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ENGINEERING COMPLIANCE WITH ENVIRONMENTAL LAW IN LAO HYDROPOWER

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Chapter I. Introduction

Hydropower is one of the most important renewable energy sources, accounting for about 14% of global electricity in 2024 (IEA, 2025). For Laos, which is landlocked, hydropower is the main way for economic development. With high rainfall and many rivers, the country has the potential to generate around 26,000 MW of electricity (ACE, 2025).

Since the 1990s, Laos has followed a strategy of building hydropower plants and exporting electricity to Thailand, Vietnam, and Cambodia. By the end of 2023, more than 80 hydropower plants were operating, and the power system's total installed capacity exceeded 11,000 MW, with additional projects under construction; electricity has become one of the country's largest exports (ACE, 2025).

This rapid expansion has raised serious environmental problems for the local area and the wider basin. The Mekong River and its tributaries support more than 60 million people in the Lower Mekong Basin with one of the world's most productive freshwater fisheries (Grumbine & Xu, 2011). Large dams have been blamed for disrupting natural river flows, blocking fish migration, trapping sediment, altering water temperatures, and modifying the seasonal floods that farmers and fishers depend on (Grumbine & Xu, 2011).

The question is whether these projects comply with environmental laws and regulations. While Laos has environmental protection laws and requires environmental impact assessments, studies have documented a serious gap between what the regulations require and what happens on the ground (International Rivers, 2008). These problems are reflected in water-quality monitoring, sediment control, fish-passage facilities, and environmental reporting; adherence to technical decisions depends on design specifications, construction quality, and operating procedures at all levels in Laos (Green & Baird, 2020).

Due to these issues, thousands of people mainly from ethnic minority groups have been forced to move as reservoirs flooded their villages. Reports show insufficient compensation, destroyed livelihoods, and conditions worse than before (Delang & Toro, 2011). The environmental impacts of hydroelectric dams in the Mekong also reach downstream, affecting fishing communities in many countries (Ziv et al., 2012; Soukhaphon et al., 2021). Even with environmental regulations at both international and national levels, there are still significant gaps between regulation and actual implementation (Green & Baird, 2020).

This study examines environmental compliance in Laos' hydropower sector, focusing on how environmental requirements are translated into actual practice. It identifies where and why lapses occur and provides practical, capacity-appropriate recommendations for improvements.

Hypotheses

H1: Hydropower projects in Laos generally meet national water quality standards in their monitoring reports.

H2: The sediment management practices of Lao hydropower projects fall short of international best-practice guidelines.

H3: Fish passage systems in Lao hydropower projects are either absent or ineffective, contrary to environmental policy requirements.

H4: Discrepancies exist between reported environmental monitoring data and the on-ground implementation of compliance measures in Lao hydropower projects.

The research compares monitoring reports with plant designs and independent evidence to show how often (or if ever) projects meet water-quality thresholds; does sediment routing or flushing practice fall short of accepted practice; and in the case of fish, are the "fish ladders" working under monsoonal conditions for all migratory species, as they were designed to do Reading the reports together bring us toward understanding the difference between "good on paper" and "good in practice" dam compliance, highlights what is driving the downstream ecological train wreck, and advances our understanding of how to put river-dependent and resettled communities (who have seen their livelihoods diminished because of huge changes in the river and upstream area) back on a more secure path (Delang et al., 2011; Soukhaphon et al., 2021).

Chapter II. Literature Review

2.1. The Energy Situation of Laos and Neighboring Countries

The electricity system in Laos is almost completely supplied by hydropower, which has an installed capacity of 11,692 MW and generates about 58,884 GWh each year (ACE, 2025). The domestic electricity demand in 2023 was 11,583 GWh (Phongsavath, 2024), with estimations projecting it to reach 13,700 GWh in 2024; however, basic generation facilities exceeded the domestic requirements by a wide margin, allowing the Electricity of Laos to not only supply its domestic customers but also export excess power to neighbouring countries. Between 2010 and 2011, the bulk of the excess capacity went to Thailand, with the Kouphokham (2013) reporting that around 81% of the production found a market downstream. Meanwhile, coal fired power primarily comes from the Hongsa plant, which has a capacity of 1,878 MW and generates around 12,582 GWh every year. Non hydro renewables, including biomass, solar, and wind, are currently part of generation installations in a very up and coming way, offering less than 7% in energy contribution (Phoumin, 2024).

Laos national energy strategy and its desire to become the "Battery of Southeast Asia" are founded on hydropower (FPRI, 2024). The country's electricity comes almost entirely from hydropower plants, and current energy plans suggest a transition to other energy sources, but it is very slow (IEA, 2023). In fact, the 2025 goal to operate more than 60 hydropower plants with several large-scale projects either under construction or planned indicates an increasing reliance on the energy source; this target has already been exceeded, with 81 hydropower plants operating by end-2023 (ACE, 2025).

Laos reliance on hydropower to meet its energy demands is deeply rooted in the country's geography and economy. Geographically, the nation is ideally suited to this form of energy generation; its rugged, mountainous terrain offers ample water catchment potential, making Laos one of the prime locations for hydroelectric plants within the Lower Mekong Basin (Tran & Suhardiman, 2020). Economically, dam construction is one of the few revenue-generation options available to the country. Laos has no indigenous fossil fuel production and imports virtually all petroleum products, making hydropower essentially the only domestic energy option (IEA, 2023; Phoumin, 2024).

By 2030, according to a plan mandated by the Lao government, the nation will have increased hydropower capacity to 20 gigawatts. By that time, Laos will be exporting the vast majority of what it produces, with the largest amounts going to Thailand and Vietnam (Saibasan, 2025).

Table 1: Major Existing and Planned Hydroelectric Power Plants

Project	**River**	**Capacity (MW)**	**Status**	**Export**
Nam Theun 2	Nam Theun → Xe Bang Fai	1,070	Operating (2010)	Thailand (majority); domestic (minor)
Xayaburi	Mekong	1,285	Operating (2019)	EGAT (Thailand)
Nam Ou Cascade (7 dams)	Nam Ou	~1,272–1,280	Completed (2016–2021)	Northern Laos grid / cross-border
Luang Prabang	Mekong	1,460	Under construction/development	EGAT (Thailand)
Pak Beng	Mekong	912	Under development	EGAT (Thailand, planned)
Pak Lay	Mekong	770	Under construction/development	EGAT (Thailand)

Source: own edition based on MRC; EGAT; WB/ADB; (2010-2025)

Table 1 summarizes the major hydropower plants already in operation or under development in the country. The most significant complete dams such as Nam Theun 2 (1,070 MW), Xayaburi (1,285 MW), and the cascade of dams along the Nam Ou River (1,280 MW) exemplify a strategy that heavily depends on large dams built for export. The current slate of projects Luang Prabang (1,460 MW), Pak Beng (912 MW), and Pak Lay (770 MW) signal a ramping up of an electrification strategy that aims for what looks a lot like energy independence: a dam-to-power-grid system that electrifies the whole country, paying for itself in foreign revenue while doing so.

Laos is effectively the regional power plant, selling clean, renewable hydropower to serve as electricity exports. Achieving universal access to reliable electricity services means putting three things in order: tariff design, loss reduction, and reliability of supply. Together, these components determine how much energy can be exported from a country without undermining domestic sustainability and affordability goals. Accomplishing these three tasks so they work together isn't easy, but it is feasible. On the domestic side, a system can use cost-reflective tariffs for large users alongside "virtual supply" measures that get sufficient electricity to vulnerable households and allow them to afford it. On the demand side, large users can be managed to smooth out peaks improving internal reliability and making firm export deliveries more likely **(**ADB, 2019; UN ESCAP, 2021). The surplus created by seasonal hydrology is largest during the wet season and narrowest during the dry season, so the value of energy exports depends on much more than sheer volume. Revenue stability hinges on power purchase agreements that specify obligations beyond simple firm/non-firm labels, Mekong River Commission. (2022) e.g., delivery windows, curtailment rules, and settlement (ADB, 2019). Laos can play a significant role in helping Thailand and Viet Nam integrate more solar and wind, but that requires a reliably balanced system. Whether Lao hydropower serves that purpose hinges as much on system operations and interconnection capacity as it does on the ability to sell power at all (MRC, 2022). This makes Laos essentially a regional electrical utility, generating power to send mainly to Thailand but also to serve as far as the ASEAN Power Grid (FPRI, 2024). Yet even "Hydropower Laos" cannot keep the Mekong healthy by itself. Laos shares the river with five other countries. When anything goes wrong with the river anywhere along its course, it then sends disastrous ripples down through the rest of the river's shared watershed. And all the bad stuff happening with the Mekong impacts it both upstream and downstream. Trapped behind concrete, silt no longer feeds the floodplains, and when the gates open or stay shut, floods can come too fierce or droughts too long (Pokhrel et al., 2018; Soukhaphon et al., 2021). Climate change compounds these pressures, with projections indicating rising temperatures by the 2040s and altered rainfall and flood patterns that will affect both hydropower output and river ecosystems (Pathirana & Evers, 2018). This situation affects Laos' economy. Upstream damming pushed by development dreams and financed by foreign banks and companies endangers not just fish but also the promise of socioeconomic development that Laos holds out to its people. A cascade of seven dams has been built on the tributaries of the Nam Ou River, which flows through some of the poorest areas of northern Laos (Soukhaphon et al., 2021). Besides the immediate social and economic damage, these dam plans and others like them throw into stark relief the necessity of regional cooperation: watershed management along the length of the river and through all its tributaries is a shared problem and a shared responsibility (Pokhrel et al., 2018).

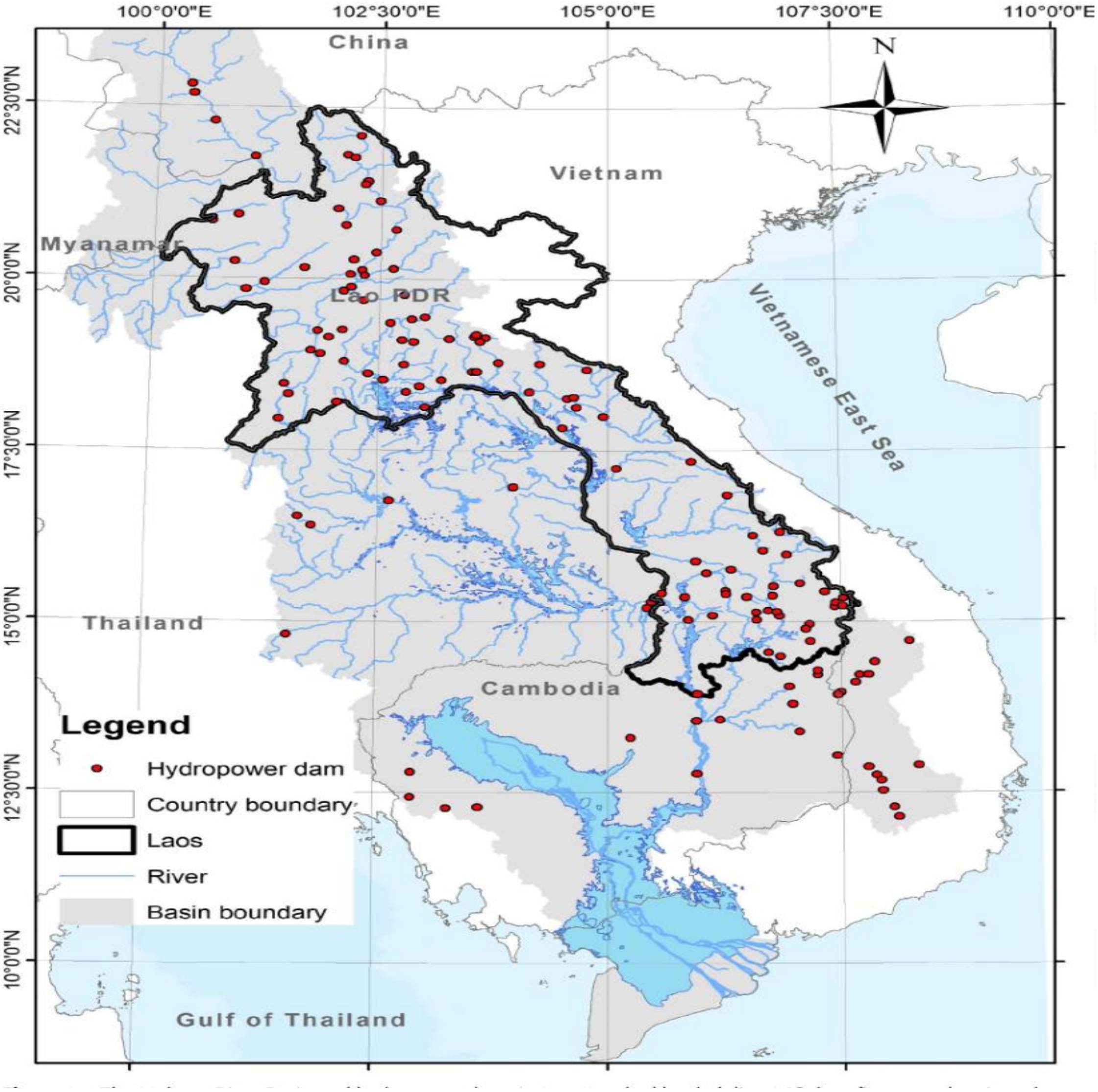

Figure 1: The Mekong River Basin and hydropower dams in Laos

Source: Tran & Suhardiman, 2020

As shown in Figure 1, Laos lies almost entirely within the Lower Mekong Basin and shares the river system with five other countries.

Laos, almost entirely within the Lower Mekong Basin, sits in a region of roughly 795,000 km² that reaches six nations China, Myanmar, Thailand, Cambodia, Vietnam, and Laos itself it shares the river's flow with all. Rugged hills, rain from 1,300 to 3,000 mm each year, plenty of runoff. The Nam Ou, Nam Ngum, Nam Theun, Xe Kong, and Nam Khan are the main hydropower routes; they tumble down from the northeastern highlands, they join the Mekong. Steep slopes everywhere Laos seems made for hydropower (Tran & Suhardiman,, 2020).

The Mekong River is one of the most lively water systems on Earth; its flow changes all the time. Rainy season bursts shove tons of sand and silt into the rivers; those piles keep Cambodia's floodplain and Vietnam's delta from eroding, so the land stays. Moreover, intensive dam building already changed those natural processes sediment transport to the delta has fallen by more than 60% since before 2000, and flood timing has turned completely irregular (Mekong River Commission, 2024). disruption hits both the environment and nearby communities hard. Because the dams on the Nam Ou and Nam Theun rivers have chopped up fish routes and shrunk their spawning spots, fisheries across the basin tumble even quicker (Baird & Hogan, 2023).

Invest in Laos hydropower, shows the land's natural power boost; it occupies a spot that's both handy and strategic, a fact that seems almost self evident. Nam Theun 2, Theun Hinboun, and Nam Ngum 1 were developed through partnerships with Thailand and Vietnam, while the even larger Nam Ou and Sanakham projects receive funding from Chinese state owned companies. Over half of new hydro plants Chinese banks and firms stand behind them the area powers up fast (Urban et al., 2013). According to those results, something surprising shows up: these money-making projects chase both profit and power they're trying to make the grid safer and build new bridges and pipelines across the area (Matthews & Motta, 2015). Most projects use the Build–Operate–Transfer (BOT) model, so money and know-how arrive, yet the country doesn't get much control over how clean the work stays.

Since the Mekong flows across several nations, it remains both a money lifeline and a political hotspot. Over 60 million people rely on its waters, they grow corn, pull in fish, and steer barges. The Mekong River Commission still stands as a key player, yet each nation chases more electricity and often puts the river's health in the back seat. The Mekong gifts Laos abundant water power, but it also traps the nation in tangled eco political ties (Tran & Suhardiman, 2020).

2.2. Types of hydroelectric power plants, the most important aspects of construction in general

Hydropower plants are classified according to their technology and capacity (Elbatran et al., 2015). The technological classification to how water is made to work is to harness, store, and release in order to produce power. The capacity classification to the size and power output range of the plant.

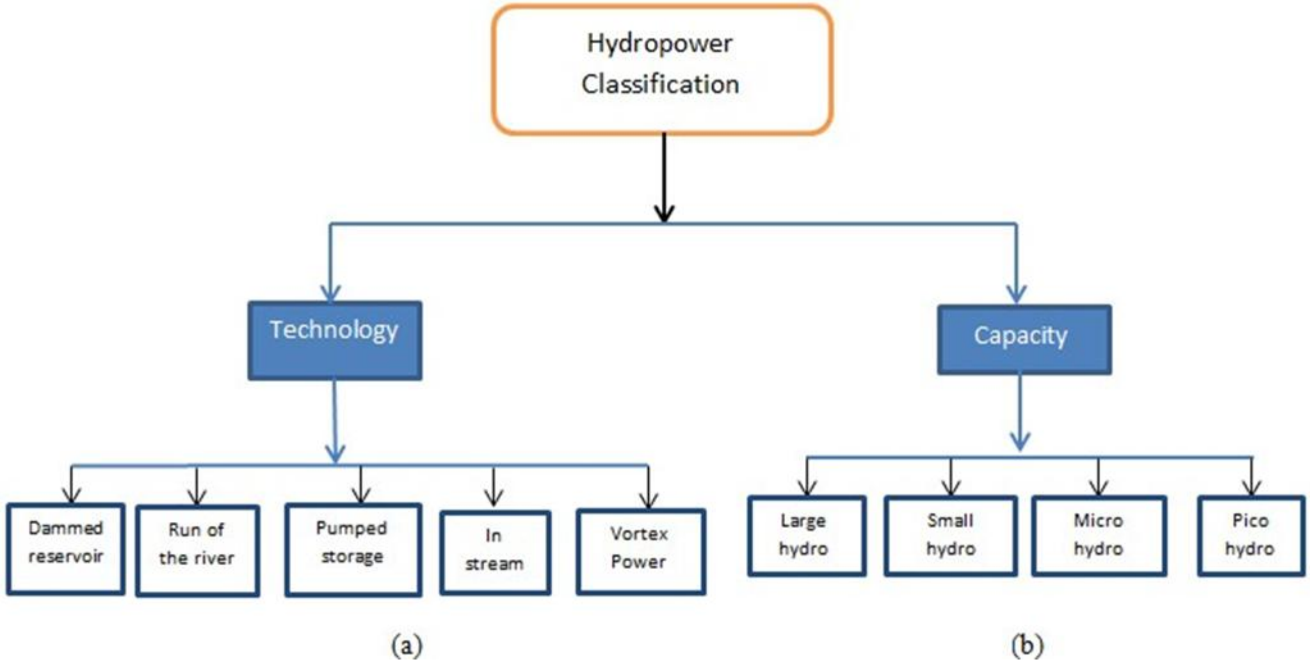

Figure 2: Hydropower Classification by Technology and Capacity

Source: Elbatran et al., 2015

The following formula governs the amount of power that a hydroelectric power plant produces:

$$P = \eta \rho g Q H$$

- P = Power (W)
- η = Overall efficiency
- ρ = Water density (≈ 1000 kg/m^3)
- g = Acceleration due to gravity (9.81 m/s^2)
- Q = Discharge (m^3/s)
- H = Effective head (m)

the electric output is contingent on the turbine's efficiency, the flow rate, and the head that can be utilized (Singh & Singal, 2017). Current hydroelectric systems are typically very efficient. "Modern hydro systems can reach efficiencies above 90 %, making them among the most effective renewable-energy converters" (Okot, 2013).

Table 2. Types of hydroelectric power plants

Type	**How it works**	**Storage**	**Typical head (m)**	**Typical capacity**
Dammed Reservoir (Storage)	Reservoir behind a dam releases water through turbines.	High (large reservoir)	Medium-high	Large
Run-of-River	Diverts part of river flow to turbines, returns it downstream.	Low (little/none)	Low-medium	Small–Large
Pumped-Storage	Pumps water up off-peak; releases it at peaks to generate.	High (two reservoirs)	high	Large
In-Stream (Hydrokinetic)	Turbines sit in moving water; no dam needed.	None	**≈0** (velocity-based)	Micro–Small
Vortex (Gravitational-Vortex)	Circular basin forms vortex driving a central turbine.	Minimal (small forebay)	Low	Micro to mini

Source: own edition based on Elbatran et al. (2015)

Hydropower "size" refers to installed capacity. Common are pico (<10 kW), micro (10–100 kW), mini (0.1–1 MW), small (1–10 MW; sometimes up to 20–50 MW by national definition), and large (> those small limits) (Kaunda *et al*., 2012).

Separately, sites are described by head the available vertical drop which is independent of capacity. A widely used convention is low head = 2–30 m, medium head = 30–100 m, high head ≥ 100 m (ESHA, 2004).

Hydroelectric dams reshaped the main rivers around the globe; waterways now look different. They supply power and curb floods, water flow goes sideways; habitats split; the variety of life drops. Egypt, China, South America. All three tell us how widespread these impacts really are.

- Egypt: The Aswan High Dam created Lake Nasser, one of the largest artificial lakes in the world. Although the dam reduced the river's supply of nutrient-rich silt, it provided something more important for the cultivation of food: stability. After eons of annual flood, a cultivated Egypt finally had a reliable supply of water (Abd-El Monsef et al., 2015). And with it, a blasted landscape beneath the blazing sun could be transformed into something with the slightest semblance of a river. Although the dam and its lake literally reshaped parts of Egypt, the Aswan project would not have been feasible without modern geology and with a figure drawn only from the ancient world (Abd-El Monsef et al., 2015; Barakat et al., 2013).
- China: China's Three Gorges Dam, the world's largest hydropower project, reached full operation in 2012 (Zheng et al., 2023). Since then, it has begun to alter a number of river-routine matters. One of the most immediately noticeable effects downstream from the dam has to do with river sediment. Impounding the river behind the dam has caused sedimentation in the newly formed reservoir. Meanwhile, as the dam has been put to work, the construction of a really big sediment trap has begun to pay off in spades for people living along the middle and lower Yangtze River. There, river flow and sediment load have dropped sharply, leading to adjustments in riverside structures, which are now eroding with greater gusto than before. (Hu et al., 2009; Zheng et al., 2023).
- South America: The Amazon Basin is home to some of the world's largest dams, including the Belo Monte Dam on the Xingu River and the Itaipú Dam on the Paraná River, which is part of the La Plata Basin (Keppeler et al., 2022). These dams have had serious impacts on tropical river systems, causing extensive and largely irreversible changes to both rivers and the adjacent floodplain environments. They have had even more dramatic consequences for the human populations dependent on these ecologically rich and diverse environments. Floodplain environments in the Amazon Basin are not only vanishing; in many places, they're being replaced by the kinds of environments that occur upstream and downstream from the dams. (Keppeler et al., 2022; Ritter et al., 2017).

The construction of large hydropower dams has a profound effect on both the landscape and the lives of people living in the area (Tilt, Braun, & He, 2009). Often, communities must be displaced, leading to change not just in their physical environment but in their historical identity as well. The rivers that fed their subsistence based agricultural communities are dammed, altering the ecology and, in many cases, undermining river based livelihoods such as fishing and flood-recession farming (Sivongxay, Greiner, & Garnett, 2017). Neighboring communities are also affected; those downstream can suffer markedly as they experience drastic changes in flora and fauna, as well as water. Compensation for the many lives that are upended is rarely sufficient and does little to mend the social tissue that keeps communities intact (Tilt, Braun, & He, 2009).

The Nya Heun community lost ritual spaces and access to forests in the area of the Houay Ho dam (Baird, 2013). Meanwhile, resettlement sites established with project and government support went up to house some of those removed from their riverine livelihoods (Delang & Toro, 2011).

Officials and project proponents promised jobs and training for those displaced; in practice, many Nya Heun reported receiving little or no training and few formal jobs or sustainable alternatives (Baird, 2013; Delang & Toro, 2011).

Across tropical river basins, large storage projects consistently reconfigure river–floodplain systems and have broader ecological effects than earlier assessments anticipated. They simplify fish communities, shift the timing of flood pulses, and alter sediment routing in ways that are hard to reverse once cascades are in place (Soukhaphon et al., 2021; Tilt et al., 2009). Because fishing livelihoods are among the first to register these changes and many impacts are cumulative and transboundary, project-level EIAs often under-capture them. Read through this lens, the literature's call to extend EIA practice and post-licensing monitoring helps sustained critiques of the Don Sahong proposal, particularly around fish migration and basin-wide effects (ICEM, 2010).

2.3. Fundamental Legal Context

The 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes (hereafter "Helsinki Convention") obliges its Parties to prevent, control and reduce transboundary impacts, to use shared waters equitably and reasonably, and to cooperate through joint institutions and the exchange of information (United Nations Economic Commission for Europe, 1992). Laos has not acceded to the Helsinki Convention and is therefore not legally bound by its provisions. the Convention is discussed for information and comparison only, as a widely recognised benchmark for good practice in the governance of transboundary rivers and large hydropower development, rather than as a binding legal framework for Lao decision-makers (UNECE, 1992).The Espoo Convention on Environmental Impact Assessment in a Transboundary Context (1991) summarizes the responsibility of the parties and the opportunity afforded to their citizens to participate in ensuring that large scale, environmentally impactful projects are sensibly planned (United Nations, 1991).

Additionally, cooperation on the Mekong River, first established in a committee agreement in 1957, moved to the next level with the 1995 Mekong Agreement, which embraces "equitable and reasonable" principles that should inform all transboundary water governance (ECAFE, 1957; Mekong River Commission, 1995; Giovannini, 2018).

The UN Sustainable Development Goals (SDGs) give an international signal about the kind of energy and environmental management that is desirable and attainable (United Nations, 2015). Goal 7 states, "Ensure access to affordable, reliable, sustainable, and modern energy for all." This is closely aligned with the Laos national development goal of becoming "the Battery of Southeast Asia," which from noticeable drop in renewable energy generation in Laos, is synonymous these days with exporting hydropower to the Laos people's neighbors and beyond (Giovannini, 2018; ERIA, 2020). Yet, dam building and the large hydropower plants that result also have serious adverse effects on water management, as signaled by SDG 6: "Ensure availability and sustainable management of water and sanitation for all" (United Nations, 2015). Improving governance in these two vital areas of sustainable development requires not only a change of heart within the government of Laos but also support from the international community (United Nations, 2020).

From a legal and governance perspective, the Sustainable Development Goals do not create a formal hierarchy in which one Goal is "stronger" than another. The 2030 Agenda describes the 17 Goals and 169 targets as "integrated and indivisible" and calls on states to pursue them in a balanced and integrated way, rather than privileging, for example, SDG 7 on energy over SDG 6 on water (United Nations, 2015, 2020). Recent work on SDG interactions therefore focuses less on ranking the Goals and more on mapping synergies and trade-offs between specific targets and designing policies that maximise co-benefits while minimising conflicts (Nilsson et al., 2016; Fuso Nerini et al., 2018; Fader et al., 2018). In the context of Lao hydropower development, this implies that progress towards SDG 7 should be assessed together with, and constrained by, commitments related to water quality, river ecosystems and local livelihoods under SDG 6 and related targets, rather than being treated as an objective that can legitimately override them.

The Constitution of the Laos grants status to the protection of the environment on par with other forms of protection such as the rights of children and women, the rights of ethnic groups, and the rights of the disabled (National Assembly of the Lao PDR, 2015). Article 19 of the 2015 Constitution provides that the State supports the protection, restoration, and development of natural resources to ensure sustainable environmental goals, and requires all organisations and citizens to protect the environment, biodiversity, and natural resources (National Assembly of the Lao PDR, 2015).

The Lao National Assembly passed the Law on Environmental Protection (No. 29/NA) on 18 December 2012, and it forms the foundation for environmental legislation in Laos as the central legal instrument that governs the implementation of environmental policies and the jurisdiction of environmental laws (MONRE, 2013). Rules and procedures to fulfil this law are in place, and there are penalties for transgressing its provisions (e.g., Part XII of the Environmental Protection Law and Article 84 of the 2019 EIA Decree) (ADB, 2020).

The Environmental Impact Assessment (EIA) is the principal means of ensuring that new developments do not cause significant and adverse effects to the environment (MONRE, 2013). EIA requirements exist for medium and large scale projects, and some smaller projects undergo an Initial Environmental Examination (IEE) (Government of the Lao PDR, 2019; MONRE, 2013). Luang Prabang, being a UNESCO World Heritage Site, also requires that the implementation of significant development projects in the town and surrounding area remain consistent with the site's designation and protection conditions (UNESCO, 2021).

In accordance with the Environmental Protection Law (2012) (National Assembly of Lao PDR, 2012), responsibility for provincial and district development oversight is assigned to the Ministry of Natural Resources and the Environment (MONRE) (MONRE, 2013). This includes the approval of Environmental Impact Assessments (EIAs) and the issuing of Environmental Compliance Certificates (ECCs), which indicate MONRE's conditional approval that a project complies with applicable requirements and may proceed subject to ongoing compliance and monitoring (National Assembly of Lao PDR, 2012; MONRE, 2013). However, MONRE has seen very limited success in actually monitoring not only the EIA process, but also the ongoing environmental impacts of road or hydropower projects at a semi annual or annual scale after they are permitted. This weak post project environmental monitoring is partly a result of a lack of staff, and it is also a result of the inadequate technical training of the staff that MONRE does have (Wayakone & Inoue, 2012). Following the pre 2012 EIA process, it remains uncertain functionally and institutionally how post project environmental monitoring is carried out in practice, with follow up widely characterized as weak (Wayakone & Inoue, 2012).

Laos has a solid environmental legal framework and comprehensive procedures for project development (ADB, 2019). Yet its post-licensing performance leaves much to be desired (Wayakone & Inoue, 2012). Three recurrent problems are noted: (i) inconsistent post-project monitoring and public reporting (Wayakone & Inoue, 2012); (ii) findings from regional processes such as MRC prior consultation and the basin strategy are not reliably translated into binding license clauses and Power Purchase Agreements (PPAs) (MRC, 2022); and (iii) when provisions are included, they often lack clear performance targets (e.g., auditable environmental-flow triggers, sediment-routing schedules, fish-passage metrics) (MRC, 2022). These gaps help to understand why the on-paper framework doers not always deliver in practice (ADB, 2019; Wayakone & Inoue, 2012).

2.4. Current events

The strategies placed by the government of the Lao People's Democratic Republic (GoL) are clear and well defined; they will push the economy toward sustainable and inclusive growth. These strategies identify the energy sector especially hydropower as the vertex for the national development ladder (ADB, 2019). The 8th National Socio Economic Development Plan (NSEDP) (2016–2020) focused on the country's push to leave the "Least Developed" label and set in place the foundations leading to an energy sector strategy to 2030 that emphasizes diversification and energy efficiency (ADB, 2019; MPI, 2016).

This strategic direction flowed without interruption into the 9th NSEDP (2021–2025), which continues emphasizing hydropower as the country's main high tech tool for pushing the national development ladder (MPI, 2021). While the sector strategy initially adopted a broad, inclusive approach with a wider renewable energy mix, its execution has tended in practice to prioritize prime (large) hydropower projects (ADB, 2019). Ten year power development planning (often referred to as the Electricity/Power Development Plan) accompanies a set of actions framed to realize a vision of development in the electricity sector.

This vision seeks to achieve universal access to electricity, provide adequate and reliable electricity supply, and ensure that electricity supply is affordable to the poor by 2030 (UN ESCAP, 2021; ADB, 2019). The planning framework encompasses several electricity-sector development projects and, together with the ADB (2019) report, offers a solid basis to understand the actions and projects necessary to move the country toward its sector development vision.

The Nam Ngum 2 (NN2) hydropower project required the resettlement of approximately 16 villages into a new township (Syladeth & Shi, 2016). The project aimed to restore livelihoods and improve living standards, but serious flaws in planning and implementation have emerged since. These flaws stem primarily from using a land allocation scheme that was new and untested, from underfunding a necessary portion of the resettlement plan, and from a lack of understanding of the basic precept needed to implement a rights based framework (Syladeth & Shi, 2016; Syladeth, 2017).

As a result, what was once an emerging story about the successful relocation of people for a clean, renewable energy project has turned into a tale of faltering project implementation and delays in promised compensation payments. Families that relied on traditional means of flood recession agriculture and inland fishery production, who had already seen their productive lives come to a standstill during construction, were unable to recover (Syladeth & Shi, 2016; Syladeth, 2017).

NN2 was supposed to be a clean energy project that showed the way forward for hydropower development in the Laos (ADB, 2020). Instead, it has highlighted how hydropower development can fall short of being clean, green, and socially responsible when social safeguards are inadequately implemented (ADB, 2020; Syladeth & Shi, 2016; Syladeth, 2017).

Under the Mekong River Commission's prior consultation process, technical reviews highlighted two critical risks: the major fisheries migration risk and the sediment management risk (MRC, 2011). These reviews also underscored a fundamental challenge that projects in basin countries must face to be successful: ensuring compliance with transboundary environmental and social standards (MRC, 2011).

Laos is trying to achieve the Sustainable Development Goals (SDGs) through a wide ranging hydropower strategy (ADB, 2019). The Lao government believes that constructing large hydropower dams will fulfill SDG 7, which calls for “affordable, reliable, sustainable, and modern energy for all,” and will lead to significant electrification of rural areas (United Nations, 2015; ADB, 2019). Laos plans to sell much of the electricity it generates to its neighbors (ADB, 2019).

However, this export policy carries serious risks. If Laos commits too many resources to dam construction, the country could wind up with a poor balance sheet for the projects, as several recent analyses forecast (ADB, 2019). Dam construction will also have a range of adverse ecological effects altered river flows, sediment trapping, and disrupted fish migration which Lao national hydropower policies do not adequately acknowledge in their risk assessments (Pokhrel et al., 2018; Soukhaphon et al., 2021).

On balance, the policies Laos is implementing to achieve SDG 7 are most likely undermining not only SDG 6, which pertains to water, but also a range of national policies aimed at conserving biodiversity and maintaining ecological integrity (Soukhaphon et al., 2021). Meeting these two commitments coherently will require much stronger Environmental Impact Assessments (EIAs); assurance that the projects comply with environmental flow (“e-flow”) standards, which are necessary for the health of downstream riverine ecosystems; provisions for fish passage and sediment management; and, above all, effective coordination of each dam’s impacts with the communities and ecosystems in both its watershed and the downstream regions (ADB, 2019; Soukhaphon et al., 2021).

Laos’s drive to develop hydropower is delivering real progress on SDG 7 (ADB, 2019). However, unless the Lao government develops an informed basin awareness and enforces rigorous compliance with basin wide safeguarding plans, this progress is in danger of systematically undermining SDG 6 along with a host of other ecological and developmental objectives in the Mekong River Basin and its shared watersheds (Pokhrel et al., 2018; Soukhaphon et al., 2021).

The following points present a synthesis of the existing literature. Strengths and Weaknesses refer to the internal components of Laos's contemporary energy strategy and its implementation. Opportunities and Threats discuss external factors relating to markets, interconnections, and basin conditions that might affect the energy strategy and its execution.

Strength: The government of Laos has maintained clear continuity in its policy priorities from the 8th to the 9th National Socio-Economic Development Plan (NSEDP) (MPI, 2021). The electricity-sector vision to 2030 emphasises three mainstays access, reliability, and affordability (ADB, 2019). Monetising surplus generation by trading with neighboring systems is also part of the strategy (ADB, 2019). Leveraging the established cross-border trading platform helps knit together what could otherwise appear as disparate energy-development measures (ADB, 2019; MPI, 2021).

Weakness: Despite strategic references to diversification, implementation remains heavily focused on hydropower, translating into a slow transition to non-hydro renewables (ADB, 2019). The post-licensing phase is uneven: monitoring and public reporting are inconsistent (Wayakone & Inoue, 2012). River-basin safeguards we would expect in plant operating rules and in the contracts that accompany them are not yet systematically embedded in licenses and PPAs (MRC, 2022). Where the EIA system is limited by agency capacity, it also limits systematic follow-up and corrective action to ensure that strong legal provisions translate into on-the-ground compliance (Wayakone & Inoue, 2012).

Opportunities: Strengthening regional interconnections and the ASEAN Power Grid raises the value of storage-backed hydropower as Thailand and Viet Nam integrate more solar and wind and need balancing, ramping, and reserves (DEPP & ERIA, 2020). International and regional frameworks provide a straightforward pathway to harden the safeguards that underpin this dependence: the Asian Development Bank's sector guidance and safeguards, together with the MRC's Sustainable Hydropower Development Strategy, set out verifiable requirements for example, auditable environmental-flow triggers, sediment-routing schedules, and fish-passage performance targets that can be written directly into licenses and PPAs (ADB, 2019; MRC, 2022). Embedding these conditions, along with transparent monitoring and reporting, links basin-aware operations to contractual obligations and makes export reliability more bankable (ADB, 2019; MRC, 2022).

Threat: Hydrology and climate variability tightening dry seasons and more intense wet-season events create cumulative basin impacts that are difficult to reverse (Soukhaphon et al., 2021). Independent technical reviews under the MRC's prior consultation process have long flagged fisheries and sediment as binding constraints for mainstream projects such as Xayaburi, shaping the positions of governments and prospective financiers (MRC Secretariat, 2011; ICEM, 2010).

When MRC Member Countries and Dialogue Partners, together with commercial lenders and IFIs, cannot agree on these technical safeguards and operating rules, permitting and implementation slow or are conditioned through additional studies, safeguards, and redesigns (ADB, 2019). In this context, donor negotiation and delay are expected outcomes especially when impacts are transboundary and draw regional scrutiny (MRC Secretariat, 2011).

Table 3: SWOT analysis

STRENGTHS	**WEAKNESSES**
• Abundant water resources and high annual rainfall • Significant hydropower potential (26,000 MW) • Strong regional energy demand from Thailand, Vietnam, and Cambodia • Existing environmental, legal, and regulatory framework • Government commitment to energy sector development • Revenue generation and economic diversification potential	• Significant gap between regulations and implementation • Limited technical and monitoring capacity • Insufficient enforcement mechanisms and oversight • Inadequate stakeholder consultation processes • Financial and human resource constraints • Poor fish passage and sediment management performance
OPPORTUNITIES	**THREATS**
• Growing international focus on environmental standards • Technology transfer and capacity building programs • Regional cooperation through MRC frameworks • International financing for sustainable projects • Learning from best practices in neighboring countries • Potential for improved fish passage technologies	• Cumulative environmental impacts on Mekong Basin ecosystems • Transboundary conflicts with downstream countries • Climate change is affecting water availability and patterns • International scrutiny and reputational risks • Continued social displacement and community impacts • Potential loss of fisheries and biodiversity

Source: own edition based on research findings

Chapter III: Materials and Method

3.1. Hydropower map of Lao PDR

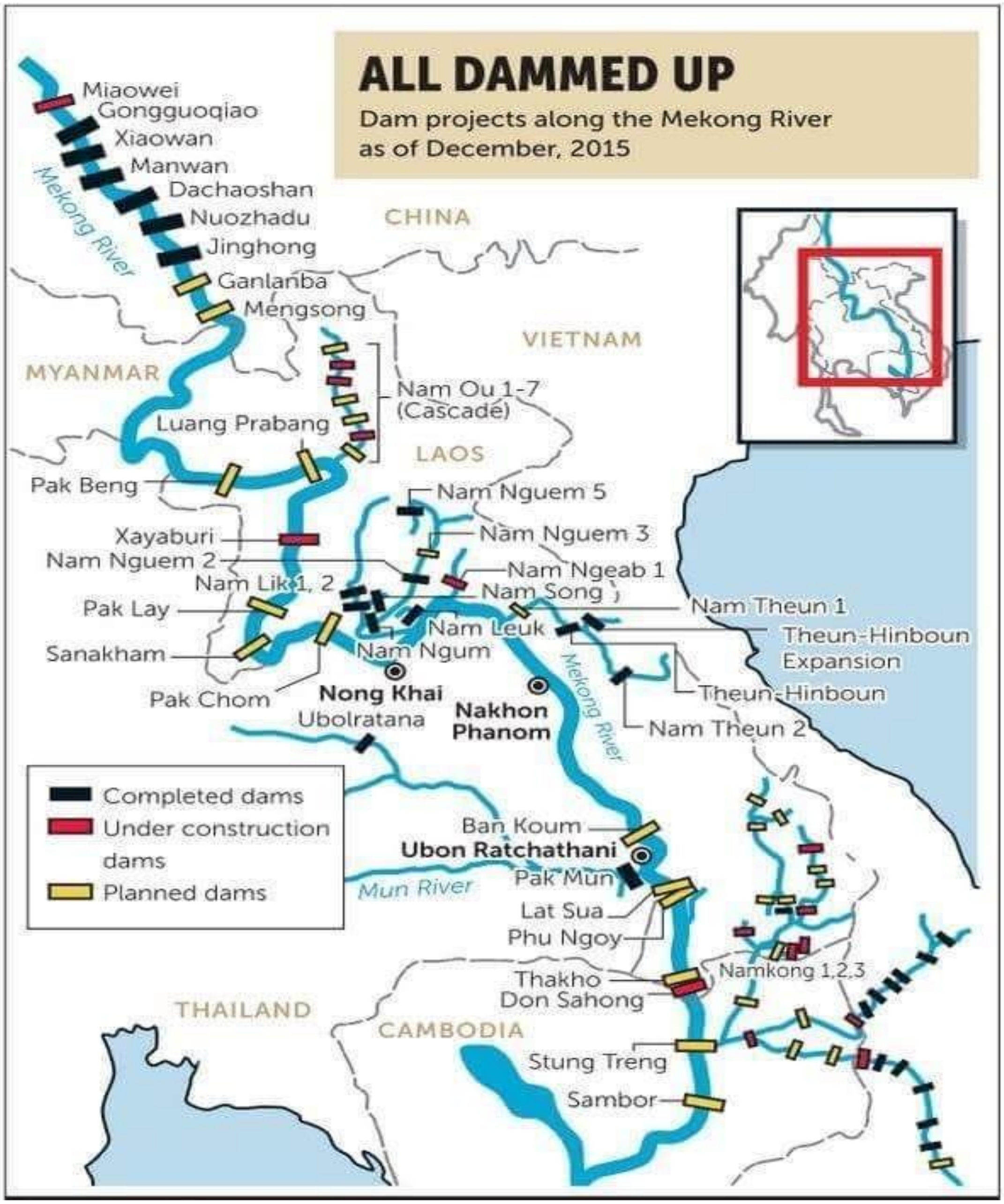

Figure 3: Map of Hydropower Projects in Lao PDR

Source: Sayavong, 2018

Lao PDR is a hydropower central point of concentration for power production (Sayavong, 2018). Among operational projects on the Mekong River in Lao PDR, two stand out: the Xayaburi Dam in the north and the Don Sahong Dam at the southern border (Sayavong, 2018). They are joined in the dam-making sequence by those proposed at Pak Beng, Luang Prabang, and downriver at Pak Lay and Sanakham, in all a disaster waiting to happen, as rural and indigenous rights to land, riverine resources, and meaningful consultation and compensation (pre and post construction) are routinely ignored (ICEM, 2010; GIZ, 2014).

Following the dam corridor from the far north of the country to its southern border, streams feeding the main river are dammed too (ICEM, 2010). In the far north, the seven dams along the Nam Ou River step from the headwaters toward the main river (Sayavong, 2018). Near Vientiane, where the National Highway No. 13 runs south, a series of large and small scale dams on the Nam Ngum, plus additional dams on tributaries, do the same (Sayavong, 2018). Further east, the same pattern is repeated along the ridge of the Nam Theun River and its tributaries (GIZ, 2014).

Yet the transboundary character of the Mekong makes this story not just a provincial but a regional one (ICEM, 2010). In general, the pattern is clear. At the upper and lower sections of the mainstream Mekong River in Lao PDR, there are a few very well known and large hydroelectric projects (Sayavong, 2018). Yet, the majority of Laos's dams, and certainly the backbone of its national energy program, are found in the river's tributaries. The three main ones Nam Ou, Nam Ngum, and the sequence of dams on the Nam Theun Kading (Theun–Hinboun/Nam Hinboun) river system are among the National Eye Catching projects (Sayavong, 2018).

3.2. Data sources and study cases

This chapter is grounded in two families of evidence that support and cross-check each other. The first is basin-wide cartography that specifies not only where every Lao dam is located but also what condition it's in. For a reliable list of what dams have been built, are being built, or are just on the drawing board, and for a mapping of each dam's main-river-or-tributary status, the Mekong River Commission's Hydropower Database is the best place to go (Mekong River Commission (MRC), n.d.). It isn't perfect, but any imperfections are much less significant than the numerous substantive and procedural problems that perfectionists have found with almost every large dam since well before the Mekong development era started. If in doubt, the next place to check is the Stimson Center's Mekong Infrastructure Tracker, which has a good basic nomenclature for the sites of various engineering works along the entire main river and named tributaries (Stimson Center, 2024). Both of these "families" could be described as constituting project-level audits of tangible development along the Mekong. The quarterly environmental monitoring reports from

Nam Ngiep 1 (NNP1) are a steady stream; they go to the ADB and contain tables with chemistry data from multiple stations (Nam Ngiep 1 Power Company, 2016–2025). In the same way, the water-quality monitoring stations operated by the MRC provide context around the mainstem of the river at the time of the assessment e.g., upstream at Luang Prabang (LLP) and downstream at Vientiane (LVT**)** supplying public ambient pH and DO that can be checked against project NES thresholds when EMR tables are unavailable (MRC, 2022; MRC, 2024).

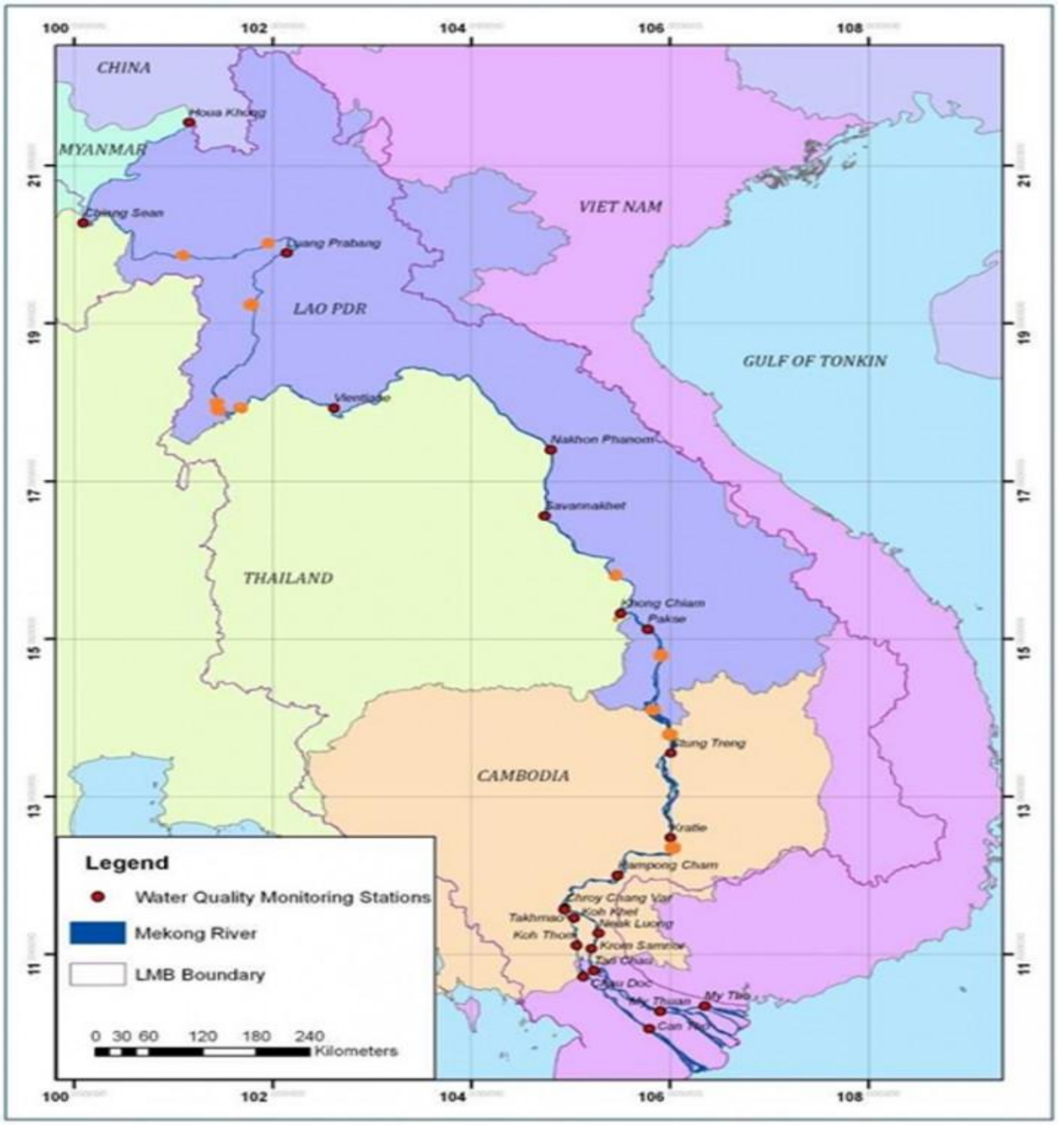

Figure 4: Water-Quality Monitoring Network (WQMN) stations across the Lower Mekong Basin

Source: (MRC, 2024)

The red and orange dots show the network of water-quality stations that regularly monitor the Mekong River and its key tributaries. In the Lao People's Democratic Republic (PDR), these monitoring stations are systematically placed from the north to the south of the country, in notable locations along the river such as Houayxay, Luang Prabang, Vientiane, Savannakhet, and Pakse (MRC, 2024). These same stations, part of the larger Water Quality Monitoring Network (WQMN), send back standard reports that make it possible to discuss the water quality of the Mekong River in a meaningful way (MRC, 2024). Near the upstream monitoring station (LLP) in Luang Prabang and the downstream monitoring station (LVT) in Vientiane, the river has a chance to return to a more natural state, and the downstream station can pick up on any major changes that happen before or after water reaches the Vientiane area. Using the reports that come back from these monitoring stations along the WQMN as standard references, it's possible to have a conversation about the effects that hydropower dams likely have on the river's water quality in different locations along the river's main branch (MRC, 2024).

3.3. Methods and Evaluation Criteria

H1 - Numeric checks to the national standard (decision rules + thresholds)

H1 is numeric checks to the national standard, we just use decision rules. With $x$observed and Las the standard, the upper-limit parameters (BOD_5, COD by dichromate, NH_3-N, and metals) use: PASS only if $x \leq L$; anything above means FAIL. The lower-limit parameter (DO) uses: PASS only if $x \geq L$; otherwise FAIL. For pH, any value within the band is a PASS; any value outside is a FAIL. Compliance rate is simply passes ÷ observations × 100 %. Deviation is the amount the value goes over or falls short of L, reported in the same units. Items are alike enough to place side-by-side for comparison. ND or <DL: count as PASS for upper-limit parameters only if DL ≤ L; otherwise mark N/E and exclude from compliance counts, "—" = not reported / not sampled → N/E (exclude from compliance counts). Respect the analytical basis; COD-Cr is not compared with COD-$KMnO_4$. Benchmark thresholds (NES numbers) are used here. (JICA, 2009, 2011).

Table 4: H1 decision rules (national standard)

Parameter / group	Threshold type	Decision rule with observed x and standard L	PASS / FAIL	Notes
BOD_5	Upper	PASS only if $x \leq L$	$x \leq L$= PASS; $x > L$= FAIL	mg L^{-1}
COD (dichromate, COD-Cr)	Upper	PASS only if $x \leq L$	$x \leq L$= PASS; $x > L$= FAIL	Do not compare with COD-$KMnO_4$
Dissolved Oxygen (DO)	Lower	PASS only if $x \geq L$	$x \geq L$= PASS; $x < L$= FAIL	mg L^{-1}
pH	Range (band)	PASS only if $L_{\min} \leq x \leq L_{\max}$	inside band = PASS; outside = FAIL	use NES band

Source: own edition based on Lao NES JICA, (2009, 2011)

Compliance rate: passes ÷ observations × 100 %. Deviation: upper limits $x - L$(exceedance); lower limits $L - x$(deficit); pH outside band = distance to nearest band edge.

Table 5: NES thresholds used for H1

#	Parameter	Unit	NES standard value (L)	Type
1	Color, Odor, Taste	—	Natural level	Descriptive
2	Temperature	°C	Natural level	Descriptive
3	pH	—	5–9	Range
4	DO	mg L^{-1}	6	Lower limit
5	COD (dichromate, COD-Cr)	mg L^{-1}	5	Upper limit
6	BOD_5	mg L^{-1}	1.5	Upper limit
7	Coliform bacteria	MPN/100 mL	5,000	Upper limit
8	Fecal coliform	MPN/100 mL	1,000	Upper limit
9	NO_3-N	mg L^{-1}	< 5.0	Upper limit
10	NH_3-N	mg L^{-1}	0.2	Upper limit

Source: own edition based on Order No. 2734/PMO-WREA (2009) reproduced by JICA (2009, 2011)

Method note: If a source reports COD-$KMnO_4$, keep it for context but do not compare it against the COD-Cr limit.

H2 - Sediment handling vs top methods (criteria scorecard)

Explanation. We compare sediment handling with top methods. Each point is 0 or 1, and only counts when the paperwork is public; hidden = 0. 0–1 Non-compliant; 2–3 Partial; 4–5 Compliant (same rules for every project). Evidence includes: low-level outlets or bypasses with size specs; written routing–flushing rules with triggers and timing; dated flood events with hydrographs or before/after bed surveys; published sediment-carry data and bed-load methods; and online reports for public review. (MRC, 2019; MRC, 2023).

Table 6: H2 sediment criteria scorecard (0–5)

Field	0 = Not evidenced / hidden	1 = Present & evidenced (public)	Examples of acceptable evidence
Low-level outlets / bypass sizing	No evidence	Size/specs documented	Drawings, as-built, design discharge tables
Routing–flushing rules (triggers & timing)	Not disclosed	Written rules published	O&M manual pages; regulator filings
Dated flood events with traces	Not evidenced	Hydrographs / level traces logged	Gate logs; WL traces; bed surveys
Sediment outcomes	Not evidenced	Time series / surveys	SSC/turbidity series; bathymetry/capacity
Public access to reports	Not accessible	Files online for public review	Portal/URL; MRC submission

Source: own edition

Classing: 0–1 Non-compliant; 2–3 Partial; 4–5 Compliant. *(MRC, 2019, 2023)*

H3 - Fish Passage

H3 - Fish passage presence & effectiveness (record → ratios → interpretation)

Explanation. First record whether a passage exists (ladder, bypass, lift, trap-and-haul, fish-friendly turbine, or none) and how it's monitored (PIT tags, acoustic, video, telemetry, trap counts). Then list Attraction Efficiency $AE = N_{\text{attracted}}/N_{\text{available}}$ and Passage Efficiency $PE = N_{\text{passed}}/N_{\text{attracted}}$ If reported, plus any downstream injury or mortality and operational context (e.g., turbine vs spill). Interpretation is then assigned: Effective / Partially effective / Ineffective / Insufficient evidence, letting the published results and monitoring quality lead. (MRC, 2019; MRC, 2023).

Table 7: H3 fish passage recording & interpretation

Field	What to record	Notes / examples
Passage / mitigation present	Ladder, nature-like bypass, lift, trap-and-haul, fish-friendly turbine, none	List all if multiple
Monitoring approach	PIT, acoustic, video, telemetry, trap counts	Include duration; targeted run(s)
Target groups	Migratory groups aimed at	Long-distance migrants, guilds, species list
AE	$N_{\text{attracted}}/N_{\text{available}}$	By species/guild if reported
PE	$N_{\text{passed}}/N_{\text{attracted}}$	Same basis as AE
Downstream injury / mortality	Injuries, fallback, delay	Note turbine vs spill context
Evidence quality	High / Medium / Low	Independence, sample size, method clarity
Interpretation	Effective / Partially effective / Ineffective / Insufficient evidence	Evidence-led call
Citation detail	Exact report/table/annex	Enables verification

Source: own edition based on MRC (2019, 2023)

H4 - Reporting vs implementation (documentation that can be verify)

Explanation. H4 checks what's written against what's actually documented and publicly repeatable. Score 0 / 0.5 / 1 per item; sum to 0–5: 0–1 Not verifiable; 2–3 Partial; 4–5 Well-documented. Require: a stations map (intake, outfall, fishway entrances) that is visible; a sampling plan (frequency and lab tests); raw tables with units and detection limits; O&M operating rules for sediment/fish with numeric triggers; and an independent or MRC review that's accessible. Each datum is stored in a single record with site; station; date; parameter; method; value/unit; NES limit; PASS/FAIL; source. Names, coordinates and status are cross-checked against recent MRC materials. (MRC, 2019, 2023)

Table 8: H4 documentation checklist (0–5; 0 / 0.5 / 1 scoring)

Field	0 = Not evidenced	0.5 = Partly evidenced	1 = Evidenced & publicly repeatable
Stations map (intake/outfall/fishway)	No map	Map without IDs/coords	Map with IDs & coordinates
Sampling plan (frequency; tests)	None	Narrative only	Frequency table by parameter
Raw tables & units (DLs noted)	None	Tables but missing units/methods	Copyable tables with units & DLs
O&M operating rules (sediment/fish)	None	Narrative w/o triggers/timing	Triggers/levels/timing published
Independent/MRC review	None	Cited but inaccessible	Public third-party/MRC link

Source: own edition

3.4. Data harmonization and cross-project comparability

This part lays out basic rules line up figures from different Lao hydropower projects. Values are pulled straight from the original papers, only the same stuff is matched, no mix-ups. First, dichromate-based COD gets compared to the national limit; it determines compliance. When permanganate-based COD shows up in a report we simply log it for context; we don't hold it to the dichromate cut-off (JICA, 2011; MRC, 2023). Metals: species, valence, digestion state; moreover, each influences results. Dissolved versus total recoverable stays exactly as reported; the threshold check uses the proper form (MRC, 2023). According to the Lao Ambient Surface-Water

Quality Standard, we just call pH a band test and leave the numbers as-is no changes made (JICA, 2011). Dissolved oxygen is read in mg L^{-1};, when a source lists only percent saturation, we change it to mg L^{-1} using the reported temperature and elevation if it's provided. If reliable conversion inputs are missing, the observation is excluded from compliance testing; we avoid misclassification (MRC, 2023).

Quick glimpse: line up units so they match, that's it. The concentrations appear as mg L^{-1}, trace metals as µg L^{-1}, using the native unit. Only when we have to line a value up with the NES base do we use the simple mass-mole or "as-ion → as-N" conversion;

each conversion gets saved beside the original units, keeping the provenance clear (JICA, 2011; MRC, 2023). Keeping the analysis true to the Lao national standard, these comparability rules still allow different project results to be placed side-by-side without mixing methods or units (JICA, 2011; MRC, 2023).

The part we label H2. We keep sediment notes on a shared, auditable base, the original metric stays, the method stays, we only compare alike data. Suspended sediment is used as SSC (mg L^{-1}) when reported; turbidity (NTU) stays as turbidity and isn't converted to SSC unless the source supplies a site-specific calibration curve, then we note the equation and its uncertainty. We pull "routing" events (fines slip through with little drawdown) and "flushing" events (drawdown pushes bed material) straight from the operator logs; each record includes date/time, reservoir level, gate set-up, and discharge (m^3 s^{-1}), the hydrographs from other years line up. Only if the surveys share the same vertical datum, the same water level (or a correction), and the same method do we compare bathymetry and capacity updates; the numbers line up. Many beam or single beam, the capacity shift is checked against the same area elevation-storage curve for that dam. Pair each sediment outcome (SSC/NTU) with the flow measured at the same moment; upstream and downstream can be compared without discharge muddling the results. Where bedload is given in kg s^{-1} or t day^{-1} the original unit stays as is, not mixed with SSC; when both values show up for the same event they sit side by side with a short note on sampler type and integration time (MRC, 2019; MRC, 2023).

So the checked fish passage specifically H3 and noted what they found. the effectiveness ratios stay exactly as the source defines: AE is the slice of fish that come to the entrance; PE is the slice of those attracted fish that manage to get through the structure. If a building has many entrances, we log AE/PE per door if that is how they were measured; when a study adds them together we keep the total and note the basis. We note the monitoring type (PIT, acoustic, video, trap counts), the array layout and detection range, the sampling window (dates and hours), the target animal group, and the set-up (turbine vs spill split, head, gate settings); the data line up across seasons or projects without having to recalculate the ratios. No pooling of species results unless the source pools them; if it does, we note the pooling rule first species specific, then biomass weighted, finally count weighted pick the one that fits. Where confidence intervals or sample sizes are reported, they get stored with AE/PE so that we can see the precision; zero denominator cases are marked as not evaluable instead of being forced to zero (MRC, 2019; MRC, 2023).

H4 documentation evidence is proof. The way we compare H4 is about origin and accessibility, not a score. A document is public when it can be reached at a stable URL without a paywall or login; then we log the exact citation, the section or figure/page, the file version/date, and for maps, the coordinate reference system and station IDs. If the same item turns up in multiple places (operator website, partner library, NGO mirror) we use the original source; the mirror serves only as backup. Every H4 link shows the access date; if a file gets a new version we store the old one too, any claim stays auditable. Registry identities (project name, status, coordinates) get matched to the MRC Hydropower Database; the Stimson Mekong Infrastructure Tracker then records any naming or status quirks. Disagreements are logged as a simple audit trail; analysis moves forward with the newest MRC entry (MRC, 2023; MRC, 2022; Stimson Center, 2024).

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Chapter IV. Results and Discussion

4.1. Results of numeric checks against the Lao national standard

The water-quality tables for the three projects evaluate stations on a like-for-like basis using predefined decision rules that score each station parameter date entry as PASS or FAIL a band test for pH, a lower-limit test for dissolved oxygen (DO), and upper-limit tests for COD Cr and BOD_5 assessed against an upper limit (JICA, 2011). The project-level compliance rate is computed as passes ÷ observations × 100%, where the denominator is the total number of scored station parameter data entries. These rules allow station-level water quality to be determined in a straightforward and reproducible manner, and they provide a consistent basis for aggregating results to the project level.

Table 9: H1 numeric checks

Date	Station	pH	PASS/FAIL	DO (mg L^{-1})	PASS/FAIL	COD-Cr (mg L^{-1})	PASS/FAIL	BOD_5 (mg L^{-1})	PASS/FAIL
Jan-2020	WSP04-2 (deep)	8.3	PASS	4.9	FAIL	n.d.	PASS	n.d.	PASS
Feb-2020	WSP03 (river)	7.4	PASS	8.1	PASS	1.25	PASS	<1.0	PASS
Feb-2020	WSP04-1 (surface)	7.3	PASS	8.3	PASS	2.50	PASS	<1.0	PASS
Feb-2020	WSP04-2 (deep)	7.3	PASS	4.0	FAIL	6.24	FAIL	1.10	PASS
Mar-2020	WSP04-1 (surface)	7.7	PASS	8.1	PASS	n.d.	PASS	<1.0	PASS
Mar-2020	WSP04-2 (deep)	7.7	PASS	3.8	FAIL	n.d.	PASS	<1.0	PASS

Source: own edition

Note. "n.d." (not detected) is treated as ≤ DL and PASS for upper-limit parameters per H1 rule.

The Nam Ngum 1 table shows that pH values are well within the acceptable range and that concentrations of BOD_5 are consistently low, while regular shortfalls occur only for DO at the deep reservoir station and not at surface or riverine sites. The most plausible explanation for this vertical contrast is dry-season stratification, which isolates the hypolimnion from atmospheric reaeration and the photosynthetically active layers, while sediment and microbial oxygen demand depresses DO despite otherwise satisfactory conditions in the epilimnion and downstream river. This implies that operational controls could be instituted to directly address the mechanism responsible for these failures, and would not impose unnecessary constraints during mixed-column periods (i.e., when the reservoir is not stratified) (Nam Ngum Hydropower Plant Expansion Project, 2020)

Table 10: H1 numeric checks

Date	Station	DO (mg L^{-1})	PASS/FAIL	COD-Cr (mg L^{-1})	PASS/FAIL	BOD_5 (mg L^{-1})	PASS/FAIL
Apr-2016	NXA01 (Nam Xao)	5.52	FAIL	—	FAIL	—	FAIL
Apr-2016	NHS01 (Houay Soup)	5.90	FAIL	—	FAIL	—	FAIL
Jun-2016	NNG01 (upstream)	7.4	PASS	13.1	FAIL	n.d. < 1.0	PASS
Jun-2016	NNG05 (downstream)	7.9	PASS	30.1	FAIL	1.3	PASS
Jun-2016	NNG06 (downstream)	7.3	PASS	37.9	FAIL	1.2	PASS

Source: Own edition based on Nam Ngiep 1, (2016)

The most striking aspect of the Nam Ngiep 1 table for the quarter under review is the regularity with which COD–Cr exceedances show up at a number of the stations on several dates (Nam Ngiep 1 Power Company Limited, 2016). In contrast, BOD_5 and DO concentrations are routinely within acceptable limits, indicating that oxidant demand is being driven by something other than fresh, readily biodegradable organic material (Nam Ngiep 1 Power Company Limited, 2016). The reliable exceedance of COD–Cr is consistent with the "pulsing" of oxidant demand by episodic or spatially heterogeneous inputs (Nam Ngiep 1 Power Company Limited, 2016). All this means that Nam Ngiep 1 has a problem with oxidant demand that is not associated with a single, persistent point source. And while the data table from the river program for this period included pH values, which are apparently part of the program, the summary table for this quarter does not (Nam Ngiep 1 Power Company Limited, 2016). Thus, the appearances of the COD–Cr exceedances are unhelpfully consistent with what one would expect to see if the water were contaminated with a number of hard-to-degrade compounds, many of which would certainly also be suspended in the water and adding to oxidant demand (JICA, 2011)

Table 11: H1 numeric checks

COD reported as COD($KMnO_4$) → not scored against the COD-Cr limit;

Date	Station (from EIA)	pH	PASS/FAIL	DO (mg L^{-1})	PASS/FAIL	BOD_5 (mg L^{-1})	PASS/FAIL
Dry (Feb*)	Ban Pha Liap Mekong mainstream	7.9	PASS	8.1	PASS	3.2	FAIL
Dry (Feb*)	Pak Nam Pa downstream of Nam Pha confluence	8.1	PASS	7.9	PASS	2.7	FAIL
Dry (Feb*)	Proposed upper dam site	7.9	PASS	8.0	PASS	1.5	PASS
Dry (Feb*)	Pak Nam Phoun confluence at Ban Moung Nua	7.8	PASS	7.4	PASS	1.5	PASS
Dry (Feb*)	Proposed lower dam site	7.8	PASS	7.9	PASS	1.5	PASS
Dry (Feb*)	Nam Xong at Mekong confluence, downstream	8.0	PASS	7.1	PASS	1.1	PASS

Date	Station (from EIA)	pH	PASS/FAIL	DO (mg L^{-1})	PASS/FAIL	BOD_5 (mg L^{-1})	PASS/FAIL
Dry (Feb*)	Pak Lay at Mekong confluence, downstream	8.1	PASS	8.6	PASS	1.5	PASS

Source: own edition based on Pak Lay, (2020)

The Pak Lay table shows that overall compliance is good, with the pH and DO always in the national bands and only a few dry-season BOD_5 exceedances at particular stations (PHP, 2020). The same season dataset shows that even though the number of exceedances is low, they are mostly best understood as happening in the dry season and under otherwise low-flow, high-suspended load conditions (PHP 2020). And if we look at the same conditions from the other end of the revealed water quality spectrum, we see that all seven river stations' COD–Cr values are below the 5 mg L^{-1} standard (PHP, 2020). Meanwhile, any mentions of CODMn (permanganate index) in the EIA are not counted in the scoring, to preserve the same methodology (JICA, 2011), but these are our river's high-compliance scenes from the end of the spectrum in which more compliance also equals better river health (DO definitely better than BOD and COD among river-watch metrics).

Considered together, the three tables imply that pH is not a parameter that limits performance as reported; they indicate that failure to meet dissolved oxygen standards is confined to a downward (deep) layer that is strongly stratified in temperature and chemistry, such that, with project-specific safeguards, the hypolimnion could be managed to maintain DO conditions typical of healthy, well-mixed systems downstream. The tables clearly show that, for late-period sampling in the quarter examined, the outcome at Nam Ngiep 1 was determined by COD–Cr, and they say nothing about pH. They also indicate a risk of exceeding BOD_5 that is primarily confined to the months from November to March in the annual cycle, with the risk driven by conditions related to low flow.

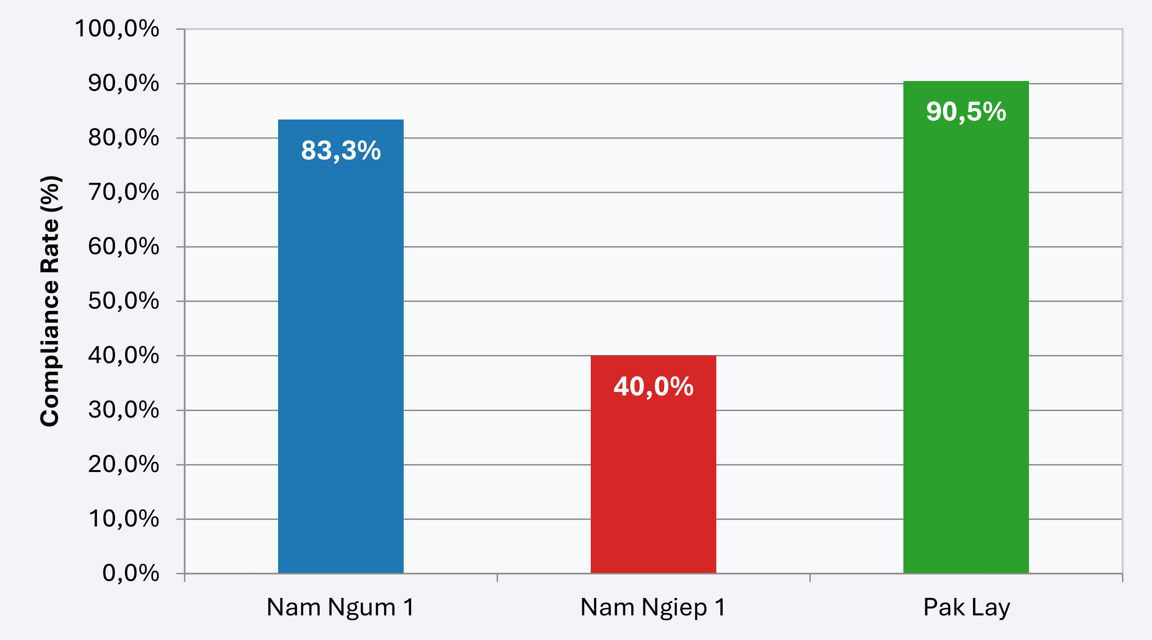

Figure 5: Overall compliance (%) for each dam

Source: own edition

Based on the data presented in Tables 8, 9, and 10, the calculated compliance rate for Pak Lay, after including the dry season COD–Cr results from the river tables but not adding any new problems from the January table, is 90.5% (19/21). For Nam Ngum 1, the number is 83.3% (20/24) because repeated dissolved-oxygen shortfalls at the single deep reservoir station depress the overall project rate, even though the surface and river stations are compliant. Finally, the rate for Nam Ngiep 1 is 40.0% (6/15), driven mainly by multiple failures to meet the COD–Cr standard; pH for the Q2/2016 river results was monitored but not tabulated, so it is not included in the calculation.

4.2. Results from sedimentation Checks

Each project is assessed against five publicly evident indicators that together capture whether it can credibly transport sediment. (1) Capacity: Does the structure have clearly documented, adequately sized low-level outlets or bypass works that can pass sediment (2) Operating rules: Is there a written operations manual that specifies, in sufficient detail, the trigger conditions by which sediment-bearing inflows initiate sluicing and/or flushing (including gate configurations, timing, and duration) (3) Dated operational records: Are there public logs of sediment-pass operations with dates and operational details (e.g., gate settings, reservoir levels, and discharges)? (4) Outcomes:

Are there publicly reported outcome measurements attributable to those operations (e.g., SSC/TSS or turbidity during/after events, and/or bathymetric/capacity change) (5) Public access: Are the foregoing documents and data publicly available in a form that can be audited over time.

The best way to classify Xayaburi is "Partial" because the MRC's technical review of the project redesign confirms the addition of four low-level gates intended to enable sediment flushing, yet provides no published operating rules that would couple sediment-laden inflows to sluicing/flush actions, and I found no public, dated operating logs indicating any "rules," "records," or "outcomes," making the project appear opaque, while the MRC Joint Environmental Monitoring portal (JEM) makes monitoring outputs publicly accessible even as its synthesis materials emphasize that **SSC** evidence remains insufficient to evaluate the effectiveness of flushing at Xayaburi (MRC, 2024; MRC, 2022)In contrast, the public monitoring reports for the Nam Ngiep 1 hydroelectric project confirm that the re-regulation reservoir is being flushed under controlled conditions, with accompanying turbidity/TSS monitoring, and that the quarterly reports are publicly accessible (NNP1, 2017; ADB, 2018). However, the reports do not set out explicit trigger rules that is when the re-regulation reservoir will be flushed and when it will not particularly in relation to the amount of sediment-laden water the system can handle under different hydrologic conditions so that specific H2 item does not score even though capacity, dated operations, outcomes monitoring, and public access are evidenced (NNP1, 2017; ADB, 2018).

The current Environmental Impact Assessment (EIA) for the Pak Lay Hydropower Project is a pre-operation document that shows the project will include bottom-orifice/bottom-outlet gates in its installation plan (PHP, 2020). This pre-operation EIA serves as a commitment document, indicating the project's design intent and includes monitoring commitments in the installation details (PHP, 2020). The inclusion of *silting monitoring* suggests that the project designers are aware of the sediment-related problems that have occurred at other existing and under-construction hydropower projects on the Mekong. On the other hand, there are no published operating rules, no dated operational events, and no outcomes linked to such events, since the project has not yet commenced operations (PHP, 2020).

Table 12: Sediment passage (H2)

Field	Xayaburi HPP	Nam Ngiep 1	Pak Lay
Capacity to pass sediment (e.g., low-level outlets/bypass documented)	1	1	1
Written operating rules that couple sediment-bearing inflows to sluicing/flush actions	0	0	0
Public, dated records of sediment-pass operations (e.g., flushing; gate settings/levels/flows)	0	1	0
Outcome measurements attributable to such operations (e.g., SSC/TSS during/after flushing; bathymetry)	0	1	0
Public access to the above (auditable reports/data)	1	1	1
Total (0–5)	2	4	2
Classification (0–1 Non-compliant; 2–3 Partial; 4–5 Compliant)	Partial	Compliant	Partial

Source: own edition based EMR Q2-2016 (NNP1); Pak Lay EIA (2020); MRC/JEM (2023)

The public record for the projects examined, particularly Xayaburi and Pak Lay, lacks the documents necessary to verify that sediment is being conveyed safely through the reservoirs—there are no publicly evidenced operating records, trigger rules, or outcomes showing sediment passage (even though “capacity” is documented in concept/design). In contrast, Nam Ngiep 1 has public reports that allow capacity, operations, and outcomes to be tracked (including dated flushing of the re-regulation reservoir), yet it does not disclose trigger rules i.e., the explicit thresholds or criteria that define when an operational response is required to manage sediment and potential downstream impacts. Interpreted strictly against the checklist, the three projects therefore score: Xayaburi = 2/5 (Partial), NNP1 = 4/5 (Compliant), Pak Lay = 2/5 (Partial).

4.3. Results from Fish passage checks

Table 13: fish-passage (H3) check

Project / Dam	Passage facility present?	AE reported?	PE reported?	Interpretation	Source
Xayaburi	Vertical-slot fish pass + two fish locks (operational)	—	≈87% (within-pass)	Partially effective (good within-pass PE; AE not yet public)	(ACIAR, 2024)
Don Sahong	Nature-like bypass channels (operational)	—	—	Insufficient evidence (telemetry pilot; no AE/PE yet)	(JEM/MRC, 2023)
Pak Lay	Fishway + navigation lock in design (pre-operation)	—	—	Insufficient evidence (commitment stage)	(PHP, 2020)

Source: own edition based on ACIAR (2024); JEM/MRC (2023); PHP (2020))

Xayaburi. The project operates a vertical-slot fish pass with two fish locks (ACIAR, 2024). The most recent public program reports a within-fishway passage efficiency of 87% for PIT-tagged fish that had reached the fishway entrance, indicating partial effectiveness of the structure once fish are engaged (ACIAR, 2024). Attraction efficiency remains unreported, so overall effectiveness cannot yet be established. In sum, the available evidence suggests that the fishway performs well for fish that enter it, while the capacity to attract fish to the entrance has yet to be quantified. Data on injury or mortality attributable to passage are likewise not available (ACIAR, 2024).

Nature-like bypassed channels are in operation at the Don Sahong Dam, and a pilot study using acoustic and radio telemetry has demonstrated the feasibility of tracking fish movements at the site (JEM/MRC, 2023). However, according to the Joint Expert Monitoring Team (JEM) and the Mekong River Commission (MRC) (2023), no appraisal of ecological effects specifically effects on fish has yet been undertaken, and thus insufficient evidence exists to concern the project under the H3 criterion used in this thesis. Until the MRC and JEM do an ecological appraisal, we don't know if the fish living in the Mekong in and around Don Sahong are being hurt by the dam (JEM/MRC, 2023).

Pak Lay. In the Environmental Impact Assessment (EIA), the project specifies a long fishway ("fish ladder") and a navigation lock, with design capacities established and an accompanying commitment to monitoring both consistent with current practice for mainstream projects (PHP, 2020). As the project is not yet in operation, there are no performance results to report. The EIA sketches a relatively elaborate performance assessment framework, which is also standard for projects of this kind. Notably, the EIA defines target aquatic species and functional guilds, thereby articulating hypotheses about which taxa are likely to use the facilities successfully; however, these propositions will require operational evidence including attraction efficiency (AE), passage efficiency (PE), and any injury or mortality metrics once the scheme is commissioned (PHP, 2020).

Across the three Lao hydropower projects reviewed, only Xayaburi currently provides a quantitative indicator of fish-pass performance. The most recent public program reports a within-fishway passage efficiency of approximately 87% for PIT-tagged fish that had reached the fishway entrance, indicating good performance once fish are engaged with the structure, although attraction efficiency has not yet been published (ACIAR, 2024). By contrast, Don Sahong has operational bypass channels and a completed telemetry pilot but no published AE/PE, and Pak Lay specifies a long fishway and a navigation lock in the EIA yet remains pre-operation, so no performance results are available (MRC, 2023; PHP, 2020). Under the H3 rubric, these findings imply partial effectiveness at Xayaburi (pending AE and impact metrics) and insufficient public evidence at Don Sahong and Pak Lay.

4.4. Result from Report vs implementation

Table 14 Report vs implementation

Field \ Project	Xayaburi	Nam Ngiep 1	Pak Lay
Stations map (intake/outfall/fishway)	0.5 - ACIAR 2024, Fig. 1, p. 8	0.5 - EMR Q2-2016, monitoring-station map	0.5 - EIA, project layout (pp. 11–12); fish passage §2.10
Sampling plan (frequency; tests)	1 - ACIAR 2024, §§5.2–5.3 (pp. 10–11); Appx 2	1 - EMR Q2-2016, methods/parameters	1 - EIA §3.2 (pp. 40–45)
Raw tables & units (DLs noted)	0.5 - ACIAR 2024, p. 61; pp. 62–66 (DLs not consistent)	0.5 - EMR Q2-2016, quarterly WQ tables (DLs not consistent)	0.5 - EIA §5.5.5 WQ baseline (pp. 90–104; DLs not consistent)
O&M operating rules (sediment/fish)	0 - not publicly evidenced	0 - not publicly evidenced	0 - pre-operation; no numeric triggers published
Independent / MRC review (public)	1 - MRC/JEM public materials (factsheets/reviews)	0 - none located specific to NNP1	1 - MRC Prior Consultation statement/report

Source: own edition based on ACIAR (2024); EMR Q2-2016 (NNP1); Pak Lay EIA (2020); MRC/JEM (2023)

Xayaburi. The public materials convey clear, mapped details of the site and facility, including the layout of the fish pass and locks (ACIAR, 2024). Complementing this rare degree of public detail are the vital statistics and corrections monitoring method of the fish pass program, as laid out by the dam's operator (ACIAR, 2024). The performance of the fish pass program, however, must be understood, as all performances should be understood, in context. And context here can only be provided by someone not invested in the outcome. This is why the MRC's JEM can serve the MRC's member states as a vital context-giver (MRC, 2023). A necessary investigation into the performance of the fish pass program and the classifying of the dam is just one part of a larger necessity (MRC, 2019; MRC, 2023).

The quarterly environmental monitoring reports for the Nam Ngiep 1 hydropower project are quite informative and beneficial (NNP1, 2016). They provide a sampling and monitoring plan, specifications for the critical parameters to assess, and sufficient data for understanding the project's environmental effects. They also exhibit a strong regularity in their issuance (NNP1, 2016; 2018; 2023; ADB, 2018). However, an assessment of the reports' information content and clarity leads to a finding of "partial compliance" with the strategic environmental assessment mandate and the ADB safeguard policy. This is in part because the reports do not clearly specify the performance standards that the project is expected to achieve (ADB, 2009; MRE, 2019;2023).

The pre-operation Environmental Impact Assessment for paklay provides several transparency elements: project and monitoring maps (generally without coordinates), a monitoring plan with indicative frequencies, and baseline tables presented with appropriate units for the relevant parameters. As a pre-operation document, it does not yet include dated operational logs or numeric O&M triggers; on balance, the public record is best characterized as partial in the H4 sense (PHP, 2020; MRC, 2019, 2023).

The binding constraints on moving from Partial to Well-documented are consistent across the three projects: publish maps with station IDs and coordinates, release copyable raw tables that specify units, detection limits, and method fields, and promulgate numeric O&M triggers paired with clear, dated operational records (MRC, 2019, 2023). Of the three, Xayaburi is closest to this level of documentation, owing to comparatively strong monitoring disclosure (MRC, 2019, 2023; ACIAR, 2024); Nam Ngiep 1 would advance quickly by publishing trigger rules and standardized raw tables (NNP1, 2016–2023); and Pak Lay can design for compliance by issuing a consistent rule set and the full document package at commissioning (PHP, 2020).

4.5. Summary of Finding

For all assessed projects, compliance is determined by specific parameters and is not uniform, showing both strengths and weaknesses among the projects. The strongest indication of compliance appears in H1 (water quality) for surface and riverine stations. Even here, however, the public record often lacks the full documentation needed for external verification, namely, georeferenced station inventories, frequency-by-parameter sampling plans, and copyable raw tables with units and detection limits so it is not possible to confirm that H1 is satisfied at all required locations (MRC, 2019, 2023).

The consistent performance of H1 gives assurance that the fundamental intent of MRC safeguards is being realized, though there are some notable contexts where this performance drops off (MRC, 2019, 2023). Downstream from large development projects, the routine application of the H1 metric indicates that river function related to hydrology and sediment transport is at least minimally maintained (ADB, 2018). However, the occurrence of DO deficits and special contexts where even basic ecosystem service delivery fails (like “smothering sediment” from dams, which is seen in the Xayaburi context and at a few other places along the main stem of the Mekong) tells us that there are still significant developmental governance challenges in play (MRC, 2018, 2023). Besides these contexts, weaknesses in the EIA process pervade developmental practice (PHP, 2020; MRC, 2019, 2023).

When compliance is weak or unverified, the H2 record is typically incomplete in terms of the operating reservoirs. Public documents show a complete picture of how low-level capacity outlets and bypass systems work (or don't work) even though our modeling indicates that they should if the reservoirs are going to comply (or be verified as complying) with the operating rules. That picture includes: adequacy of inlet/outlet facilities, assurance that those facilities are "really" working, the reservoir's compliance with key physiochemical outcome metrics (such as SSC/TSS), and outcome metrics that are in a consistent datum and suitable for our design work (including day/night, dry/wet season, and stochastic event variability) (MRC, 2019, 2023).

In summary, four practical steps stand out. First, prioritize profile-aware operations in problem areas that are vertically confined or seasonally expressed (e.g., selective withdrawal; targeted destratification/oxygenation during stratified periods; event-triggered responses when COD spikes occur). Second, publish the full rule-and-result chain numeric operating triggers, dated gate settings/hydrographs, and copyable raw tables with units and detection limits so compliance can be independently verified. Third, make H3 evaluable by instrumenting for attraction efficiency (AE) and passage efficiency (PE) using PIT/telemetry/video and reporting injury, mortality, and delay by species and season. Fourth, design for H4 compliance from the outset via geo-referenced station inventories, standard data schemas, and an auditable public archive linked to independent/MRC review, so implementation can be tracked and exceptions transparently flagged (MRC, 2019, 2023; ACIAR, 2024).

Overall, the checks shows strong baseline H1 performance and credible design commitments at pre-operation sites, while the weak links remain sediment continuity (H2), fish-pass effectiveness (H3), and operational transparency (H4). Publishing clear rules, dated logs, and AE/PE metrics would shift several projects from Partial to Well-documented in forthcoming quarters (MRC, 2019, 2023; ACIAR, 2024).

Chapter V. Conclusion

This check examines the practical occurrence of environmental compliance in hydropower projects in Laos through the testing of four specific hypotheses. The first hypothesis (H1) states that the reported water quality generally meets national standards. The second hypothesis (H2) asserts sediment management underperforms relative to best practices. The third hypothesis (H3) makes the case for the absence or ineffectiveness of fish-passage systems. Finally, the fourth hypothesis (H4) postulates that gaps exist between reported monitoring and on-the-ground implementation.

The findings support H1: project and national surface-water monitoring at riverine and surface-reservoir stations generally meet headline parameters (e.g., pH, BOD_5); however, in impounded reaches, especially the deep reservoir layer during seasons, recurring low DO and episodic COD events point to operational risks. H2 is weak: absent numeric trigger rules, reliable gate/flow logs, and event-based outcome data (SSC/TSS, bathymetry), effectiveness cannot be credibly judged. H3 is only partially confirmed: fish-passage structures exist at some sites, but effectiveness evidence is thin, particularly for attraction efficiency and through-structure passage efficiency. H4 is strongly confirmed: operations remain a mystery; the lack of transparent, versioned data is the system's dominant design flaw (MRC 2022–2024; NNP1 2025).

Methodologically, it offers a transparent, repeatable approach to numeric pass/fail checks for water-quality standards and a compact 0–5 scorecard for sediment and fish-passage compliance usable by operators, regulators, financiers, and civil society for consistent cross-project comparisons. Limitations come from reliance on public materials and method differences (e.g., COD variants), which constrain operational detail and some cross-site comparability, but these limitations reinforce the standardization and transparency. (NNP1 2025; ADB 2018).

Overall, Lao hydropower projects generally meet basic water-quality standards, but the credibility and durability of that compliance are uncertain. The most fundamental risk is stratification in deep reservoirs: mixing is not assured, and without proven, profile-aware operations (e.g., selective withdrawal, destratification, oxygenation), deep-water quality will periodically fall below standards regardless of surface compliance. Until this mixing/oxygenation problem is explicitly solved and transparently operated, improvements in sediment routing, fish-passage performance, or species-resolved monitoring while important cannot by themselves deliver environmental compliance the public can trust. The path forward is evidence driven operations with clear triggers, auditable data, and independent review to build confidence and support better long-term outcomes for the country.

Chapter VI. summary

This thesis investigates whether Lao hydropower projects *truly* comply with environmental law and proposes a practical way to verify that claim, building a transparent audit framework that checks core water-quality indicators against national standards (pH, dissolved oxygen, BOD_5, COD-Cr), scores the presence and day-to-day use of sediment-routing measures, measures fish-passage performance with attraction and passage-efficiency metrics, and cross-verifies what operators report against dated, auditable evidence; the framework is road-tested on case studies such as Nam Ngiep 1, Xayaburi, Nam Ngum 1 and Pak Lay.

Applied in practice, the method finds that headline compliance is typically met at river and surface-reservoir stations, yet risks cluster in seasonally stratified deep layers where low dissolved oxygen and episodic COD spikes emerge operational issues that can and should be mitigated; credible judgments on sediment management are often impossible because public records lack numeric trigger rules, time-stamped gate/flow logs, and outcome data (e.g., TSS, bathymetry); fishways can move fish once they enter them, but attraction efficiency and injury/mortality reporting are few, leaving overall ecological effectiveness uncertain; above all, the dominant weakness is transparency, because without standardized, copyable raw tables (with units and detection limits), geo-referenced station lists, numeric O&M triggers, and dated operational logs, independent verification remains out of reach.

In response, the thesis recommends "profile-aware" operations selective withdrawal, destratification/oxygenation, and event-triggered responses together with publication of the full rule-and-result chain (what threshold triggers what action, backed by time-stamped gate/level/flow records), rigorous instrumentation of fish passages to report attraction and passage efficiency plus injury/mortality by species and season, and an auditable public data pipeline linked to independent/MRC review so that compliance can be shown.

While limits from reliance on public/secondary sources and methodological differences (e.g., COD variants), the work contributes a repeatable, evidence-first compliance toolkit numeric checks plus compact scorecards that regulators, operators, financiers, and communities can use; the overall conclusion is that projects may meet the standards, but durable, trusted compliance depends on active management of reservoir stratification and on making operations testable in public; transparency is the key deficit.

References

1. Abd-El Monsef, H., Smith, S., & Darwish, K. (2015). Impacts of the Aswan High Dam after 50 years. Water Resources Management, 29(6), pp. 1873–1885. https://doi.org/10.1007/s11269-015-0916-z
2. ASEAN Centre for Energy. (2025). An energy sector roadmap to net zero emissions for Lao PDR. https://aseanenergy.org/publications/an-energy-sector-roadmap-to-net-zero-emissions-for-lao-pdr/
3. Asian Development Bank. ([N. d.]). Nam Theun 2 Hydroelectric Project. https://www.adb.org/projects/37734-013/main
4. Asian Development Bank. (2018). Nam Ngiep 1 Hydropower Project: Environmental Monitoring Report (Project No. 41924-014). https://www.adb.org/sites/default/files/project-documents/41924/41924-014-emr-en_5.pdf
5. Asian Development Bank. (2019). Lao People's Democratic Republic: Energy sector assessment, strategy, and road map. https://doi.org/10.22617/TCS190567
6. Australian Centre for International Agricultural Research (ACIAR). (2024). Assessing upstream fish migration measures at the Xayaburi Hydropower Project in Lao PDR: Final report (FIS/2017/017). https://www.aciar.gov.au/sites/default/files/2024-11/FIS-2017-017%20final%20report%20MASTER.pdf
7. Baird, I. G. (2013). Remembering old homelands: The Houay Ho Dam, the resettlement of the Heuny (Nya Heun), memory, and the struggle for places. In V. Pholsena & O. Tappe (Eds.), Interactions with a violent past: Reading post-conflict landscapes in Cambodia, Laos, and Vietnam (pp. 241–263). https://doi.org/10.4000/12ehw
8. Baird, I. G., & Hogan, Z. (2023). Hydropower dam development and fish biodiversity in the Mekong River Basin: A review. Water, 15(7), 1352. https://doi.org/10.3390/w15071352
9. Barakat, R. M. R. (2013). Epidemiology of schistosomiasis in Egypt: Travel through time (Review). Journal of Advanced Research, 4(5), pp. 425–432. https://doi.org/10.1016/j.jare.2012.07.003

10. Delang, C. O., & Toro, M. (2011). Hydropower-induced displacement and resettlement in the Lao PDR. South East Asia Research, 19(3), pp. 567–594. https://doi.org/10.5367/sear.2011.0056

11. Department of Energy Policy and Planning, Ministry of Energy and Mines (Lao PDR), & ERIA. (2020). Lao PDR Energy Outlook 2020 (pp. xi, 72–74). ERIA. https://www.eria.org/uploads/media/Research-Project-Report/Lao-Energy-Outlook-2020/Lao-PDR-Energy-Outlook-2020.pdf
12. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). (2014). Training manual on hydropower and economic development in the Lower Mekong Basin. https://www.giz.de/en/downloads/giz2014-en-hydropower-economic-development-mekong.pdf
13. Economic Commission for Asia and the Far East (ECAFE). (1957). Statute of the Committee for Co-ordination of Investigations of the Lower Mekong Basin. https://gis.nacse.org/tfdd/tfdddocs/216ENG.pdf
14. Elbatran, A. H., Abdel-Hamed, M. W., Yaakob, O. B., Ahmed, Y. M., & Ismail, M. A. (2015). Hydro power and turbine systems reviews. Jurnal Teknologi, 74(5), pp. 83–90. https://doi.org/10.11113/jt.v74.4646
15. Electricity Generating Authority of Thailand. (2019). Annual report 2019. https://www.egat.co.th/home/en/wp-content/uploads/2021/12/annual-report-2019-en.pdf
16. Environment Protection Fund. (2025). Lao Pollution and Waste Management Project (P510198): Environmental and Social Management Framework, Volume I. https://laoepf.org.la/wp-content/uploads/formidable/112/PWMP_ESMF-Vol-I_May-2025.pdf
17. European Small Hydropower Association. (2004). Guide on how to develop a small hydropower plant. https://skat.ch/wp-content/uploads/2017/03/5115-Handbook-on-small-hydropower-Layman-2004.pdf
18. Foreign Policy Research Institute. (2024). The battery of Southeast Asia: Challenges to building a regional transmission grid. https://www.fpri.org/article/2024/04/the-battery-of-southeast-asia-challenges-to-building-a-regional-transmission-grid/

19. Fuso Nerini, F., Tomei, J., To, L. S., Bisaga, I., Parikh, P., Black, M., Borrion, A., Spataru, C., Castán Broto, V., Anandarajah, G., Milligan, B., & Mulugetta, Y. (2018). Mapping synergies and trade-offs between energy and the Sustainable Development Goals. *Nature Energy, 3*(1), pp. 10–15. https://doi.org/10.1038/s41560-017-0036-5
20. Fader, M., Cranmer, C., Lawford, R., & Engel-Cox, J. (2018). Toward an understanding of synergies and trade-offs between water, energy, and food SDG targets. *Frontiers in Environmental Science, 6*, 112. https://doi.org/10.3389/fenvs.2018.00112
21. Giovannini, G. (2018). Power and geopolitics along the Mekong: The Laos–Vietnam negotiation on the Xayaburi Dam. Journal of Current Southeast Asian Affairs, 37(2), pp. 63–93. https://doi.org/10.1177/186810341803700203
22. Global Energy Monitor. (2025). Hongsa power station. https://www.gem.wiki/Hongsa_power_station
23. Government of the Lao PDR. (2019). Decree on Environmental Impact Assessment, No. 21/PMO (31 January 2019). (Unofficial English translation). https://laoofficialgazette.gov.la/kcfinder/upload/files/EIA%20Decree_English_unofficial%20%20translation%2011.6.2019.pdf
24. Green, W. N., & Baird, I. G. (2020). The contentious politics of hydropower dam impact assessments in the Mekong River basin. Political Geography, 83, 102272. https://doi.org/10.1016/j.polgeo.2020.102272
25. Grumbine, R. E., & Xu, J. (2011). Mekong hydropower development. Science, 332(6026), pp. 178–179. https://doi.org/10.1126/science.1200990
26. Hongsa Power Company Limited. (2014). News & activities. https://www.hongsapower.com/index.php?id=123&layout=news_page&model=cms&view=news_page
27. Hu, B., Yang, Z., Wang, H., Sun, X., Bi, N., & Li, G. (2009). Sedimentation in the Three Gorges Dam and the future trend of Changjiang (Yangtze River) sediment flux to the sea. Hydrology and Earth System Sciences, 13(11), pp. 2253–2264. https://doi.org/10.5194/hess-13-2253-2009
28. ICEM. (2010). Strategic environmental assessment of hydropower on the Mekong mainstream: Summary of the final report. International Centre for Environmental Management for the Mekong River Commission.

https://www.icem.com.au/documents/envassessment/mrc_sea_hp/SEA_Final_Report_summary_Oct_2010.pdf

29. International Council for Science (ICSU). (2017). *A Guide to SDG Interactions: From Science to Implementation* [D. J. Griggs, M. Nilsson, A. Stevance, & D. McCollum (Eds.)]. International Council for Science. https://doi.org/10.24948/2017.01
30. International Energy Agency. (2023). Electricity market report 2023. https://www.iea.org/reports/electricity-market-report-2023
31. International Energy Agency. (2025). Global energy review 2025: Electricity. https://www.iea.org/reports/global-energy-review-2025/electricity
32. International Rivers. (2008). Power surge: The impacts of rapid dam development in Laos. https://www.riverresourcehub.org/wp-content/uploads/files/attached-files/powersurge_execsumm_eng.pdf
33. Japan International Cooperation Agency (JICA). (2011). The study on improvement of water environment in Vientiane City, Lao People's Democratic Republic: Final report (Summary). https://openjicareport.jica.go.jp/pdf/12044244_01.pdf
34. Japan International Cooperation Agency (JICA). (2011). The study on improvement of water environment in Vientiane City, Lao People's Democratic Republic: Final report (Vol. 1). https://openjicareport.jica.go.jp/pdf/12044236_01.pdf
35. Japan International Cooperation Agency (JICA). (2012). Preparatory survey on Nam Ngum 1 Hydropower Station Expansion in Lao PDR: Final report (Phase 2). https://openjicareport.jica.go.jp/pdf/12083093_01.pdf
36. Kaunda, C. S., Kimambo, C. Z., & Nielsen, T. K. (2012). Potential of small-scale hydropower for electricity generation in Sub-Saharan Africa. ISRN Renewable Energy, 2012, Article 132606. https://doi.org/10.5402/2012/132606
37. Keppeler, F. W., Andrade, M. C., Trindade, P. A. A., de Sousa, L. M., Arantes, C. C., Winemiller, K. O., Jensen, O. P., & Giarrizzo, T. (2022). Early impacts of the largest Amazonian hydropower project on fish communities. Science of the Total Environment, 838, 155951. https://doi.org/10.1016/j.scitotenv.2022.155951
38. Kouphokham, K. (2013). Lao PDR country report. In Energy Outlook and Energy Saving Potential in East Asia 2013 (pp. 1–4). ERIA. https://www.eria.org/RPR_FY2012_No.19_chapter_10.pdf

39. Matthews, N., & Motta, S. (2015). Chinese state-owned enterprise investment in Mekong hydropower. Water, 7(11), pp. 6269–6284. https://doi.org/10.3390/w7116269
40. Mekong River Commission. (1995). Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin. https://www.mrcmekong.org/wp-content/uploads/2024/08/The-Mekong-Agreement.pdf
41. Mekong River Commission. (2019). Review of the design change made for Xayaburi Hydropower Project (Technical Reference Paper No. 65). https://www.mrcmekong.org/wp-content/uploads/2024/08/Review-of-the-Design-Change-Made-for-Xayaburi-Hydropower-Project-A-Technical-Reference-Paper-No.65.pdf
42. Mekong River Commission. (2022). Joint Environmental Monitoring Programme at two Mekong mainstream dams: The Don Sahong and Xayaburi hydropower projects. https://www.mrcmekong.org/publications/joint-environmental-monitoring-programme-at-two-mekong-mainstream-dams-the-don-sahong-and-xayaburi-hydropower-projects/
43. Mekong River Commission. (2022). Sustainable Hydropower Development Strategy: A basin-wide strategy for a changing Mekong River Basin. https://www.mrcmekong.org/wp-content/uploads/2022/06/Sustainable-Hydropower-Development-Strategy-A-Basin-wide-Strategy-for-a-Changing-Mekong-River-Basin.pdf
44. Mekong River Commission (MRC). (2023). Joint Environmental Monitoring Programme at two Mekong mainstream dams: The Don Sahong and Xayaburi Hydropower Projects. https://www.giz.de/en/downloads_els/JEM%20Fish%20Passage%20Acoustic%20PILOT%20study%20final%20report.pdf
45. Mekong River Commission (MRC). (2023). Preliminary Design Guidance for Proposed Mainstream Dams in the Lower Mekong River Basin (PDG 2023). https://www.mrcmekong.org/wp-content/uploads/2023/02/PDG2023.pdf
46. Mekong River Commission. (2024). Mekong Sediment from the MRC Study. https://www.mrcmekong.org/wp-content/uploads/2024/08/Mekong-Sediment-from-the-Mekong-River-Commission-Study.pdf
47. Mekong River Commission. (2025). Hydropower project map. https://portal.mrcmekong.org/hydropower/map

48. Mekong River Commission Secretariat. (2011). Proposed Xayaburi Dam Project: Prior Consultation Project Review Report. Vientiane, Lao PDR. https://www.riverresourcehub.org/wp-content/uploads/files/attached-files/mrc_technical_review_of_xayaburi_march_2011.pdf
49. Mekong River Commission Secretariat. (2019). Statement on the Prior Consultation Process for the Pak Lay Hydropower Project in Lao PDR. https://www.mrcmekong.org/Statement-on-the-Prior-Consultation-Process-for-the-Pak-Lay-Hydropower-Project-in-Lao-PDR.pdf
50. Ministry of Natural Resources and Environment (MONRE). (2013). Ministerial Instruction on Environmental and Social Impact Assessment Process of Investment Projects and Activities, No. 8030/MONRE. (Unofficial English translation). https://s3.amazonaws.com/rgi-documents/78fead1e03882bd42905ac84841c21a20ad6ef15.pdf
51. Ministry of Planning and Investment (MPI). (2016). 8th Five-Year National Socio-Economic Development Plan (2016–2020). https://laopdr.un.org/sites/default/files/2019-08/2016_8th%20NSEDP_2016-2020_English.pdf
52. Ministry of Planning and Investment (MPI). (2021). 9th Five-Year National Socio-Economic Development Plan (2021–2025). https://rtm.org.la/wp-content/uploads/2022/12/ENG-9th-NSEDP_FINAL_PRINT_21.Oct_.21_V1_CLEAN.pdf
53. MRC Environmental Management Division. (2022). Joint Environment(al) Monitoring of Mekong Mainstream Hydropower Projects (Version 7.0). https://www.giz.de/en/downloads_els/JEM%20programme_v7_Final.pdf
54. Nam Ngiep 1 Power Company. (2016). Quarterly Monitoring Report — 01 April to 30 June 2016 (NNP1PC QMR). https://ewsdata.rightsindevelopment.org/files/documents/14/ADB-41924-014_utIw6KY.pdf
55. Nam Ngiep 1 Power Company. (2025). Quarterly Environmental Monitoring Report—First quarter of 2025. https://namngiep1.com/wp-content/uploads/formidable/26/NNP1-O-J0905-RP-017-A-Environment-Monitoring-Report-First-Quarter-of-2025_EN_Signed.pdf

56. Nam Ngiep 1 Power Company Limited. (2017). Environment Monitoring Report—Fourth Quarter of 2017. https://namngiep1.com/wp-content/uploads/formidable/26/Environment-Monitoring-Report-Fourth-Quarter-of-2017.pdf
57. Nam Ngiep 1 Power Company Limited. (2017). Environmental Monitoring Report—Q4 2016. https://ewsdata.rightsindevelopment.org/files/documents/14/ADB-41924-014_h7zTbXY.pdf
58. Nam Ngiep 1 Power Company Limited. (2018). Quarterly Environmental Monitoring Report—Q3 2018. https://namngiep1.com/wp-content/uploads/formidable/26/Environment-Monitoring-Report-Third-Quarter-of-2018.pdf
59. Nam Ngiep 1 Power Company Limited. (2023). Environmental Monitoring Report: April–June 2022 (Quarterly) (ADB Project No. 41924-014). https://www.adb.org/sites/default/files/project-documents/41924/41924-014-emr-en_17.pdf
60. Nam Ngiep 1 Power Company Limited. (2024). Quarterly Environmental Monitoring Report—Q4 2023. https://namngiep1.com/wp-content/uploads/formidable/26/NNP1-O-J0905-RP-012-A-Quarterly-Environmental-Monitoring-Report-Fourth-Quarter-of-2023_FINAL.pdf
61. Nam Ngum Hydropower Plant Expansion Project. (2020). Quarterly Report No. 11 (January–March 2020). Japan International Cooperation Agency. https://www.jica.go.jp/english/our_work/social_environmental/id/asia/southeast/laos/c8h0vm000090sdhe-att/c8h0vm0000dqfa9t.pdf
62. National Assembly of the Lao PDR. (2013). Environmental Protection Law (Revised Version), No. 29/NA (adopted 18 December 2012). (Unofficial English translation). https://policy.asiapacificenergy.org/sites/default/files/Environmental-Protection-Law-2013%20Ed_English.pdf
63. Nilsson, M., Griggs, D., & Visbeck, M. (2016). Policy: Map the interactions between Sustainable Development Goals. *Nature, 534*(7607), pp. 320–322. https://doi.org/10.1038/534320a

64. National Assembly of the Lao PDR. (2015). Constitution of the Lao People's Democratic Republic (Amended). (Unofficial English translation). https://ecnl.org/sites/default/files/files/2021/LaoConstitution-2015.pdf
65. Nippon Koei Co., Ltd. (for JICA). (2012). Study on power supply and demand in Central Region in Lao PDR: Chapter 5—Confirmation of the role of Nam Ngum 1 hydropower expansion (Final report). https://openjicareport.jica.go.jp/pdf/12083077_02.pdf
66. Okot, D. K. (2013). Review of small hydropower technology. Renewable and Sustainable Energy Reviews, 26, pp. 515–520. https://doi.org/10.1016/j.rser.2013.05.006
67. Pak Lay Power Company Limited. (2020). Environmental Impact Assessment (EIA): Pak Lay Hydropower Project (Table 14, pp. 95–96). https://www.paklaypower.com/en/pdf/01-Environmental-Impact-Assessment-EIA.pdf
68. Pathirana, A., & Evers, J. (2018). Adaptation to climate change in the Mekong River Basin: Introduction to the special issue. Climatic Change, 149(1), pp. 1–11. https://doi.org/10.1007/s10584-018-2242-y
69. Phongsavath, A. (2024). Renewable electricity and energy transition in Lao PDR: Opportunities for green hydrogen and ammonia. In H. Phoumin & A. Phongsavath (Eds.), Energy Security White Paper: Policy directions for inclusive and sustainable development for Lao PDR and the implications for ASEAN (pp. 3–4). ERIA. https://www.eria.org/uploads/10_Part_2-Ch_9_Renewable_Electricity_and_Energy_Transistion.pdf
70. Phoumin, H., & Phongsavath, A. (Eds.). (2024). Energy Security White Paper: Policy directions for inclusive and sustainable development for Lao PDR and the implications for ASEAN. ERIA. https://www.eria.org/research/energy-security-white-paper--policy-direction-for-inclusive-and-sustainable-development-for-lao-pdr
71. Pokhrel, Y., Bury, S., Khan, S., & Bell, A. (2018). A review of the integrated effects of changing climate, land use, and dams on Mekong River hydrology. Water, 10(3), 266. https://www.mdpi.com/2073-4441/10/3/266
72. Ritter, C. D., McCrate, G., Nilsson, R. H., Fearnside, P. M., Palme, U., & Antonelli, A. (2017). Environmental impact assessment in Brazilian Amazonia: Challenges and prospects to assess biodiversity. Biological Conservation, 206, pp. 161–178. https://doi.org/10.1016/j.biocon.2016.12.031

73. Saibasan, A. O. (2025). Laos' large hydropower capacity to reach 16 GW in 2035, forecasts GlobalData. Energy Global. https://www.energyglobal.com/other-renewables/28052025/laos-large-hydropower-capacity-to-reach-16-gw-in-2035-forecasts-globaldata/
74. Sayavong, V. (2018). Risk and opportunities: The productive capacities in Lao PDR. https://www.researchgate.net/publication/329443395_Risk_and_Opportunities_the_Productive_Capacities_in_Lao_PDR
75. Singh, V. K., & Singal, S. K. (2017). Operation of hydro power plants: A review. Renewable and Sustainable Energy Reviews, 69, pp. 610–619. https://doi.org/10.1016/j.rser.2016.11.169
76. Sivongxay, A., Greiner, R., & Garnett, S. T. (2017). Livelihood impacts of hydropower projects on downstream communities in central Laos and mitigation measures. Water Resources and Rural Development, 9, pp. 46–55. https://doi.org/10.1016/j.wrr.2017.03.001
77. Soukhaphon, A., Baird, I. G., & Hogan, Z. (2021). The impacts of hydropower dams in the Mekong River Basin: A review. Water, 13(3), 265. https://doi.org/10.3390/w13030265
78. Stimson Center. (2024). All Dams Map of the Mekong Basin. https://www.stimson.org/2024/all-dams-map-of-the-mekong-basin/
79. Syladeth, B. (2017). Integrating environmental and social impact assessment into resettlement management. International Journal of Engineering Research and Management (IJERM). https://www.ijerm.com/download_data/IJERM0407003.pdf
80. Syladeth, S. (2016). Resettlement implementation management caused by hydropower development: A case study of Nam Ngum 2 hydropower project in Laos. Journal of Public Administration and Policy Research, 8(4), pp. 36–47. https://doi.org/10.5897/JPAPR2015.0337
81. Tabuchi, T., Aosaka, Y., Murakami, Y., & Tsutsui, S. (2021). Dam break accident and resulting sediment management at downstream dams in Lao PDR—Highly turbid flood-flow and sediment flushing at Nam Ngiep 1 Hydropower Project. In Proceedings of the ICOLD Symposium on Sustainable Development of Dams and River Basins (New Delhi). https://search.jcold.or.jp/icold/symposium/2020/2020.7.pdf

82. Tilt, B., Braun, Y. A., & He, D. (2009). Social impacts of large dam projects: A comparison of international case studies and implications for best practice. Journal of Environmental Management, 90(Suppl. 3), pp. S249–S257. https://doi.org/10.1016/j.jenvman.2008.07.030
83. Tran, T. A., & Suhardiman, D. (2020). Laos' hydropower development and cross-border power trade in the Lower Mekong Basin: A discourse analysis. Asia Pacific Viewpoint, 61(2), pp. 219–235. https://doi.org/10.1111/apv.12269
84. UNESCO World Heritage Centre. (2021–2024). Town of Luang Prabang: State of Conservation pages & decisions. Retrieved November 2, 2025, from https://whc.unesco.org/en/soc/4356/
85. United Nations. (1991). Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 25 February 1991). https://unece.org/sites/default/files/2021-03/Espoo%20Convention.pdf
86. United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development (A/RES/70/1). https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf
87. United Nations. (2020). The Sustainable Development Goals Report 2020. https://doi.org/10.18356/214e6642-en
88. United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP). (2021). SDG7 Roadmap for the Lao People's Democratic Republic. https://www.unescap.org/sites/default/d8files/knowledge-products/SDG7%20road%20map%20Lao%20PDR.pdf
89. United Nations Economic Commission for Europe. (1992). Convention on the Protection and Use of Transboundary Watercourses and International Lakes. https://treaties.un.org/doc/treaties/1992/03/19920317%2005-46%20am/ch_xxvii_05p.pdf
90. Urban, F., Nordensvärd, J., Khatri, D., & Wang, Y. (2013). An analysis of China's investment in the hydropower sector in the Greater Mekong Sub-Region. Environment, Development and Sustainability, 15(2), pp. 301–324. https://doi.org/10.1007/s10668-012-9415-z

91. Wayakone, S., & Inoue, M. (2012). Evaluation of the Environmental Impacts Assessment (EIA) system in Lao PDR. Journal of Environmental Protection, 3(12), pp. 1656–1663. https://doi.org/10.4236/jep.2012.312182
92. World Bank. (2019). Nam Theun 2 project: Overview and update. https://www.worldbank.org/en/country/lao/brief/nam-theun-2-project-overview-and-update
93. Zheng, S., An, C., Wang, H., Li, L., Wang, F., & Hassan, M. A. (2023). The migration of the erosion center downstream of the Three Gorges Dam, China, and the role played by underlying gravel layer. Water Resources Research, 59(11). https://doi.org/10.1029/2022WR034152
94. Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., & Levin, S. A. (2012). Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. Proceedings of the National Academy of Sciences, 109(15), pp. 5609–5614. https://doi.org/10.1073/pnas.1201423109

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List of Abbreviations

ACE: ASEAN Centre for Energy

ACIAR: Australian Centre for International Agricultural Research

ADB: Asian Development Bank

AE: Attraction Efficiency (fish passage metric)

BOD_5: Biochemical Oxygen Demand (5-day)

COD–Cr: Chemical Oxygen Demand (dichromate method)

CODMn / COD-$KMnO_4$: Chemical Oxygen Demand (permanganate index)

DL / DLs: Detection Limit(s)

DO: Dissolved Oxygen

EIA: Environmental Impact Assessment

EGAT: Electricity Generating Authority of Thailand

EMR: Environmental Monitoring Report

ERIA: Economic Research Institute for ASEAN and East Asia

GoL: Government of the Lao PDR

H1: Hypothesis 1 - water-quality compliance vs national standard

H2: Hypothesis 2 - sediment handling/continuity

H3: Hypothesis 3 - fish passage presence & effectiveness

H4: Hypothesis 4 - reporting vs implementation (verification)

IEA: International Energy Agency

IFIs: International Financial Institutions

JEM (MRC): Joint Environmental Monitoring (MRC program)

JICA: Japan International Cooperation Agency

Lao PDR: Lao People's Democratic Republic

MONRE: Ministry of Natural Resources and Environment (Lao PDR)

MPI: Ministry of Planning and Investment (Lao PDR)

MPN: Most Probable Number (microbial counts)

MRC: Mekong River Commission

NES: National Environmental Standard (Lao ambient surface-water standard)

NH_3-N: Ammonia-Nitrogen

NO_3-N: Nitrate-Nitrogen

NN1 / NN2: Nam Ngum 1 / Nam Ngum 2 (hydropower projects)

NNP1: Nam Ngiep 1 (hydropower project)

NNP1PC: Nam Ngiep 1 Power Company

NTU: Nephelometric Turbidity Units

O&M: Operations and Maintenance

PE: Passage Efficiency (fish passage metric)

PIT: Passive Integrated Transponder (fish tags)

PMO: Prime Minister’s Office (Lao PDR)

PPA: Power Purchase Agreement

QMR: Quarterly Monitoring Report

SSC: Suspended Sediment Concentration

TSS: Total Suspended Solids

UN ESCAP: United Nations Economic and Social Commission for Asia and the Pacific

WB: World Bank

WL: Water Level

WQ: Water Quality

WQMN: Water-Quality Monitoring Network (Lower Mekong Basin)

WREA: Water Resources and Environment Administration (Lao PDR, former agency name)

PHP: Paklay Hydropower Project

DECLARATION

the public access and authenticity of the thesis

Student's name:	Phoutthaxay Boulom
Student's Neptun code:	OZHMJR
Title of thesis:	Engineering compliance with environmental law in Lao hydropower
Year of publication:	2025
Name of the consultant's institute:	Institute of Agricultural and Food Economics
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I declare that the submitted Thesis is my own, original creation. Any part taken from another author work's work are clearly marked, and listed in the table of content

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As a consultant of Phoutthaxay Boulom (student Neptun code: OZHMJR), **I declare** that I have reviewed the thesis and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

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.... Dr. Csegődi Tibor László ....

Insider consultant

Declaration of Students and Doctoral Candidates on the Use of Artificial Intelligence (AI)”

1. general information:

Name of the student:	Phoutthaxay Boulom
Neptun ID:	OZHMJR
Level of program (mark with X):	☒ BSc/BA ☐ MSc/MA ☐ Doctoral School (PhD) ☐ Other: ………………………
Name and code of the subject*:	**Environmental Engineering, B-GOD-N-EN-KORNY**
Title of the work:	**Engineering Compliance with Environmental Law in Lao Hydropower**

* Not required to be completed in the case of a doctoral dissertation.

2. Declaration on the Use of AI

I, the undersigned, fully aware of my ethical responsibility, make the following declaration:

(Please choose one of the options below!)

☐ A) I have not used any artificial intelligence system or service.

(If you selected this option, completing the subsequent tables is not required.)

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TABLE I: Assistant or Minor Usage (e.g., translation, language proofreading, brainstorming, etc.)

(For these uses, attaching the specific prompts and responses is not required.)

Purpose of Use	**Name and Version of the AI Tool Used**	**Affected Section (if not applicable to the entire text)**
Grammar correction, gathering information, and literature for writing, getting ideas.	**Chatgpt 5** **Grammarly 1.2.207** **Claude Sonnet 4.5**	**Part of the literature review** **Part of the material** **Part of the method**

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Purpose of Use	**Name, Version, and Access Information of the AI Tool Used**	**Exact Number of the Affected Chapter / Figure / Table**	**Entry Number of the Appendix Containing the Prompt Log**

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Dr. Csegődi Tibor László

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Signature of the Advisor/Supervisor