in 2006 and formally announced the project in 2013, other Mekong Basin states demanded prior consultation.[21] This process started on 25 July 2014 but lacked sufficient data and a long-term transboundary EIA, limiting states' ability to assess legal impacts.[22] Despite MRC recommendations for further studies, Laos began construction in January 2016, with the plant operational by 2020.[23] The 2003 PNPCA revealed significant gaps, and unresolved legal issues under the 1995 Agreement underscore the need for a stronger, collaborative mechanism for sustainable hydropower governance.

2. China's energy policy in the Greater Mekong subregion

It is necessary to consider the energy development policy in general and hydropower in particular of China separately due to the geographical position and economic and political potential of China in the region. Owing to its geographical location, China ranks first in the world in the number of hydropower plants - 24,089 according to the statistics of 2023.[24] The installed capacity of hydropower in China is 370.2 GW for 2020, compared to the world total of 1,130 GW.[25]

The idea of renewable energy development in China was reinforced in "the New Energy and Renewable Energy Development Plan for the period 1996-2010".[26] In March 2016, China approved the "13th Five-Year Development Plan for 2016-2020",[27] which stipulates that the share of non-fossil energy consumption

21 Mekong River Commission. (2015). *Technical review report on Prior Consultation for the Proposed Don Sahong Hydropower Project*. https://www.mrcmekong.org/assets/Publications/Consultations/Don-Sahong/Technical-Review-Report-DSHPP-040315.pdf

22 International Rivers. (2015). *The Don Sahong Dam: Gambling with Mekong food security and livelihoods*. https://www.internationalrivers.org/sites/default/files/attached-files/dsh_factsheet_2015_-_english.pdf

23 Mekong River Commission. (2015), *supra* note 23.

24 International Commission on Large Dams. (2023). *Number of dams by country members*. https://www.icold-cigb.org/article/GB/world_register/general_synthesis/number-of-dams-by-country-members

25 International Hydropower Association. (2023). *Hydropower status report: Executive summary*. https://www.hydropower.org/status-report

26 Huang, M., & Fu, Z. (2001). Development and policy support of small hydropower in China. *China Water Resource, 10*, 10–15, p. 74.

27 National Development and Reform Commission (2016). https://policy.asiapacificenergy.org/node/2918#:~:text=Based%20on%20the%20China's%2013th,and%20efficient%20modern%20energy%20system

should reach 15%. At the same time, hydropower development as the most important sector for renewable energy generation and is being developed on a mega scale in three areas: Sichuan, Yunnan, and Tibet.[28] In terms of preventing and mitigating the negative impacts on the ecosystem caused by HPPs' construction and operation, China has developed several relevant regulations at the national level.[29] However, such acts do not address the issue of transboundary watercourse, emphasizing that China was within their rights to exploit water resources of the Langcan – part of the Mekong located within the Chinese territory.

Moreover, China plays an important role in the development of hydropower in the Lower Mekong by providing technical services and financial support for the construction of hydropower plants as a contractor and/or investor.[30] In doing so, China not only exports construction expertise, develops trade ties, and increases the profits of state-owned enterprises, but also connects the Lower Mekong states to China's power grid and strengthens its socio-economic and political influence in the region.[31] It should be noted that HPPs have been built by China largely unilaterally, without consultation with or consent from the lower Mekong states, despite the cross-border impacts of such power plants, especially during the dry season. China is not a member of the 1995 Agreement. Without clear regulation, China's duty to cooperate lacks normative traction.[32] So far, there is no binding agreement between China and the Lower Mekong states on hydropower development, despite some attempts to engage China in negotiations, and this poses a certain danger. The issue at stake is that China is free to pursue any project on the Mekong River without hindrance. On the other hand, China has repeatedly asserted that it will respect the laws of the states where Chinese investment comes in.

China, though not a member of the 1995 Mekong Agreement or a party to the 1997 UN Convention, increasingly aligns with international environmental principles. Emphasizing bilateralism and sovereignty, it uses non-binding agreements and technical cooperation to address transboundary water issues. Despite mistrust

28 Gosens, J., Kåberger, T., & Wang, Y. (2017). China's next renewable energy revolution: Goals and mechanisms in the 13th Five-Year Plan for energy. *Energy Science & Engineering, 5*(3), 141–155. https://doi.org/10.1002/ese3.161, p. 144.

29 Li, X., Chen, Z., Fan, X., & Cheng, Z. (2018). Hydropower development situation and prospects in China. *Renewable and Sustainable Energy Reviews, 82*, 232-239. https://doi.org/10.1016/j.rser.2017.08.090, p. 238.

30 Urban, F., Siciliano, G., Sour, K., Lonn, P. D., & Sotharith, C. (2013). An analysis of China's investment in the hydropower sector in the Greater Mekong sub-region. *Environment, Development and Sustainability, 15*(2), 301-324. https://doi.org/10.1007/s10668-012-9415-z, p. 302.

31 Matthews, N., & Motta, S. (2013). *China's influence on hydropower development in the Lancang River and Lower Mekong River Basin: State of knowledge*. CGIAR Water, Land and Ecosystems. https://wle-mekong.cgiar.org/download/state-of-knowledge/china-influence-hydropower-development/

32 Wouters, P. (2014). *Considering China's approach to the UN Watercourses Convention – Time to revisit?* International Water Law Project Blog. https://www.internationalwaterlaw.org/blog/2014/07/28/professor-patricia-wouters-considering-chinas-approach-to-the-un-watercourses-convention-time-to-revisit/

over extensive HPPs, China fosters multilateral engagement.[33] In 2002, China and MRC reached an agreement to share hydrological data in flood season with updates in 2008 and 2013. Amid criticisms that operation of Chinese dams' may be causing drought for downstream countries, in 2020 China and MRC countries reached an agreement on year-round data sharing. While upholding national sovereignty over water recourses as the "overriding principle"[34] China actively engages other Mekong Basin states in cooperation, especially through initiatives like the Langcang-Mekong cooperation (LMC). The LMC's goals concentrate in promoting social-economic development, eliminating development gaps between Mekong Basin states, and enhancing sustainability in Mekong subregion. Obviously, the LMC has outpaced other existing initiatives and platforms for cooperation in Mekong subregion, such as: Mekong-Ganga cooperation, Lower Mekong initiatives, and Japan-Mekong cooperation programme in terms of institution-building, cooperation scope and project financing.[35] According to the newest MRC's official report in 2021[36], the MRC's broad activities have supported and implemented over 500 projects in agriculture, fisheries, healthcare, education, poverty reduction and others fields.

With its political and economic great influence, China is the leader, the coordinator, and the investor of the LMC. All hydrological stations of the LMC are in Chinese territory, which could raise criticism relating neutrality of LMC – the crucial element of an international organization.

3. Hydropower plant project and sustainability in the Greater Mekong Subregion

Hydropower development in the Mekong River basin could be interpreted as good or bad,[37] a solutions to overcome the myriad challenges in subregion or a "deadlock" of a sustainable pathway. As analyzed above, the existing regulatory framework in the Mekong subregion have failed to govern effectively the HPP construction process, especially in the context of sustainable development.

"Sustainable development" is a global phenomenon aiming to harmonize three core elements: economic development, social inclusion and environmental protection.[38] The UN Secretary-General remarked that the world has transitioned

33 He, D., Wu, R., Feng, Y., Ding, C., Wang, W., & Yu, D. W. (2014). China's transboundary waters: New paradigms for water and ecological security through applied ecology. *Journal of Applied Ecology, 51*(5), 1159-1168. https://doi.org/10.1111/1365-2664.12298, p. 1159.

34 Ha, H. T. (2022). China's Hydro-Politics through the Langcang-Mekong cooperation'. *ISEAS Perspective*, *2022*(116), p. 3.

35 *Ibid*.

36 Yi, W. (2021). *Lancang-Mekong Cooperation: After five fruitful years, a new journey awaits – Marking the fifth anniversary of the Lancang-Mekong Cooperation*. lmcchina. http://www.lmcchina.org/eng/2021-03/23/content_41530584.html

37 Richard, G., Wenling, W., & Yan, F. (2022). Politicization of the hydropower dams in the Lancang-Mekong Basin: A review of contemporary environmental challenges. *Energies, 15*(5), Article 1682. https://doi.org/10.3390/en15051682

38 United Nations. (n.d.). *The sustainable development agenda*. https://www.un.org/sustainabledevelopment/development-agenda-retired

from an era of global warming to an era of global boiling.[39] In the Mekong region, increased human activities such as irrigation, hydropower construction, and deforestation, combined with natural pressures like climate change, are degrading the river's natural state, threatening biodiversity and affecting residents' rights. Climate change and extensive hydropower development reduce river connectivity, disrupt ecological balance, and cause water scarcity, leading to inequalities among Mekong Basin states. According to a 2018 Stockholm Environment Institute report, numerous hydropower plants in China, Thailand, and Laos are the main cause of the Mekong's shallowing, preventing nutrient-rich silt from flowing downstream.[40] As a result, downstream fish lack nutrition and rice fields are insufficiently fertilized during spills".

The MRC has adopted a series of strategies, policies, programmes fighting against climate change and water-related disasters and minimizing the negative effects of this process. However, as mentioned above, the existing legal framework lacks direct regulation to hydropower development. There are incompatibilities in the implementation of environmental standards and rules. This could be the consequence of historic approach regarding "ASEAN way" and "Mekong spirit", that bases on principle of non-intervention in internal state affairs and "two-countries solution" approach. Despite the PNPCA launch, EIA implementation for Mekong HPPs lacks consensus, with final reports failing to address major concerns and transboundary impacts.

Furthermore, mega-dam work on the Mekong mainstream has enormous transboundary environmental and socio-economic impacts that could degrade the entire river ecosystem. The land clearance for building water reservoirs of hydropower dams means destroying the corresponding vegetation, tropical forests, peatlands, and biodiversity. Statistics show that annual fishery losses will amount to 550,000 – 880,000 tons compared to the situation in 2000.[41] 54% of all river gardens on the Mekong will be lost (approximately $25.1 million per year) soon, and 10% of fisheries will be reduced (more than 40 fish species are on the verge of extinction due to dam work on the river mainstream, including Mekong giant catfish – the symbol of Mekong biodiversity).[42] Many scientific studies show negative consequences of hydropower plants operations on the Mekong mainstream and

39 Rutherfurd, I. D., & Peel, M. C. (2009). The hydrology of the Mekong River. In I. C. Campbell (Ed.), *The Mekong: Biophysical environment of an international river basin* (pp. 53–76). Academic Press.

40 *Volkov, K. (2019, August 27).* Одна из крупнейших рек в мире обмелела до рекордных значений [One of the world's largest rivers has shallowed to record levels]. *Rossiyskaya Gazeta*, https://rg.ru/2019/08/27/odna-iz-krupnejshih-rek-v-mire-obmelela-do-rekordnyh-znachenij.html

41 Baran, E. (2010). Mekong fisheries and mainstream dams. In *Fisheries sections in ICEM 2010 Mekong River Commission Strategic Environmental Assessment of hydropower on the Mekong mainstream* (pp. 1–145). International Centre for Environmental Management, p. 145.

42 Mekong River Commission. (2010c). *Strategic environmental assessment of hydropower on the Mekong mainstream: Summary of the final report*. International Center for Environmental Management. http://www.mrcmekong.org/assets/Publications/Consultations/SEA-Hydropower/SEA-FR-summary-13oct.pdf

tributaries on biodiversity and annual fisheries.[43] Overall, these developments cause a series of economic, environmental, and social impacts, raising controversy among researchers about the "sustainability" of this so-called renewable energy.[44] A series of researches have examined three core elements of sustainable development in the Mekong river basin, including: economic development, social inclusion and environmental protection as follow.

As the initiator of several HPPs on the transboundary Mekong River mainstream, the Laos Government has tried to allay fears by pointing to the positive aspects of economic growth. Apart from that, the Laos Government refined national legislation relating the Mekong mainstream hydropower dam development and committed to share hydrological data and information required.[45] Laos' lack of specific EIA criteria in national regulations exacerbates the environmental impact of HPPs, causing ecosystem disruptions like altered river geology and obstructed migratory fish habitats.[46] These projects threaten agricultural productivity, particularly in Vietnam's Mekong Delta, endangering food security[47] and livelihoods.[48] Additionally, high construction and resettlement costs often outweigh economic benefits. HPPs and reservoirs also contribute to biodiversity decline and freshwater shortages, worsened by climate change, population growth, and urbanization.[49]

Additionally, the result of a water quality study[50] showed high levels of heavy metal pollution because of operational activities of Chinese mega-hydropower plants locating afar from assessed water monitoring station. According to official data from the Mekong River Commission, the Lower Mekong states have built about

43 Ziv, G. et al. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences of the United States of America, 109*(15), 5609–5614. https://doi.org/10.1073/pnas.120142310; Nam, S., Souvanny, V., Ly, V., Theerawat, S., Son, M., Malasri, P., Peng, B., Sovanara, K., Degen, P., & Starr, P. (2015). Lower Mekong fisheries estimated to be worth around $17 billion a year. *Catch and Culture, 21*(3), 4–7.; Baker, C. (2012). Dams, power and security in the Mekong: A non-traditional security assessment of hydro-development in the Mekong River Basin. *NTS-Asia Research Paper,* No. 8.

44 Bogaart, P. (2023). The potential for sustainable hydropower. *Nature Water, 1*(1), 22-23. https://doi.org/10.1038/s44221-022-00018-9, p. 23.

45 Telle, A. (2023). The challenge of national implementation of international water law: The case of Mekong hydropower development in Lao People's Democratic Republic. *Journal of Water Law, 28*(1), 54–64, p. 62.

46 Stone, R. (2016). Dam-building threatens Mekong fisheries. *Science, 354*(6316), 1084–1085, pp. 1084–1085.

47 According to World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF), about 900 million people do not have access to improved drinking water supplies. See WHO, & UNICEF. (2006). *Meeting the MDG drinking water and sanitation target: The urban and rural challenge of the decade*. World Health Organization. https://www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf

48 Costa-Cabral, M. C. et al. (2008). Landscape structure and use, climate, and water movement in the Mekong River Basin. *Hydrological Processes, 22*(12), 1731-1746. https://doi.org/10.1002/hyp.6740, p. 1731.

49 Wagner, F., Tran, V. B., & Renaud, F. G. (2012). Groundwater resources in the Mekong Delta: Availability, utilization, and risks. In Renaud, F. G., & Kuenzer, C. (Eds.), *The Mekong Delta system* (pp. 201–463). Springer, pp. 463, 201.

50 Fu, K. et al. (2012). Pollution assessment of heavy metals along the Mekong River and dam effects. *Journal of Geographical Sciences, 22*, 874–884. https://doi.org/10.1007/s11442-012-0969-3, p. 882.

100 monitoring stations to assess water quality.[51] The operation of hydropower plants and industries in coastal states cause pollution, including hazardous heavy metal pollution. With increasing demand for irrigation in the Mekong Basin, the region faces mounting pressure on its natural resources, further highlighting the need for sustainable water and energy governance.[52]

Mass construction of HPPs on the Mekong River poses severe risks to human rights, including food, education, housing, health, and access to water, as well as procedural rights like access to information, decision-making, and justice.[53] Indigenous peoples and ethnic minorities face significant threats due to their deep ties to land. The Xayaburi dam displaced at least 18 villages, submerging living areas, livelihoods, and cultural heritage, violating collective land rights under the 2007 UN Declaration on Indigenous Peoples.[54] Despite promises, Laos failed to deliver resettlement infrastructure, leaving displaced communities unsupported, while CH Karnchang benefits from electricity sales.[55] Forced displacement disrupts reintegration and ethnic identity.

Hydropower development in the Mekong River basin aligns with the 1995 Agreement and MRC procedures but lacks a mutual binding agreement among all basin states. The regional legal framework fails to balance upstream and downstream states' rights and obligations. This imbalance, coupled with evolving geopolitical and environmental complexities, highlights the ineffectiveness of the current framework. An urgent, integrated water governance approach is needed to harmonize national interests and regional cooperation.[56]

Conclusion

Hydropower is promoted in the Mekong Basin for socio-economic development and climate change mitigation, yet unregulated projects cause significant environmental, social, and economic harm. The lack of oversight, coupled with differing national sustainability standards and voluntary participation by China and Myanmar, worsens challenges.

51 Mekong River Commission. (2018). *State of the basin report: MRC for sustainable development*. http://www.mrcmekong.org/assets/Publications/technical/tech-No15-diagnostic-study-of-water-quality.pdf

52 Теймуров, Э. С. *(2017)*. Проблемы регулирования рационального использования и охраны пресной воды в двусторонних договорах Российской Федерации [Problems of regulation of rational use and protection of freshwater in bilateral treaties of the Russian Federation]. *Альманах Кафедры Международного Права Ceteris Paribus*, Prospect Publishing House, p. 82.

53 Maureen, H. (2016). *A matter of rights in the future of the Mekong*. International Rivers. https://www.internationalrivers.org/blogs/721/a-matter-of-rights-in-the-future-of-the-mekong

54 Mekong River Commission (2018), *supra* note 51, p. 23.

55 Open Development Mekong. (2019). *Population and censuses*. https://opendevelopmentmekong.net/topics/population-and-censuses/; Itzchak, K. (2020). *Mega-dams and indigenous human rights*. Edward Elgar Publishing, Inc. p. 187; Percy, K. E., Mohammad, J. A. S., Lorraine, L. T. C., & Holly, E. R. (2023). Social consequences of forced and refugee migration. *Annual Review of Sociology, 49*, 129–153.

56 Tran, T. A., & Tortajada, C. (2023). Responding to transboundary water challenges in the Vietnamese Mekong Delta: In search of institutional fit. *Environmental Policy and Governance, 32*(4), 345.

Thus, Mekong states must adopt stricter legal frameworks, including comprehensive EIAs addressing environmental and socio-cultural impacts, while avoiding sensitive areas like heritage sites and conservation zones. Although global conventions on transboundary water management do not directly apply, customary water law principles and standards are crucial for harmonizing legal frameworks. The MRC needs to further promote its role as a bridge to reconcile differences in national water policy between Mekong Basin states, ensuring that GMS can function as a unified bloc. Furthermore, the MRC should extend EIA evaluation timelines to 2-3 years for large projects, enhance hydrological data sharing, and strengthen cross-border cooperation to build trust, protect vulnerable communities, and ensure sustainable river management. Improving international legal mechanisms is vital to build trust and protect human rights, especially for vulnerable groups in the river basin. ●

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Author Contribution

The author solely contributed to the study conception and design. The author read and approved the final manuscript.

Declarations

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