AN ASSESSMENT OF INDUSTRY RISK IN HYDROPOWER FINANCING IN NEPAL

Prepared By:
National Banking Institute Ltd.
& Nepal Bankers' Association

July 2026

DISCLAIMER

This report entitled *"An Assessment of Industry Risk in Hydropower Financing in Nepal",* prepared jointly by Nepal Bankers' Association and National Banking Institute, aims to provide evidence-based insights into the industry risks associated with hydropower financing in Nepal. The findings of this study are presented as accurately and comprehensively as possible based on the information available during the study period. However, it is intended for general information and reference purposes only and should not be construed as professional, financial, legal, or investment advice.

The analyses, findings and recommendations presented in this report are based on information obtained from secondary sources, Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), expert consultations, and primary data collected from selected stakeholders, including commercial banks, Independent Power Producers (IPPs), and regulatory authorities. While every reasonable effort has been made to ensure the accuracy and reliability of the information, the authors do not guarantee that the report is free from errors or omissions. The findings reflect the prevailing industry conditions at the time of the study and may not fully capture subsequent policy, regulatory, market, or technological developments.

The opinions and perspectives presented in this report are those derived from the study and should not be interpreted as representing the official views or positions of any participating institution or stakeholder unless explicitly stated.

For enquiries, comments, or suggestions regarding this report, please contact:

National Banking Institute
Central Plaza, 6th Floor, Narayan Chour, Naxal, Kathmandu, Nepal
977 – 1 – 4515903, 4515905, 4536001
info@nbi.com.np

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADB	Asian Development Bank
AML	Anti-Money Laundering
BFIs	Banks and financial institutions
BOOT	Build, Own, Operate and Transfer
CFT	Combating the Financing of Terrorism
ERC	Energy Regulatory Commission
ESG	Environmental, Social, and Governance
FGDs	Focus Group Discussions
FIU Nepal	Financial Intelligence Unit Nepal
FoREX	Foreign Exchange
GLOFs	Glacial Lake Outburst Floods
HPP	Hydropower Plant
IFC	International Finance Cooperation
IPPAN	Independent Power Producers' Association Nepal
IPPs	Independent Power Producers
I-REC	International Renewable Energy Certificate
KIIs	Key Informant Interviews
KYC	Know Your Customer
MW	Megawatt
NDCs	Nationally Determined Contributions
NEA	Nepal Electricity Authority
NRB	Nepal Rastra Bank
PPA	Power Purchase Agreement
PSMP	Power System Master Plan
ROR	Run-of-the-River
SOL	Single Obligor Limit
SPVs	Special Purpose Vehicles

ABSTRACT

This study aims to assess the regulation, technology, and demand of hydropower in Nepal and explore major industry risks and identify risk mitigation strategies. The research employed a mixed-method approach, combining qualitative desk research, Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and expert validation to capture insights from diverse stakeholders, including from commercial banks, Independent Power Producers (IPPs), and regulatory bodies such as the Energy Regulatory Commission (ERC). Moreover, primary data was collected from nine senior-level banking professionals. Qualitative insights were cross-verified through quantitative analysis, providing a comprehensive understanding of regulatory, financial, and environmental challenges in Nepal's hydropower sector. The findings of the study highlight the dual nature of hydropower, risky but highly attractive, driven by its clean energy profile, carbon credit opportunities, and strong regional demand. From the banking perspective, key priorities include stable and transparent regulations, stronger feasibility studies of the project, establishment of green data bank, and policy reforms in PPAs to minimize uncertainty. Banks also emphasized the need for complementary solar investments to manage seasonal fluctuations. Moreover, Independent Power Producers (IPPs) stressed forward-looking policies, fair electricity pricing, streamlined licensing, and private sector participation in power exports to unlock international markets and attract foreign investment at lower costs.

Overall, this study concludes that hydropower financing in Nepal requires a holistic approach that combines stable regulatory frameworks, public-private collaboration, diversified energy sources, and robust financial safeguards. Despite high exposure to environmental and regulatory risks, banks can mitigate these challenges through structured financing, resilient infrastructure, and investor-friendly policies. If effectively addressed, hydropower can serve as Nepal's strongest pathway to achieving long-term prosperity, energy security, and regional economic influence.

Keywords: *Hydropower Financing, Industry risk, Triple Bottom Line Model*

CHAPTER I: INTRODUCTION

1.1 Background of the Study

Nepal's abundant rivers and steep terrain make hydropower one of its most valuable natural endowments (Pandey & Patodiya, 2023), positioning the sector as both a driver of domestic energy and a potential export hub for South Asia (Bishwakarma, 2020). Hydropower refers to the generation of electricity through the use of flowing or failing water, typically harnessed by dams or run of the river projects (Nepal et al., 2021; Yang, 2024). It stands at the heart of Nepal's development aspirations, not just as a source of energy but as a driver of economic growth, rural electrification, and regional trade (Pandey & Patodiya, 2023). Blessed with abundant water resources and steep topography, Nepal is often portrayed as having the potential to become the "Battery of South Asia," (Hekel, 2016) with an estimated hydropower capacity of 83,000 MW, of which around 45,000 MW is considered technically and economically viable (Warren, 2025). Despite this vast potential, the country has been able to harness only a fraction. As of 2025, installed hydropower capacity stands at 3,388.744 MW, supplied by hundreds of operational plants and many more projects currently under development (Ministry of Energy, Water resources and Irrigation, 2025). The strategic importance of hydropower for Nepal cannot be overstated. It is one of the most reliable and renewable energy sources, contributing to sustainable development and positioning Nepal as a prospective exporter of clean energy (Warren, 2025; Niroula et al., 2024). Recent years have seen concrete steps in this direction: Nepal has started exporting electricity through cross-border grids, sending 40 MW to Bangladesh and 80 MW to India's Bihar (Reuters, 2025), a milestone that underscores the regional dimension of its hydropower sector. For a country heavily dependent on remittances and tourism (World Bank Group, 2019), such outcome represents not only an energy milestone but also a new stream of economic opportunity.

Financing has been central to these developments. Hydropower projects in Nepal typically secure funds through a combination of equity from developers, loans from banks and financial institutions (BFIs), foreign direct investment, and support from development partners such as the World Bank and Asian Development Bank (Asian Development Bank [ADB], n. d.). Among these, Nepal's banks and financial institutions also play a crucial role in financing hydropower (Nepal et al., 2023). Nepal Rastra Bank (NRB), the central bank of Nepal, regulates BFIs and issues investment guidelines. Under its current provisions, domestic BFIs are required to allocate a portion of their investments to the hydropower sector (Nepal et al., 2023). According to Nepal Rastra Bank [NRB] (2022), commercial banks are required to allocate a specific share of their lending portfolios to the energy sector i.e. 6% by mid-2022, increasing to 10% by mid-2025. Some banks, such as Prime Commercial Bank, Sanima Bank, and NMB Bank, have already exceeded these thresholds, allocating over 8 to 11% of credit to hydropower sector (Chaudhary, 2024). Financial institutions also team up in consortiums to underwrite big projects (Financial Notices, 2025), for example, NMB Bank and Agricultural Development Bank financed NPR 3.745 billion of the NPR 5.35 billion 24.8 MW Bajra Madi project in 2025 (Equity Nepal, 2025). At the same time, capital market instruments like IPOs, and foreign institutional support, are playing a supplementary role in bridging financing gaps (Asian Development Bank [ADB], 2023; Nepal Rastra Bank [NRB], 2024).

Despite these promising initiatives, hydropower financing in Nepal faces significant challenges, particularly from the perspective of banks and financial institutions (BFIs). Large-scale projects are highly capital-intensive and involve long gestation and repayment periods, making them inherently riskier for lenders (Tuladhar, 2015). Nepalese banks, with relatively small capital bases, are limited in their capacity to finance individual large projects. Their ability to provide long-term loans is further restricted by an asset–liability maturity mismatch, as the short-term deposits they collect do not align with the long-term financing needs of hydropower projects (World Bank Group, 2019). Regulatory provisions also add complexity: strict exposure limits (e.g., restricting lending to a single borrower beyond 25% of core funds), stringent provisioning for non-performing loans, and demands for excessive collateral, sometimes extending to several generations of financial documentation create additional barriers for lenders as well as project developers (Nepal Economic Forum, 2014).

Beyond financial barriers, non-financial risks exacerbate the challenges for BFIs. Environmental and social concerns, such as community displacement, biodiversity loss, and local conflicts, frequently stall projects and heighten uncertainty for lenders. Climate change further compounds risks, with studies highlighting how altered rainfall patterns, glacier-fed water flows, and river hydrology can directly affect electricity generation capacity (Chaulagain et al., 2025). Adding to these constraints, the underdeveloped capital market in Nepal leaves hydropower firms heavily reliant on internal cash flows, exposing them to volatility and limiting opportunities for diversified funding (Subedi, 2018).

While hydropower remains Nepal's most promising pathway for sustainable development and regional energy integration, its financing is constrained by deep-rooted financial, regulatory, and environmental risks. These challenges are especially pronounced for BFIs, which bear the responsibility of mobilizing large-scale, long-term capital under conditions of uncertainty. Unlike conventional lending, hydropower financing ties up resources for extended periods and exposes banks to risks that are difficult to mitigate. As a result, hydropower financing becomes complicated by long project timelines, asset–liability mismatches, regulatory exposure limits, and policy or market unpredictability. Therefore, this study focuses on examining the risks faced by banks and financial institutions when financing hydropower in Nepal. By analyzing regulatory, financial, environmental, and climate-related challenges, the research aims to provide insights that can guide lenders, policymakers, and developers in designing more effective and sustainable financing strategies for the sector.

1.2 Objectives of the Study

To cater the lender's need and to understand lending risks and mitigation practices, this study has the following objectives:

- To assess the regulation, technology, and demand of hydropower in Nepal.
- To explore major hydropower industry risks from the lender's perspective.
- To identify risk mitigation strategies from the lender's perspective.
- To analyze indicative index of cost per MW.

CHAPTER II: APPROACH AND METHODOLOGY

In this section, the theoretical framework is outlined by linking regulation, technology, and demand as drivers that support or hinder hydropower development from the lender's perspective to understand risks and mitigation strategies followed by methodology used.

2.1 Theoretical Review

John Elkington first introduced the idea of the Triple Bottom Line (TBL) in 1994, arguing that the conventional measure of business success—financial profit—was insufficient to capture a company's overall value (Elkington, 1994). He later expanded this argument in Cannibals with Forks: The Triple Bottom Line of 21st Century Business*,* proposing that businesses should be evaluated across three dimensions: economic, social, and environmental (Elkington, 1997). This framework, often summarized as the "three Ps" — people, planet, and profit—has since become a cornerstone in sustainability thinking. As HEC Paris (n.d.) explains, a firm may be financially profitable yet still harm the society or ecosystem in which it operates, which underscores the need for companies to report not only on financial performance but also on their ecological and social impacts. TBL is a sustainability framework that evaluates organizational performance across three dimensions: social (people), environmental (planet), and economic (profit), rather than focusing solely on financial returns. Elkington (2018) stressed that the original intent of TBL was system change, not just balancing three performance indicators. He called for rethinking the framework to focus more on regenerative sustainability, and long-term value creation**.**

Triple Bottom Line (TBL) framework was used by Coro Strandberg (2009) and integrated into the Structured Decision-Making (SDM) decision-making processes of BC Hydro, Canada's third-largest electric utility. When planning and managing hydropower, this approach helps to balance social, economic, and environmental objectives. World Bank (2017) highlights how integrating TBL considerations can enhance the sustainability of hydropower projects. De Oliveira et al. (2025) investigate the socioeconomic impacts of renewable energy projects, including hydropower, using the Triple Bottom Line framework. By integrating the three dimensions—profit, people, and planet—the framework allows project developers and policymakers to evaluate trade-offs holistically and ensure sustainable decision-making in hydropower planning and operations.

Similarly, sustainability as a policy concept has its origin in the Brundtland Report of 1987. That document was concerned with the tension between the aspirations of mankind for a better life on the one hand and the limitations imposed by nature on the other hand. In the course of time, the concept has been re-interpreted as encompassing three dimensions, namely social, economic and environmental (Kuhlman & Farrington, 2010). The three approach of TBL are further described below:

2.1.1 Economic (Profit) Dimension

Profit is a central component of the Triple Bottom Line (TBL) approach, as businesses must generate financial returns to survive, grow, and invest in the future. Among the three Ps—People, Planet, and Profit—profit is often considered the most fundamental requirement for long-term sustainability. In hydropower projects, one of the biggest economic/financial risks arises from cost overruns during construction and operation. Inaccurate estimates of project timelines and budgets can result in significant financial losses, reducing the project's overall economic value (Baurzhan et al., 2021). Such overruns may occur due to delays in approvals, unexpected geological conditions, or increases in material costs. To ensure economic sustainability, robust financial planning and realistic feasibility studies, including long-term cost projections, are necessary to maintain profitability throughout the project's life (Braeckman et al., 2022). Effective risk management is therefore crucial for making hydropower projects both reliable and sustainable (Shaktawat & Vadhera, 2021).

2.1.2 Social (People) Dimension

Under the Triple Bottom Line (TBL) approach, businesses must address social issues to achieve long-term sustainability. In hydropower financing, various social risks can emerge, particularly in Nepal, where projects often face disputes over benefit-sharing, land acquisition conflicts, and community displacement (Williams, 2025). Relocation and resettlement can disrupt livelihoods, lifestyles, and living conditions, leading to grievances among affected communities (Herath et al., 2021). Marginalized groups are especially vulnerable, as they may suffer greater economic hardship rather than gaining benefits from such projects (Luu et al., 2017). Urban et al. (2015) argue that progress in social sustainability can be achieved when financing mechanisms comply with strict performance standards set by organizations such as the International Hydropower Association (IHA) and the International Finance Corporation (IFC). BFIs can mitigate social risks by engaging stakeholders early, ensuring fair resettlement and compensation, promoting benefit-sharing, establishing grievance mechanisms, and monitoring compliance. Implementing these measures not only reduces conflicts but also strengthens project sustainability and supports long-term profitability (Sustainable Finance Department, 2022). The role that banks can play in reducing social risks and promoting sustainable development is examined in this study.

2.1.3 Environmental (Planet) Dimension

Businesses must address environmental issues in order to achieve sustainability under the Triple Bottom Line (TBL) approach. In hydropower financing, environmental risks are critical to long-term project success. In Nepal, hydropower projects are highly vulnerable to landslides, floods, and climate change impacts. Run-of-river (RoR) plants face additional hazards, including flash floods, glacial lake outburst floods (GLOFs), and landslide dam outburst floods (LDOFs) (Bhatta, 2017). The construction and operation of hydropower projects can also threaten local biodiversity, disrupt habitats, and reduce water quality, making it challenging to balance energy generation with ecological health (Ghimire, 2021). Climate change further complicates sustainability, as shifts in rainfall patterns and evaporation rates affect river flows and reduce hydropower generation efficiency (Oyerinde et al., 2016). Environmental protection efforts, such as maintaining ecological flows, may also reduce electricity output, creating a trade-off between profitability and sustainability (Rand, 2018). To address these challenges, the Environmental and Social Risk Management (ESRM) Guidelines encourage banks and financial institutions (BFIs) to adopt Environmental and Social Management Systems (ESMS) that cover environmental risks. The shift to a sustainable banking environment is accelerated by the efficient application of ESRM guidelines (Tiwari, 2024). This study additionally examines at how banks can help lower environmental risks and advance sustainable development.

2.2 Research Methodology

This study employed a mixed-methods approach, integrating qualitative and quantitative research to provide a comprehensive understanding of the hydropower sector's dynamics. To address the first objective i.e. assessing the regulation, technology, and demand of hydropower in Nepal, a desk study was undertaken, beginning with a literature review of academic research papers, policy documents, and industry reports to identify prevailing trends, challenges, and opportunities in the sector. Similarly, to achieve the second and third objectives i.e. exploring major hydropower industry risks and identifying risk mitigation strategies from the lender's perspective, primary qualitative data was collected through Key Informant Interviews (KIIs) with senior executives from commercial banks, Independent Power Producers (IPPs), and regulatory bodies such as the Energy Regulatory Commission (ERC). These were complemented by Focus Group Discussions (FGDs) involving representatives from banks, IPPs, and regulators, which provided deeper insights into sectoral practices, financing challenges, and policy priorities. Expert feedback from industry practitioners, academicians, and policymakers further validated preliminary findings and refined interpretations, while a peer review process ensured analytical rigor, clarity, and credibility.

To cross-verify these qualitative findings and quantify perceived risks, a structured questionnaire survey was conducted with nine respondents from commercial banks, holding positions such as Assistant Manager, Deputy Manager, Senior Relationship Manager, Chief Risk Officer, and Senior Manager, each with 5 to 11 years of professional experience. Finally, to meet the fourth objective, i.e. analyzing the indicative index of cost per MW, a quantitative study was conducted using secondary data obtained from the annual reports of the Ministry of Energy, Water Resources, and Irrigation.

This integrated methodological approach enabled the study to comprehensively achieve its objectives, offering a holistic understanding of the hydropower industry's attractiveness, risk dynamics, and cost structures, and ensuring that the findings are both robust and actionable.

2.2.1 Data Analysis Method

The study employed both qualitative and quantitative data analysis techniques to align with its mixed-methods approach. For qualitative data, insights from Key Informant Interviews (KIIs), and Focus Group Discussions (FGDs) were systematically coded and thematically analyzed. Thematic analysis allowed for the identification of patterns and recurring perspectives, enabling a nuanced understanding of risks and strategies from the perspective of banks and financial institutions. Expert feedback and peer review were further incorporated to validate the interpretation of qualitative findings and to minimize potential researcher bias. For quantitative data, responses from the questionnaire survey were compiled and analyzed using Microsoft Excel. Each respondent evaluated risk factors on a five-point Likert scale (1 = low risk, 5 = high risk). The scores were averaged across respondents to calculate mean risk values for each factor, which were then ranked to highlight the most significant risks.

By integrating thematic insights with numerical risk scores, the data analysis method ensured a balanced and comprehensive evaluation of Nepal's hydropower sector, addressing both subjective perceptions and objective measurements.

CHAPTER III: STATUS OF HYDROPOWER IN NEPAL

3.1 Historical Development of Hydropower in Nepal

The Pharping Hydropower Plant (HPP), the second HPP in South Asia, was inaugurated in 1911A.D., marking the beginning of Nepal's hydropower journey. However, this early start was not capitalized because it took until 1965 for the public to have access to electricity, and the next HPP was established 23 years later. Due to financial limitations and a lack of sectoral priorities, hydropower development in Nepal has been sluggish for nearly a century. The government's stance on hydropower investments changed in 1990 along with Nepal's political landscape. An important turning point in the liberalization of the hydropower industry was the Hydropower Development Policy (1992) and the Electricity Act and Water Resource Act (1992).

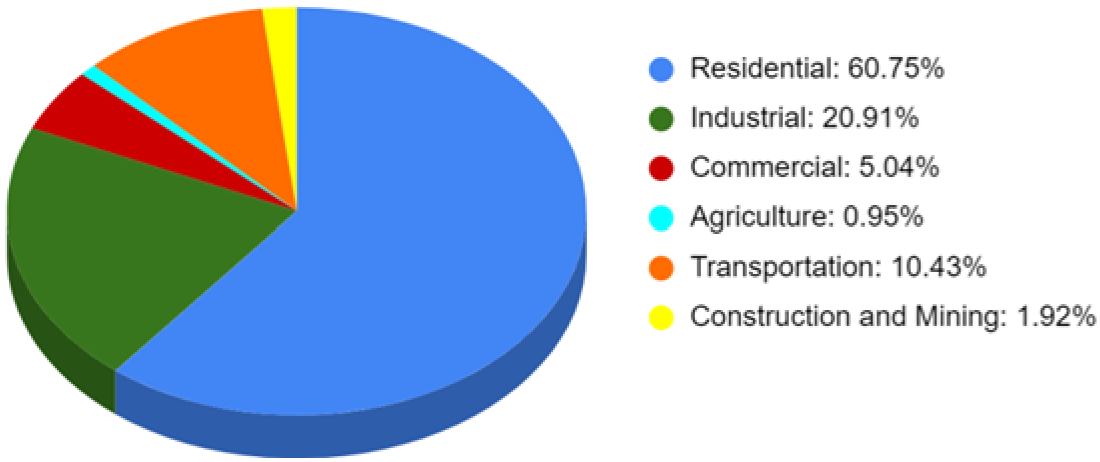
To guarantee the development of hydropower, which was previously owned and developed by the government-affiliated NEA, the sector was liberalized by attracting private sector investment through the "build, own, operate and transfer (BOOT)" mechanism. However, despite the intention to promote private investment in the sector, progress was essentially halted for more than ten years following the political change because of armed conflicts, political disputes among the parties, and environmental movements (e.g., Arun III HPP's forced withdrawal). Political conflicts have made both domestic and foreign investors even less inclined to invest in the nation.

Nevertheless, between 2000 and 2008, two government-affiliated projects (144 MW Kali Gandaki A and 70 MW Middle Marsyangdi) and two foreign-invested projects (60 MW Khimti and 36 MW Bhotekoshi) were completed. The slow growth in the middle of the 2000s signaled the start of a ten-year energy deficit, or "load-shedding." However, the industry gradually began to thrive with a wide variety of Nepali investors following the country's political transformation as a Federal Democratic Republic in 2008. These investors included commercial banks, institutional investors, and businesses founded by investors, especially for the development of hydroelectric projects. With competitively priced hydroelectric technology, Chinese suppliers have recently entered the Nepali market, drawing in IPPs with their low bid prices but geopolitical tensions between India and China makes this sector vulnerable. Nepal has seen a considerable decrease in load shedding as a result of this expansion, with hydropower significantly enhancing the country's energy security (Aryal et al., 2024).

3.2 Electricity Consumption

Figure 3.1 illustrates the sectoral energy consumption share in Nepal. The residential sector dominates energy consumption with 60.75%. The industrial sector follows, consuming 20.91% of the energy. The transportation sector accounts for 10.43%, while the commercial sector uses 5.04%. The agriculture sector accounts for 0.95% and construction and mining sectors accounts for 1.92% of the total energy consumption.

Figure 1: Electricity Consumption



Source. Water and Energy Commission Secretariat (2024)

3.3 Total Electricity Demand and Average Growth Rates

The projected final electricity demand and its growth rates in Nepal from 2015 to 2040 under different scenarios are illustrated in Table 3.1. The business-as-usual (BAU) scenario represents the baseline trend without any policy interventions. The "Reference Scenario" incorporates moderate policy interventions, while the "High Scenario" assumes more aggressive policy measures. The "Policy Intervention @ 7.2%" and "Policy Intervention @ 9.2%" scenarios explore the impact of specific policy interventions on electricity demand growth.

Overall, the table indicates a significant increase in final electricity demand in Nepal over the projected period. The growth rate is expected to fluctuate under different scenarios, with higher growth rates observed under the "High Scenario" and policy intervention scenarios. The "Policy Intervention" scenarios demonstrate the potential for accelerated electricity demand growth through targeted policy measures. Supporting the above narrative, in the Focus Group Discussion (FGD), one of the discussants stated the promise of the hydropower sector in Nepal as follows:

> *According to Uttam Bhlon Lama, an independent power producer: Two things should be examined while talking about hydro: One is resource and another is policy framework. We have enough technical manpower, resources and demand. If economic growth will be like this for next ten years, then we need additional 10,000MW. Other things remaining the same, for that production Nepal has enough resource to generate additional 10,000MW. At present, regulatory framework seems less supportive to achieve those goals. So, forward looking policy should be formulated by government.*

Table 1: Total Final Electricity Demand and Average Growth Rates

Year	Final Electricity Demand (GWh)					Growth Rate of Final Electricity (% p.a.) Demand				
	BAU	Reference Scenario	High Scenario	Policy Intervention @ 7.2%	Policy Intervention @ 9.2%	BAU	Reference Scenario	High Scenario	Policy Intervention @ 7.2%	Policy Intervention @ 9.2%
2015	3866.36	3866.36	3866.36	3866.36	3866.36					
2020	7600.75	8110.66	8522.97	14870.92	15304.29	14.5	15.1	17.13	30.92	31.67
2025	12998.25	14863.67	16545.84	22431.68	24265.05	11.3	12.19	14.19	8.57	9.66
2030	20073.83	24956.79	29864.09	35334.66	41264.82	9.1	10.25	12.54	9.51	11.2
2035	29744.69	40709.77	52983.16	1771.84	65657.50	8.2	9.64	12.15	7.94	9.73
2040	43016.68	66096.60	94851.06	81958.97	115294.44	7.7	9.5	12.35	9.62	11.92

Source. Water and Energy Commission Secretariat (2017)

3.4 Power Purchase Agreements Terms and Conditions

In 2017, the NEA Board introduced structured guidelines and rate systems to standardize Power Purchase Agreements (PPAs) for hydropower projects. These guidelines cater to various project types, including Run-of-River (ROR), Peaking Run-of-River (PROR), and Storage-based plants, to ensure fairness and sustainability. ROR (Posted rate with 3% simple escalations for 8 years for the capacity up to 100 MW and the base rate to be lowered for projects above 100 MW with ROE higher than 17 %). Storage projects, crucial for energy stability during low-flow periods, benefit from higher base tariffs during the dry season, encouraging consistent power supply. Seasonal tariffs reflect the variability in hydropower generation, with dry-season rates being higher to support energy demands during peak periods.

PROR projects are incentivized for providing energy during peak hours, with tariffs ranging from NPR 8.50 to NPR 10.55 per kWh, depending on the duration of peak supply. Storage projects, on the other hand, have the highest dry-season rates at NPR 12.40 per kWh, while the wet-season tariff is NPR 7.10 per kWh. However, if wet-season output exceeds 50%, the tariff may be reduced. These comprehensive rules ensure reliable energy supply, promote financial stability, and encourage long-term resilience in the hydropower sector (Nepal Electricity Authority [NEA], 2017).

3.5 Regulatory Landscape

Nepal has a well-defined regulatory framework to facilitate the development and management of hydropower resources, which are vital to the country's energy sector. The regulatory landscape is governed by policies, acts, and agencies that aim to encourage investment, ensure sustainable resource use, and align energy development with national and environmental priorities. Below are the key elements of Nepal's hydropower regulatory framework:

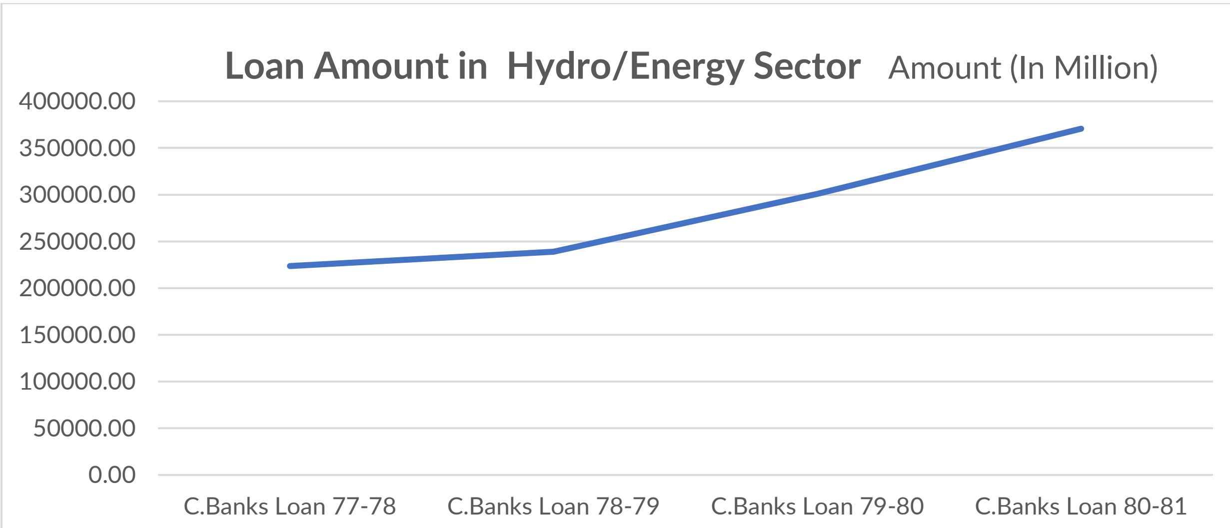
- **Electricity Act, 1992:** This foundational law regulates the generation, transmission, and distribution of electricity. It provides for licensing requirements, tariff determination, and the roles of developers and operators in hydropower projects.
- **Hydropower Development Policy, 2001:** This policy promotes private sector participation and ensures that hydropower projects are developed sustainably. It emphasizes environmental protection, equitable resource sharing, and the prioritization of domestic energy needs.
- **Environment Protection Act, 2019:** Depending on various factors, all hydropower projects are required to conduct either Environmental Impact Assessments (EIA) or Initial Environmental Examinations (IEE) to minimize ecological damage and promote sustainable development.
- **Electricity Regulatory Commission:** To streamline and standardize the generation, transmission, distribution, and trade of electricity, ensure a balance between supply and demand, regulate tariffs, protect consumer rights, foster a competitive electricity market, and provide reliable, accessible, and safe electricity services, the Government of Nepal established an independent regulatory body. This decision, based on the Electricity Regulatory Commission Act, 2074, and the Electricity Regulatory Commission Rules, 2075, was finalized by the Council of Ministers on 2076/01/23.
- **NRB Directives for BFIs:** Hydropower generation projects and transmission line or substation construction and operation projects are classified as productive sector loans. Loans issued for such purposes — including those fully secured and unsecured — can be counted within the 50% limit of productive sector lending. However, to classify loans to hydropower generation projects under the 25% limit of productive sector lending based on fully secured collateral, the project must have signed a Power Purchase Agreement (PPA) with the relevant authority (Nepal Rastra Bank [NRB], 2010).

In the case of a loan provided for hydropower generation where the project has been completed but has not yet started generating electricity, the loan can remain classified as a performing loan for up to 5 years. However, if the hydropower project is completed but has not commenced electricity generation within that period, the loan must be downgraded to sub-standard, and a 25% loan loss provision must be made accordingly.

BFIs must also prioritize lending to productive sectors, with energy loans comprising around 10% of total portfolio—commercial banks had about 8% in mid-2024, increasing to the mandated target by 2027. Additionally, all hydropower financing must comply with the ESRM (Environmental & Social Risk Management) framework, which requires BFIs to integrate E&S assessments into their loan processes consistent with national and international standards

Figure 2 illustrates the trend in loan amounts provided by commercial banks in the hydropower/energy sector from the fiscal year 2077/78 to 2080/81. The data shows a steady increase in lending, with the loan amount rising from around NPR 220 billion in 2077/78 to NPR 380 billion in 2080/81. This indicates a growing confidence among commercial banks in the hydropower/energy sector and a positive trend in financing for projects in this area (Nepal Rastra Bank [NRB], 2025).

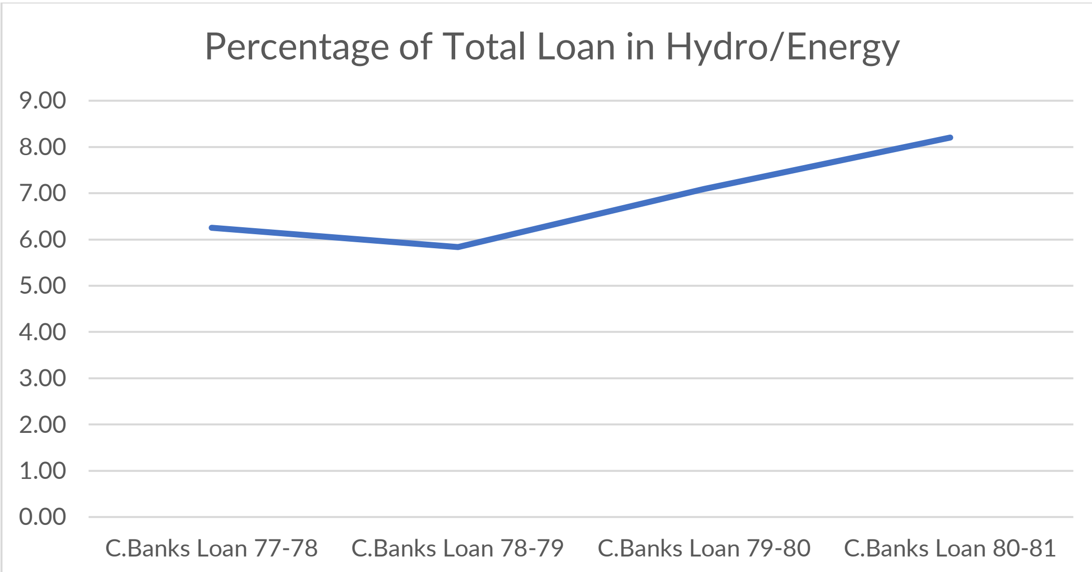
Figure 2: Loan Amount in Hydro/Energy Sector (Millions NRS)



Source. Nepal Rastra Bank (2025)

Figure 2 illustrates the percentage of total loans provided by commercial banks in the hydropower/energy sector from the fiscal year 2077/78 to 2080/81. The data shows a slight decrease in the percentage of total loans allocated to hydropower/energy in 2077/78, followed by a steady increase in subsequent years.

Figure 3: Percentage of Total Loan in Hydro/Energy



Source. Nepal Rastra Bank (2025)

This suggests a growing emphasis on the hydropower/energy sector by commercial banks, with the percentage reaching 8% of total loans in 2080/81.

In this section, Nepal's 16th plan ambitions are revisited by the latest *'Energy Development Roadmap and Action Plan 2081'* and NEA's next few years target/strategy are outlined.

3.6 16th Plan Ambitions

Nepal aims to achieve 15,000 MW of total energy capacity by 2029, with a major focus on large and small hydropower projects. Also, enhance rural electrification, aiming for universal access by the end of the plan. However, this has been revised in '*Energy Development Roadmap and Action Plan 2081*' with a target of 28,500 MW of electricity generation by 2035 not only for export but to encourage domestic consumption and industrial development.

3.6.1 NEA's Next Few Years Target/Strategy

- Power Generation: The Nepal Electricity Authority (NEA) aims to increase installed capacity to 10,000 MW by 2027 to help meet the national target of 15,000 MW by the same year through new ventures, optimization of existing plants, exploration of storage and pump storage projects and encouraging other renewable options. The Authority also plans to achieve 100% electrification of the population and expand energy export through regional power trade initiatives, especially via the cross-border transmission line projects with India.

- Distribution and Transmission: Significant upgrades and optimization planned for national grid infrastructure. Also, it enhances domestic electricity consumption by incentivizing industries to switch to electric energy sources.
- Sustainability Focus: Integrate solar and other renewable energy sources to balance the seasonal variability of hydropower.

CHAPTER IV: REGULATION AND TECHNOLOGY

Apart from the demand forecast in Nepal illustrated in section one, Indian and Bangladeshi markets provide a great opportunity for Nepal's hydropower export.

4.1 Status of the Energy Sector in India

India's total installed power capacity as of July 2025 is 485418.82 MW and total installed hydropower capacity stands at 49628.16 MW, which accounts for 10.2% of the country's total installed capacity. Hydropower plays a vital role in the energy mix, contributing significantly to the renewable energy sector. It is particularly important for meeting peak demand due to its ability to quickly adjust generation levels. The growth in hydropower generation has been consistent, but the sector faces challenges, including dependence on seasonal rainfall and environmental concerns. Despite these hurdles, hydropower remains a crucial part of India's energy transition, with ongoing projects aiming to expand capacity. The government's focus on clean energy includes increasing the share of hydropower in the overall mix. However, its contribution is still lower compared to wind and solar energy, which have seen rapid growth. As India targets 1750 BU of total electricity generation in 2023-24, hydropower is expected to meet a significant portion of the renewable energy needs. In addition, there are efforts to harness small hydro and pumped storage to enhance grid stability. The sector continues to receive attention as part of the broader push for energy security and sustainability (Ministry of Power, n. d.).

4.2 Indian Energy Demand as an Opportunity for Nepal

India's energy demand is set to soar, reaching 1,852 billion kWh by 2026–27 and 2,459 billion kWh by 2031–32, creating a growing dependency on imports to bridge the gap in domestic production. With non-fossil fuels already contributing 43% of its generation capacity, India is accelerating its shift towards renewables like hydro and solar. Nepal's clean hydropower presents an ideal complement to India's sustainable energy goals, especially during peak demand periods, as 57% of India's electricity still relies on fossil fuels. Additionally, the shared border between the two countries ensures streamlined energy trade, positioning Nepal as a key partner in India's renewable energy transition

4.3 Bangladesh as an Opportunity for Energy Export

In Bangladesh, hydroelectricity makes up just 1 percent of the total generation of 24,911 MW of this, renewable energy is only 2 percent (459 MW).[1]

Energy demand in Bangladesh: As per Vision 2041, the government is working towards the implementation of a power generation capacity of 40,000 MW by 2030 and 60,000 MW by 2041 as per the Power System Master Plan (PSMP) (Bangladesh Power Development Board, 2023).

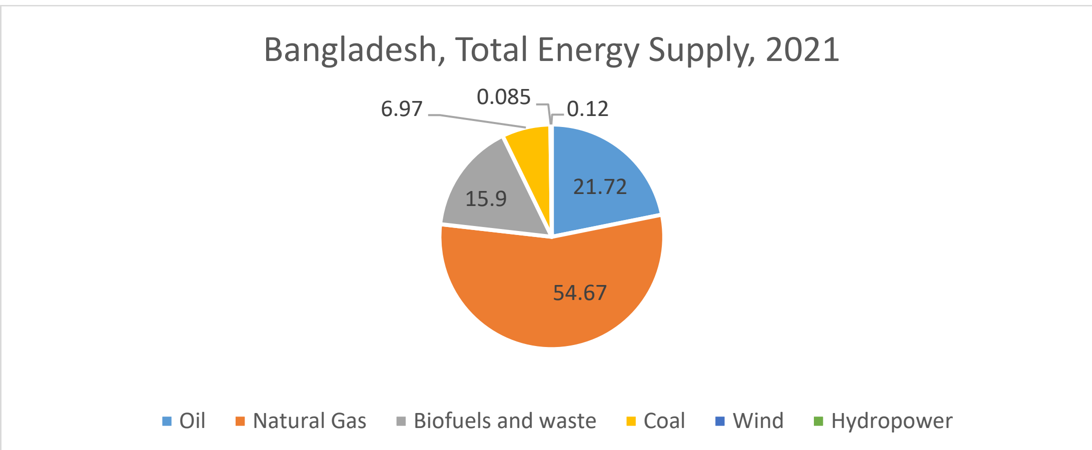
[1] Energy Scenario of Bangladesh 2022-23, Energy and Mineral Resource Division

Power Generation Capacity

Total grid-based installed capacity was 22,482 MW in FY 2021-22 including 10,130 MW public sector, 1,244 MW in JV, 9,948 MW in the private sector, and 1,160 MW from cross-border power import from India. Till January 2023, the total grid-based installed capacity is 23,482 MW including 10,246 MW in the Public Sector, 1,861 MW in JV, 10,215 MW in the Private Sector, and 1,160 MW of power imported from India (Ministry of Finance, 2025).

The energy profile highlights Bangladesh's heavy reliance on natural gas as its primary energy source, with oil and biofuels also playing significant roles. Renewable energy sources like wind and hydropower remain a small fraction of the total supply as shown in Figure 4.1.

Figure 4: Total Energy Supply of Bangladesh, 2021



With energy exports already underway, Bangladesh's growing demand presents significant opportunities for Nepal's hydropower. Currently, only 1% of Bangladesh's electricity comes from hydropower and 2% from renewables, highlighting the need to diversify its energy mix with clean imports. The country aims to expand its power generation capacity to 40,000 MW by 2030 and 60,000 MW by 2041, and importing hydropower from Nepal can support these ambitious goals while reducing dependence on natural gas and oil. With existing energy imports of 1,160 MW from India, Bangladesh has demonstrated its readiness to partner with external suppliers, and Nepal's hydropower aligns perfectly with its 2041 vision for increased renewable energy use.

Some initiations have already been taken to achieve the power cooperation between Nepal and Bangladesh. The Nepal Electricity Authority (NEA) signed a historic tripartite power trade agreement with the Bangladesh Power Development Board and Vidyut Vyapar Nigam of India on October 3, 2024 to facilitate electricity exports to Bangladesh. Under this agreement, Bangladesh committed to importing 40 MW of electricity from Nepal each year during the monsoon season (June to November) for a period of five years. The agreement was inaugurated on November 15, 2024 with a 12-hour pilot export of 40 MW of power transmitted through India's power grid and marked a significant step for Nepal's energy sector, opening up a new electricity export market beyond India (Reuters, 2025).

4.4 Regulatory Challenges in Hydropower Financing

Hydropower development in Nepal faces significant regulatory hurdles that affect investment and project execution. Lengthy approval procedures, overlapping mandates among government agencies, and frequent policy changes create uncertainty for investors. One major concern is the inconsistent power purchase agreement (PPA) framework, especially regarding tariff structures and currency risks, which complicates financial planning. Additionally, while environmental and social impact assessments are crucial, bureaucratic delays and shifting compliance requirements often stall projects. To create a more favorable investment climate, Nepal needs to streamline approval processes, ensure policy consistency, and establish a transparent and predictable regulatory framework.

As reported by *Republica* on January 26, 2025, IPPAN expressed concerns over a Supreme Court decision that dismissed an amendment to the National Parks and Wildlife Conservation Act. According to IPPAN, this ruling could halt more than 20,000 MW of hydropower projects, including those under construction and already completed, as it prohibits infrastructure development in protected areas. The association warned that this could lead to an annual loss of more than NPR 400 billion to the state.

In August 2023, *The Himalayan Times* reported that IPPAN raised objections to certain recommendations made by a government panel regarding Power Purchase Agreements (PPAs). The association argued that prioritizing hydropower projects promoted by the government and its subsidiaries would be unfair to private power producers. IPPAN advocated for a 'first come, first served' basis for approving PPAs to ensure fair treatment of private investments in the sector.

A stable policy environment is crucial for the hydropower sector, as project costs and construction timelines are typically planned based on the assumption that government policies will remain consistent over the long term. However, recent trends show that many of these policies are being altered annually through the national budget. For instance, frequent changes in VAT rates, customs duties, licensing requirements, environmental and forest-related charges, and Power Purchase Agreement (PPA) terms have introduced uncertainty and instability. Such unpredictable policy shifts undermine the financial viability of hydropower projects and discourage private sector participation and investment.

4.5 Technological Opportunities in Hydropower Development

Emerging technologies are transforming the hydropower sector, making it more efficient, reliable, and financially attractive. Advanced monitoring systems and predictive maintenance tools can help optimize plant performance, reduce operational costs, and minimize downtime. Small-scale and modular hydropower solutions offer an opportunity to bring electricity to remote areas without the need for extensive infrastructure. Additionally, integrating hydropower with pumped storage systems and renewable sources like solar and wind can improve grid stability and address seasonal fluctuations in power generation. As Nepal modernizes its energy sector, innovations such as blockchain-based power trading and smart grids for better demand management can further enhance efficiency and transparency. Embracing these technological advancements can strengthen the sector's sustainability and attract greater investment.

4.6 Strategic Advantage for Nepal

By exporting hydropower not as a raw material but using it as an input to green hydrogen or other exportable products, Nepal can generate significant revenue, reduce trade deficits, and strengthen regional energy cooperation. Additionally, clean hydropower exports position Nepal as a leader in sustainable energy development while contributing to the decarbonization goals of the region (Pokhrel, 2017).

Apart from this, nationally determined contributions will be possible through hydropower rather than traditional energy sources. Nepal's Nationally Determined Contributions (NDCs) outline the country's commitment to addressing climate change through both mitigation and adaptation strategies. The Energy Policy of Nepal supports the acceleration of renewable energy services and aims to increase access to renewable energy technologies through subsidy provisions.

Reviewing latest hydro news in local media, following strategic advantage can be drawn. Per *The Rising Nepal*, on February 2, 2025, the Independent Power Producers' Association, Nepal (IPPAN) signed a memorandum of understanding with ProClime to acquire the International Renewable Energy Certificate (I-REC). This agreement aims to make 2,000 MW of electricity eligible for carbon trading in the first phase, out of the 2,700 MW generated by the private sector in Nepal. The initiative is expected to enable Nepal's private sector to engage in carbon trading worth around NPR 1 billion annually.

4.7 Lenders' Perspective on Regional Hydropower Markets

According to the Ministry of Energy, Nepal plans to generate 28,500 MW of electricity by 2035. Government policy seems supportive but in implementation, there might be problems. Many hydropower companies have already completed projects and are in operation thus there exists viable cash flow.

Banks generally prioritize business sustainability over simply providing financing. With the future in mind, it would be beneficial for Nepal to diversify its energy focus and place more emphasis on developing other new energy sources alongside hydropower.

Risk Management in Hydropower Financing with International Stakeholders

Independent Power Producers (IPPs) may face challenges in securing international financing, as the documentation process can take 2-3 years, and fulfilling the complex Environmental, Social, and Governance (ESG) criteria can be difficult.

The major highlights presented in Figure 4.2 cover the risk landscape of Nepal's hydropower sector,

Key areas of concern include Climate Risk (4.63), Hydrology Risk (4.50), and Equity Risk (4.38), which dominate the risk profile. These underscore vulnerabilities to climate variability, water flow inconsistencies, and challenges in securing equity investments. Additionally, risks such as Insurance Risk (4.25) and Transmission Line Risk (4.25) emphasize financial exposure and infrastructure bottlenecks.

Moderate risks, including Interest Rate Risk (4.00), Engineering Workmanship Risk (3.88), and ESG Compliance Risk (3.88), suggest the need for robust project execution and alignment with environmental and social standards. However, lower risks like Threat of Substitute Risk (1.88) and Economic Cyclicality Risk (2.75) reflect limited competition from alternative energy sources and economic resilience.

The high scores for Climate Risk and Hydrology Risk are justified, as Nepal's hydropower heavily depends on monsoon-fed rivers, making it vulnerable to seasonal variations and climate change impacts. Addressing these risks necessitates investments in climate-resilient infrastructure and diversified energy sources, such as solar power.

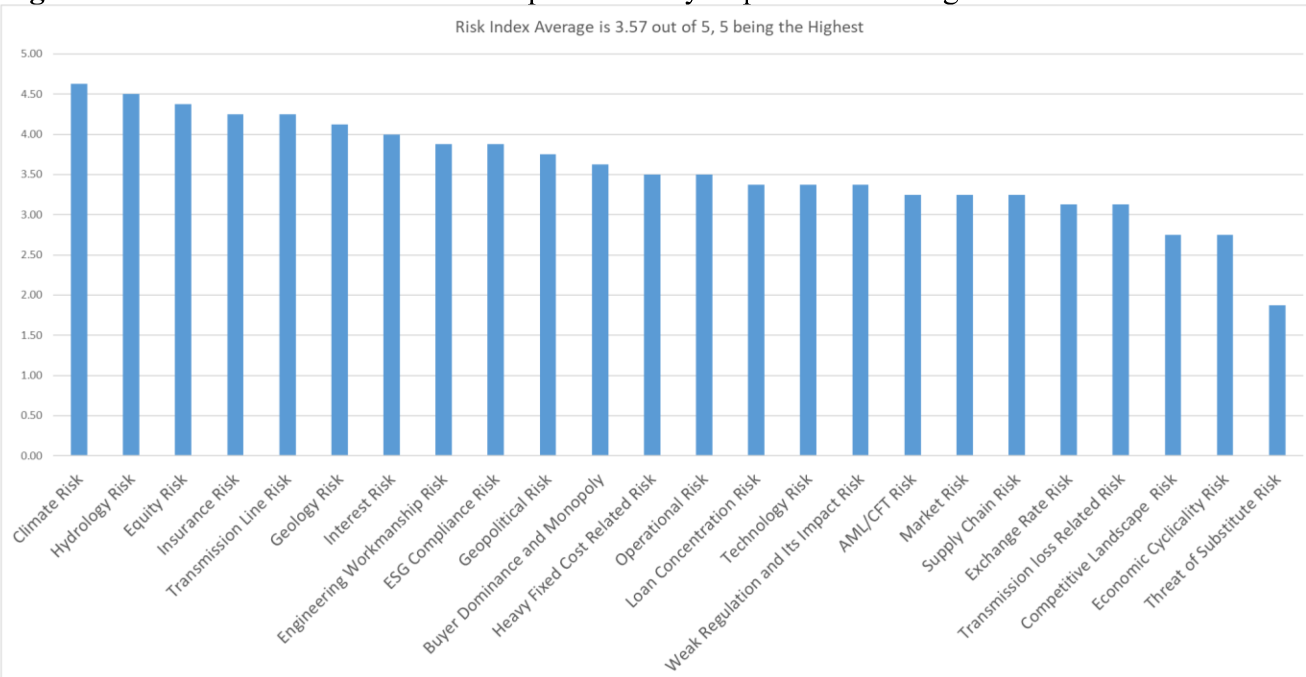
The moderately high Equity Risk highlights challenges in attracting private investment, indicating the need for more investor-friendly policies, such as improved PPAs and streamlined regulatory approvals. Similarly, Insurance Risk and Transmission Line Risk point to gaps in financial and infrastructure readiness, both critical for project sustainability.

Conversely, Competitive Landscape Risk (2.75) and Threat of Substitute Risk (1.88) are relatively low, suggesting limited competition in the hydropower sector. However, this may also indicate a lack of innovation and diversity in energy offerings, which could hinder market growth in the long term.

The average risk index of 3.57 confirms the sector's exposure to a blend of high and moderate risks. To mitigate these, strategic interventions, such as risk-based project prioritization, capacity building, and adoption of global best practices, are crucial. Furthermore, the lower scores for Technology Risk (3.38) and Market Risk (3.25) present opportunities for leveraging advanced technologies and fostering market expansion with minimal additional risk exposure.

In conclusion, while Nepal's hydropower sector faces significant risks, especially from environmental and infrastructural factors, targeted reforms and investments can substantially mitigate these challenges, ensuring long-term sustainability and growth.

Figure 5: Risk Index from Lenders' Perspective in Hydropower Financing



Source. Survey Data (2025)

To mitigate the risks identified in Nepal's hydropower sector, a multi-pronged strategy is essential. For climate and hydrology risks, investing in climate-resilient infrastructure, such and real-time hydrological monitoring systems, can enhance adaptability. Strengthening equity and financial risks requires investor-friendly policies, including improved Power Purchase Agreements (PPAs), tax incentives, and access to green financing. Addressing insurance and transmission line risks involves developing comprehensive risk-sharing mechanisms, such as public-private insurance schemes, and accelerating investments in transmission infrastructure to ensure efficient energy evacuation. For engineering and ESG compliance risks, adopting international quality standards, capacity-building programs for local contractors, and robust environmental and social safeguard frameworks are critical. Additionally, leveraging technology advancements, such as AI for predictive maintenance and block chain for transparent project financing, can reduce operational and market risks. Enhancing regulatory frameworks to address weak governance, loan concentration, and market monopolies will foster a competitive and transparent environment. Lastly, diversifying energy sources, such as integrating solar and wind power, will reduce dependence on hydropower and create a more balanced energy mix, minimizing overall risk exposure.

In the following section, a detailed illustration of each risk type and mitigation strategies are provided.

Detail Assessment of Risks

In the following section, various risks from the lender's perspectives are analyzed and mitigation approaches are discussed.

Macroeconomic Risk

Macroeconomic risks in Nepal, such as inflation volatility, currency fluctuations, and external economic shocks, pose significant challenges for hydropower projects. Inflation can drive up construction and operational costs, impacting profitability. Additionally, Nepal's dependence on imports for critical materials and equipment exposes the sector to foreign exchange rate risks, as any sharp depreciation of the local currency could increase project expenses. Global market fluctuations, like the rise in fuel prices or changes in international energy demand, may also affect the viability of hydropower projects, particularly in terms of revenue generation and financial stability.

Mitigation Approach

Banks should closely monitor macroeconomic conditions and maintain operational flexibility to effectively respond to adverse movements. In the context of Nepal's hydropower sector, factors such as exchange rate volatility, inflation, political instability, and regulatory changes can significantly impact project viability. By proactively tracking these macroeconomic indicators, banks can adjust their risk management strategies, such as revising interest rates, restructuring loan terms, or employing hedging instruments, to mitigate potential losses. This adaptive approach is crucial for ensuring sustainable financing and maintaining the financial viability of long-term, capital-intensive hydropower projects."

PPA-related Risk

The current structure of Power Purchase Agreements (PPAs) in Nepal poses risks for lenders due to their inflexibility and lack of key provisions, such as adaptable tariff models and risk-sharing mechanisms. These shortcomings undermine investor confidence by making long-term financial agreements difficult to secure. With market dynamics constantly shifting, the rigid nature of the PPAs can destabilize the financial viability of hydropower projects, creating significant uncertainties for lenders.

Mitigation Approach

The proposed mitigation strategies, such as flexible pricing, inflation adjustments and currency hedging, are certainly noteworthy. However, the strategy does not address potential implementation challenges- the limited financial capacity of the NEA and how to address it. The recommendations regarding environmental guidelines and IPOs seem not so significant to the concerns related to PPA. This needs further explanation to relate them. In fact, banks should assess whether PPA escalation adequately compensate for the inflationary impacts.

SOL (Single Obligor Limit)

The Single Obligor Limit (SOL) presents a notable risk in hydropower financing, particularly because these projects often require significant capital investment. This leads to a situation where banks may have substantial exposure to a single borrower or project. If the project faces issues such as delays, cost overruns, or operational challenges, the financial consequences can be severe. In such cases, the bank might breach regulatory limits on exposure to a single entity, resulting in penalties and potential damage to its reputation. Additionally, the long timelines typical of hydropower projects mean that unexpected risks, like natural disasters or policy shifts, could threaten the project's success. Regulatory provision by NRB guides on how much a single lender can lend to a borrower (Nepal Rastra Bank [NRB], 2025a).

Mitigation Approach

In Nepal, hydropower projects are generally financed through consortium lending, a common practice among banks to reduce exposure to large project risks. By pooling resources, multiple banks share both the financing responsibilities and the associated risks, thereby minimizing the burden on individual institutions. This approach not only enhances risk distribution but also increases the financing capacity for large-scale projects, ensures better monitoring and oversight, and builds collective confidence in the project's viability. Consortium lending thus serves as an effective mechanism to safeguard lenders while enabling the development of capital-intensive hydropower projects.

Loan Concentration Risk

As per the survey, the average risk in loan concentration Risk scores is 3.4 out of 5. A Loan Concentration Risk score of 3.4 out of 5 indicates a moderate level of risk stemming from over-reliance on a few large borrowers in the hydropower sector. This score suggests that while the project or portfolio may have a manageable degree of concentration, there are concerns regarding the potential vulnerability to a small number of borrowers or lenders.

Mitigation Approach

To mitigate loan concentration risk, lenders can broaden their borrower base by involving more financial institutions, development agencies, and private equity investors to distribute risk more evenly. Public-private partnerships can further reduce dependence on individual entities. Borrower-specific risks can be managed through detailed credit assessments and robust loan covenants. Exploring alternative financing options, such as equity financing or consortium loans, can also help diversify risk. Building strong, long-term relationships with investors across sectors, conducting regular stress tests, and adopting financial hedging or credit insurance measures can provide additional safeguards against defaults and market volatility.

Exchange Rate Risk

Financing demands for Nepal's growing number of large-scale build-own-operate-transfer (BOOT) hydropower projects have necessitated increased foreign investment. When funding such projects, foreign lenders and investors view a high level of foreign exchange (FoREX) risk (Kuikel et al., 2023). The public sector's mechanisms for allocating FoREX risks to project sponsors in Nepal and other developing nations have not been able to draw in a sizable amount of foreign investment. Alternative FoREX risk-allocation mechanisms are therefore required by the industry to maintain reasonable electricity tariffs for consumers, minimize downside risk to the public sector, and guarantee reasonable returns to project sponsors (Ehrlich, 2010). Since the Asian financial crisis of 1997, investors and lenders have recognized foreign exchange (FoREX) risk. as a major risk factor when investing in infrastructure projects in developing countries (Kuikel et al., 2023).

Mitigation Approach

The role of the public sector in Nepal in mitigating FoREX risk has remained contentious since its first engagement in the Khimti and Upper Bhotekoshi hydropower projects in the 1990s. To reduce sponsors' exposure to FoREX risk, the public sector set the tariffs for both projects in USD. Then, between 1996 and 2020, the Nepalese rupee (NPR) unluckily depreciated by about 100% against the US dollar. The Nepal Electricity Authority (NEA), which executed the power purchase agreements (PPA) for these projects, suffered heavy financial losses as a result. Until 2016, the public sector was hesitant to provide additional risk mitigation measures for FoREX due to the substantial downside risk and the ensuing public criticism. However, the Nepalese public sector has reexamined its role in FoREX risk management due to the severe power crisis that lasted from 2006 to 2016, which was made worse by low investments in the hydropower sector and the growing demand from domestic sponsors to arrange debt from foreign sources (Kuikel et al., 2023).

A new FoREX risk-allocation mechanism was introduced by the public sector in 2016 and is intended to be used for projects supported by Korean sponsors. However, it doesn't seem to be doing enough to get sponsors to invest in foreign currencies (World Bank Group, 2019). Nepal's hydropower projects often involve international investors, which exposes the sector to exchange rate risk. This arises when there are fluctuations in the value of the Nepali Rupee (NPR) compared to foreign currencies, particularly the US dollar or Indian Rupee. Lenders face the risk of devaluation or currency fluctuations affecting the repayment of loans, especially for projects with foreign currency-denominated loans or international investors. The exchange rate risk can increase the cost of repaying loans in foreign currency (Nepal Rastra Bank [NRB], 2025b).
It is concluded above that the 2016 FoREX risk-allocation mechanism has not sufficiently attracted foreign currency investments, but it does not explain why. Is it due to any structural limitations, lack of guarantees or just unattractive terms? It also does not emphasize enough the requirement for practical solutions like partial risk guarantees, hedging facilities or foreign currency-linked

tariffs. Tools like future contracts to buy or sell a currency at predetermined price and date, and even currency swaps, etc. are completely ignored. Mitigation recommendation does not offer specific policy steps on how the bank and developers should share the risks.

Equity Risk

Equity risk refers to the risk of loss associated with the value of equity investments in a project. In the case of hydropower projects, banks may face significant risks if the equity investors in the project do not fulfill their financial commitments or if the project's performance does not meet expectations. If the project faces financial difficulties or delays, lenders may have to bear a larger share of the risks. Hydropower projects often require substantial upfront investment, and if there are challenges with the equity portion of financing, it can make it difficult for lenders to recover their funds.[2]

As per the survey, an average equity risk score of 4.4 out of 5 highlights significant challenges for hydropower projects in Nepal, with most falling into the High-Risk category and some classified as Very High Risk. These levels indicate that many projects face serious issues due to insufficient equity investments or the intention of the promoters, leaving them vulnerable to delays, funding shortfalls, or even financial collapse. Projects in the Very High-Risk category are likely at a critical stage, requiring immediate attention and additional funding to remain viable.

Recently a growing trend has emerged in hydropower sector, where project promoters award major contractors (like main civil works, pre-construction activities including road construction, etc.) to related construction companies without following due process. This is done mainly to raise mandatory equity before the disbursement begins. So, when developers channel equity obligations through such circular payments to their own construction companies, it increases financial risk. It is risky not only for the lenders, but also for the minority equity shareholders.

Mitigation Approach

Developers should work on increasing the equity base of projects, as having a larger equity buffer enhances financial stability and lowers overall risk exposure. It is also important to identify potential funding gaps by evaluating whether current developers have the financial capacity to sustain their projects, or if there is a need to bring in external investors to bridge the gap. Furthermore, strengthening financial oversight mechanisms is crucial, with robust monitoring systems in place to track risk levels continuously and ensure timely corrective measures before challenges escalate.

A lending bank must scrutinize and control the contracts, project execution plan primarily through contractual and oversight mechanisms. A minimum equity contribution (often 50%) from developers before any loan disbursements is in practice to prevent misuse of debt but does not seem to be strictly implemented. The sources of cash raised and injected in project SPV account

[2] **Nepal Hydropower Investment Policy**. (n.d.). Retrieved January 10, 2025, from https://www.np.hydropower.com

as equity must be verified to ensure that they are non-project sources. Full disclosure of related party contracts must be made mandatory and strictly implemented. Physical verification and certification of completed works by the Engineer employed by the lending Bank must be done strictly to control early-stage misuse of project funds to meet equity requirements. A mechanism with these steps has become even more important lately as more large projects (> 200-300MW) are being promoted by IPPs. Such projects require substantial amounts of money to meet the equity commitments.

AML/CFT Risk

As per the survey, the average risk in AML/CFT Risk scores is 3.3 out of 5. The 3.3 risk score is a signal that hydropower projects need enhanced due diligence, improved financial monitoring, and stricter compliance measures. Immediate focus should be on improving transparency in financial reporting, implementing tighter controls on fund flow, and ensuring that projects are not vulnerable to illicit financial activities.

Mitigation Approach

In Nepal, banks can minimize AML/CFT risks in hydropower lending by strictly applying regulatory requirements issued by Nepal Rastra Bank (NRB) and the Financial Information Unit (FIU), while also adopting sector-specific measures. Comprehensive Know Your Customer (KYC) and enhanced due diligence are particularly important in verifying the ultimate beneficial ownership of Independent Power Producers (IPPs) and Special Purpose Vehicles (SPVs), as many projects involve joint ventures with foreign investors and politically exposed persons. Given that hydropower projects often rely on large-scale financing with cross-border equity and debt flows, banks must closely examine the legitimacy of foreign investments, monitor capital inflows and outflows, and ensure compliance with both domestic AML/CFT directives and FATF standards. Transaction monitoring is equally critical, with special attention to red flags such as unusual third-party payments, inflated procurement contracts, or early repayments from unrelated revenue sources. To strengthen transparency, banks can require independent audits of project accounts, enforce disclosure of financial flows, and encourage developers to adopt environmental, social, and governance (ESG) reporting practices. Furthermore, close collaboration with regulators, FIU-Nepal, and peer institutions, coupled with training programs to enhance bankers' understanding of hydropower-specific vulnerabilities, can significantly improve risk detection and mitigation. By combining regulatory compliance with proactive monitoring and sector-focused measures, Nepalese banks can effectively reduce AML/CFT risks in hydropower project financing.

Hydrology Risk

As per the survey, the average risk in Hydrology Risk scores is 4.5 out of 5. A score of 4.5 indicates that this is a critical area of concern that requires urgent and focused action to reduce the impact of hydrology-related risks.

Mitigation Approach

Introduce a new insurance-like mechanism, which compensates when discharge falls below critical level. General design practice in hydropower is to forecast river discharge based mainly on historical data of rivers and streams, which has become insufficient and unreliable due to climate change. As a part of technical due diligence by the Bank, developers must be asked to simulate multiple climate scenarios considering frequent and longer dry periods, decreasing snowfalls, disappearing glaciers, unpredictable rainfall intensity and variability (this could be costly and thus, the Bank should be willing to share some costs if it decides to invest in the project).

Although the NEA allows hydrological revision in PPA after 5 years of operation, it is a 'too little, too late' rescue option in the current scenario. Immediate action is required. The PPA restructuring is necessary to include provisions whereas the NEA (or the buyer) share some hydrological risk in force majeure situations (like extreme drought).

Water is used for irrigation, community needs. The competition is severe during dry periods. The water used by the community must be properly calculated and deducted in the planning and design of the project, so that the design discharge calculated is reliable).

Interest Rate Risk

Swanson and Sakhrani (2023) provide essential insights into minimizing interest rate risk in hydropower projects from a lender's perspective. Further, the study discusses three critical financing arrangements that enhance the bankability of the Nachtigal Hydropower Project. Firstly, the use of guarantees mitigates risks associated with cost overruns, schedule delays, offtake risk, and climate-related low flow, thereby protecting the project's value. Secondly, the implementation of financial options on locally sourced loans significantly reduces interest rate charges, directly addressing interest rate risk. Lastly, the inclusion of an interest rate swap further stabilizes financing costs, making private finance more attractive. Collectively, these strategies not only lower interest rate exposure but also promote long-term sustainability benefits, making them vital for lenders in hydropower financing.

As per the survey, the average risk in Interest Rate Risk scores is 4 out of 5. A Risk Score of 4 out of 5 for Interest Rate Risk indicates a high level of risk for the hydropower projects, primarily due to the potential impact of fluctuating interest rates on loan repayment and overall financial stability.

Mitigation Approach

Interest rate risk in the hydropower sector is a serious concern, which dramatically may increase the cost of the project. Conduct rigorous interest rate sensitivity test; attract and redirect to HPPs in Nepal facilities like low interest loans from multilateral agencies like WB, ADB, climate funds.

Economic Cyclicality Risk

As per the survey, the average risk in Economic Cyclicality Risk scores is 2.75 out of 5. An Economic Cyclicality Risk score of 2.75 out of 5 indicates a moderate level of risk related to economic fluctuations. This score suggests that the hydropower projects are somewhat exposed to the effects of economic cycles, such as recessions, booms, or other economic shifts, but the risk is not overwhelming.

Mitigation Approach

Economic Cyclicality Risk can be minimized if operation is monitored properly and lean period revenue is optimized. The operation phase is where the revenue is generated and critical for the loan repayment. However, it is often observed that overtly scrutinizing lenders during the construction period becomes relaxed once the project is commissioned. So, the performance phase, which actually generates the revenue is ignored. Lenders seem uninterested on facts like how qualified are the employees in the plant, do they have enough experience to tackle various scenarios of operation, how the plant efficiency is maintained, how frequently the NEA imposes dispatch instructions and whether they are justified and as per the PPA; whether the O&M budget is strictly utilized or not; lender should also ask for read-only access to performance dashboard of the plant for occasional monitoring; etc. All the above can be effectively done by appointing a third-party operations auditor.

In addition, promoting cross-border electricity trade with neighboring countries such as India and Bangladesh can further reduce economic cyclicality risk. Expanding access to regional electricity markets enables hydropower projects to diversify their revenue sources, reduce dependence on domestic electricity demand, and create opportunities to export surplus electricity during periods of excess generation. Such market diversification can help stabilize revenues during economic downturns and seasonal fluctuations, thereby strengthening the financial sustainability of hydropower projects. Government support in negotiating and implementing cross-border power trade agreements is therefore an important long-term risk mitigation strategy.

Climate Change Risk

Meng et al. (2020) offer valuable insights into managing climate change risks in hydropower financing. Their analysis of global warming scenarios (1.5°C vs. 2°C) shows that hydropower production is more favorable under a 1.5°C scenario, with a 40% higher production-to-demand ratio. For lenders, this highlights the importance of factoring in climate-related risks when assessing hydropower projects. By incorporating climate projections into financial evaluations, lenders can better anticipate production fluctuations and reduce exposure to economic risks. The study also stresses the need for a balance between hydropower generation and environmental concerns to ensure long-term project sustainability and financial returns.

Climate change can disrupt hydropower by altering precipitation patterns, reducing river water levels, and increasing the risk of Glacial Lake Outburst Floods (GLOFs) that can damage infrastructure. Prolonged dry seasons reduce water storage and generation capacity, while more frequent floods can threaten plant safety and cause operational issues. These changes, particularly in the Himalayan region, pose significant risks to hydropower projects at all stages, from planning to operation, potentially causing severe damage across the country (P.C. et al., 2021).

In the Himalayan region, glaciers and ice cover around 17% of the area, with 35,000 km^2 of glaciers and 3,700 km^3 of ice reserves. This region is home to nine major rivers that provide water to over 1.3 billion people. Warming in Nepal and Tibet, ranging from 0.2–0.6°C per decade, has accelerated glacier melt, increasing the frequency of risks like floods, avalanches, and GLOFs. These events have caused significant damage to hydropower projects, including the destruction of the 36 MW UBHP in 2016 and the Namche HEP in 1985, highlighting the growing threat to Nepal's hydropower infrastructure (Bhatta, 2017).

As stated by KIIs, Nepal's hydropower projects are increasingly exposed to climate-induced hazards such as glacial lake outburst floods (GLOFs), unpredictable monsoon rains, and associated landslides. These risks compromise infrastructure and delay project timelines

As per the survey, the average risk in Climate Change Risk scores is 4.6 out of 5. A Climate Change Risk score of 4.6 out of 5 indicates a very high level of risk associated with the potential impacts of climate change on hydropower generation and infrastructure. This score suggests that the projects are significantly exposed to climate-related disruptions, which could have severe long-term implications for their performance and sustainability.

Mitigation Approach

Climate Resilience Strategies for Hydropower Development

Integrating climate resilience into hydropower planning is essential to adapt to climate change and ensure long-term sustainability. Adaptation strategies include reinforcing dams and flood defenses while upgrading infrastructure to withstand extreme weather events. Enhanced forecasting and real-time monitoring systems enable accurate water availability predictions and rapid responses to extreme weather conditions. Collaboration with stakeholders and local communities is vital for sustainable water management, while adopting environmentally sustainable practices aligns hydropower development with climate goals and societal expectations.

Climate Change Risk arises in both over-flow and under-flow situations. Sensitivity analysis of energy output must be conducted under different climate scenario, assess how many consecutive years of flow below the design discharge can still be fine for debt service, assess whether the basin has glaciers: if yes, then proper technical investigation must be done and the extreme scenario must be incorporated in the design, incorporate technological advancement in design to operate in wide range of discharge and extreme weather conditions, include provisions for contingency plan to tackle climate-induced stoppages.

Technological Risk

Liu and Luo (2023) discuss the integration of digital intelligent construction technologies in hydropower engineering, which is crucial for minimizing technology risks. The article highlights the use of Building Information Modeling (BIM) for intelligent design, which enhances collaboration and management, thereby improving design quality and efficiency. Furthermore, it emphasizes the role of automation and robotics in construction processes, which reduces human errors and associated safety risks. The implementation of Internet of Things (IoT) and big data technologies for real-time monitoring ensures timely problem detection and enhances project stability. Collectively, these advancements contribute to a robust management system that mitigates technology risks in hydropower projects (Liu & Luo, 2023).

As per the survey, the average risk in Technological Risk scores is 3.375 out of 5. The technological Risk score of 3.375 out of 5 indicates moderate risk from the potential impact of outdated or inefficient technology on the operations of hydropower projects. This suggests that while technological issues are not immediately critical, there is a noticeable concern regarding the performance and longevity of key equipment such as hydro-mechanical and electromechanical systems.

Mitigation Approach

Upgrading and modernizing hydropower infrastructure is critical for enhancing efficiency, reliability, and sustainability. Prioritizing the replacement of outdated equipment with modern, efficient alternatives, along with implementing smart grid technologies and digital monitoring systems, can significantly reduce maintenance costs and improve real-time performance tracking. Proactive maintenance, including predictive analytics using IoT devices and frequent inspections, helps minimize unplanned downtime and extend the life of critical components. Investments in research and development, alongside partnerships with technology providers, ensure the adoption of cutting-edge solutions like high-efficiency turbines and advanced control systems. Additionally, comprehensive staff training programs and retaining specialized technical expertise are essential for seamless adoption of new technologies and maintaining long-term operational excellence.

Operational Risk

Li et al. (2020) discusses a comprehensive approach to assessing and mitigating operational risks in hydroelectric generation systems. Utilizing a fuzzy-entropy comprehensive evaluation method, the study estimates the dynamic safety level of the system through probabilistic analysis. It identifies the influence of various assessment indices on the operational risks associated with hydroelectric generation. Furthermore, the authors propose specific risk mitigation and maintenance strategies aimed at minimizing operational and maintenance losses in hydropower stations. This methodology is validated through practical implementation in an existing hydropower station, particularly during the start-up transient process, thereby enhancing risk warning capabilities and informing maintenance strategies. This reference is crucial for understanding effective risk management practices in hydropower operations, making it a valuable addition to a literature review focused on minimizing operational risks in this sector.

As per the survey, the average risk in Operational Risk scores is 3.5 out of 5. An Operational Risk score of 3.5 out of 5 indicates a moderate to high risk from potential outages, breakdowns, and mismanagement within the hydropower projects. This score suggests that while operational risks are a significant concern, they are not yet at a critical level but require attention to mitigate possible impacts on energy production and financial performance.

Mitigation Approach

From a lender's perspective, ensuring the reliability and efficiency of hydropower operations is critical to safeguarding investments and mitigating risks. Proactive maintenance schedules, supported by predictive technologies and sufficient spare parts inventory, minimize the risk of unexpected failures and costly downtime. Comprehensive staff training, emergency response plans, and adherence to robust safety protocols reduce operational and financial risks associated with human error or disruptions. Real-time monitoring systems and automation enhance performance visibility, optimize resource utilization, and improve operational resilience. Regular efficiency and environmental compliance audits help maintain regulatory standards, avoiding reputational and legal risks. Furthermore, contingency measures, including risk funds and backup systems, ensure continuity in operations, reinforcing the project's ability to withstand unforeseen challenges and deliver consistent returns, strengthening lender confidence in the project's long-term viability. Also, the appointment of an operations auditor is vital to ensure that the plant is properly operated and maintained with sufficient spare parts and an emergency plan.

Geological Risk

As per the survey, the average risk in Geological Risk scores is 4.1 out of 5. A Geology Risk score of 4.1 out of 5 indicates a high level of risk related to geological conditions that could impact the stability and safety of the hydropower project. This score suggests that geological factors such as soil composition, rock stability, seismic activity, and other natural conditions could significantly affect the project's viability and long-term success.

(Geological risks can be further discussed under 1) geological uncertainty for underground and surface structures 2) fragile mountains - for siltation and landslides 3) effect of earthquake.

Mitigation

Parsa and Salehi (2016) discusses the spatio-temporal analysis of hydropower projects in terrestrial environmentally sensitive areas in Nepal, which is crucial for minimizing geological risks associated with hydropower development. The study highlights that hydropower projects often interact with biodiverse areas and protected regions, which can lead to significant environmental impacts, including geological instability and habitat disruption.

To minimize geological risks, lenders should prioritize thorough due diligence, including detailed geological surveys before project initiation. Requiring seismic-resilient designs and erosion control measures will help protect infrastructure from earthquakes, landslides, and erosion. Adaptive designs, like flexible foundations and robust dams, enhance resilience to geological and climatic challenges. Lenders should also establish contingency funds and emergency response protocols for unforeseen issues. Ongoing collaboration with geotechnical experts ensures timely updates to risk management strategies, safeguarding both investment returns and long-term project stability.

Developers often want to economize by doing only the minimum geological studies [e.g.: limited core drilling, geophysical and geotechnical testing, etc. However, in hilly areas, most tunnel alignments are inaccessible due to high altitudes. In addition, the capacity of available drilling equipment in the country is limited. As a result, geologists mostly rely on their experience to understand tunnel geology. Obviously, all possible geological problems or problematic areas that might appear during construction cannot be detected with this approach.

However, areas like the powerhouse, headworks and dam sites are easily accessible and must be investigated thoroughly. Lenders must insist developers provide full details of geological studies conducted in those areas for a DD by an independent expert. An independent DD must clearly indicate any geological uncertainties and explain how these could affect project costs and timelines.

One more area, which is often ignored, is the geology of access roads! Hydropower sites, due to their high altitudes and inaccessibility, require long access roads through difficult and unstable terrain. Construction in such locations often triggers large landslides. This becomes a potential cause of serious delays in the construction schedule. Therefore, lenders should ask developers to provide detailed geological studies of the road alignment, a clear road maintenance plan and enough budget allocated for it).

Geopolitical Risk

In the context of our location between two large and emerging global powers, geopolitical risks refer to political and international factors that can disrupt or delay hydropower projects and potentially cause financial and operational losses. As per the survey, the average risk in Geopolitical Risk scores is 3.75 out of 5. Geopolitical Risk score of 3.75 out of 5 indicates a moderate to high-risk level from political instability and cross-border tensions that could affect the hydropower project.

Mitigation Approach

In simple terms, banks manage geopolitical risk by securing reliable contracts, involving trusted international and local partners, and setting up financial protections to make sure loans are repaid even in uncertain political situations.

The uncertainty of cross-border transmission and trade is by far the most important. Nepal is heavily dependent on India for the export of energy to both India and Bangladesh (those two countries that we have already been doing business within this sector). So, any change in India's import policies due to bilateral issues can seriously disrupt the trade and NEA's financial sustainability.

Similarly, diplomatic disputes create numerous problems. If history is any indication, even seeming minor disputes with India becomes potentially harmful because it might disrupt ongoing cross-border cooperation on transmission infrastructure, seriously affect import of important construction materials, hydro equipment, fuel, explosives; and also affects the contracts with third country partners and contractors.

Securing some kind of insurance from institutions like the World Bank to cover such risks could be helpful. However, given their international leverages, engagement of multilateral institutions, like ADB, WB, for project funding will be helpful not only financially but also in terms of necessary diplomatic support and reducing political interference).

Market Risk

As per the survey, the average risk in Market Risk scores is 3.25 out of 5. A Market Risk score of 3.25 out of 5 indicates a moderate level of risk related to the uncertainty about whether there will be a sufficient market for the electricity generated by the hydropower project. While the project is likely to have some level of market demand, there are concerns about its ability to secure stable long-term contracts (securing long-term PPA is not an issue, but whether the NEA will be able to keep buying is the issue!), achieve desired sales, or respond to market fluctuations.

Mitigation Approach

Lenders can mitigate market and pricing risks by promoting diversified power purchase agreements (PPAs) with multiple long-term buyers from different sectors (it has not been practiced yet and currently there are no buyers other than the NEA. However, the power-trade landscape is changing with the planned reform by the government). This reduces dependence on a single off-taker and allows flexibility to adjust to fluctuating energy prices. Demand forecasting and economic scenario planning help predict market trends and future electricity needs. Lenders should focus on grid connectivity and infrastructure investment, supported by smart grid solutions. Strategic partnerships, cost reduction strategies, and technological innovations like energy storage can further stabilize demand. Financial hedging or market risk insurance can protect against volatility, ensuring long-term financial resilience.

Buyer Dominance and Monopoly Risk

Buyer dominance and monopoly risk in hydropower means that since Nepal Electricity Authority (NEA) is almost the only buyer of electricity in Nepal, it holds strong bargaining power over developers and lenders. This creates a risk that NEA could delay signing PPAs, dictate unfavorable terms, delay payments, or refuse to purchase power during surplus seasons.

As per the survey, the average risk in Buyer dominance and monopoly Risk scores is 3.625 out of 5. A Buyer Dominance and Monopoly Risk score of 3.625 out of 5 indicates a moderate to high level of risk due to the influence of dominant buyers in the market, who may be able to negotiate unfavorable terms for the hydropower project. This score suggests that the project may face significant challenges if there is a lack of market competition or if few buyers control the purchasing power, potentially leading to terms that may not be favorable for the seller.

Mitigation

From a lender's perspective, direct mitigation of monopoly risk is often limited. However, by incorporating covenants that restrict unilateral control, banks can gain certain oversight and protection, helping shield themselves from the adverse effects associated with monopolistic influence.

Supply Chain Risk

Supply chain risk in the context of the hydropower sector refers to the potential disruptions, delays or increased costs due to problems associated with the sourcing, transportation and delivery of materials, equipment and services required for project construction and operation. As per the survey, the average risk in Supply Chain Risk scores is 3.25 out of 5. A Supply Chain Risk score of 3.25 out of 5 suggests a moderate level of risk arising from the dependency on critical suppliers for the hydropower project. This score indicates that while the project may not be immediately exposed to severe disruptions, there are potential vulnerabilities in the supply chain that could affect operations if key suppliers experience issues.

Mitigation

The hydropower supply chain can also be disrupted by exchange rate fluctuations. It is crucial because a large portion of equipment and materials is imported. Sudden currency changes can make purchases more expensive and thus put more pressure on the project budget. Due to Nepal's heavy reliance on transit through India, diplomatic issues with it or changes in customs policies can delay or even block the movement of goods (It has happened many times in the past).

Often, through its annual budgets, the government introduces regulatory changes affecting import duties, taxes or compliance regulations. This will cause uncertainty and unexpected increases in costs for ongoing projects (it has also happened in the past).

THIS IS VERY IMPORTANT and THE MAJOR CAUSE OF DELAY IN CONSTRUCTION: We have witnessed that very often contractors face serious cash flow issues or sometimes even go bankrupt. In such situations, delayed payments to suppliers and workers become their only survival strategy. As a consequence, suppliers retaliate by stopping materials delivery and thereby causing massive disruptions in construction. It has to be monitored closely. The client or developer may have to directly manage or control the contractor's cash flow to ensure timely payments to critical suppliers. To help reduce such delays, lenders should come forward by adopting less bureaucratic and quicker disbursement procedures to make cash available to the clients for payments to contractor's suppliers. This will help maintain the flow of funds and materials on site.

Competitive Landscape Risk

As per the survey, the average risk in Competitive Landscape Risk scores is 2.75 out of 5. A Competitive Landscape Risk score of 2.75 out of 5 indicates a moderate level of risk related to competition in the hydropower sector. While competition exists and could pose challenges, the risk is not extreme. This score suggests that while there may be some competitive pressures, they are not yet severe enough to threaten the project's viability significantly, though they should be monitored and addressed strategically.

Mitigation

To stay competitive, lenders should advise hydropower projects to regularly monitor market trends by tracking competitors, technological advancements, and regulatory changes, while benchmarking the project's performance against competitors. Focusing on differentiation through investment in advanced technology and offering value-added services can help the project stand out. Geographic diversification and exploring alternative revenue streams can reduce reliance on a single market. Strengthening relationships with key stakeholders, including governments and utilities, will provide strategic advantages and secure long-term contracts. Leveraging economies of scale by optimizing costs and utilizing bulk procurement can improve cost efficiency. Finally, adopting flexible pricing models will allow the project to stay competitive in fluctuating markets.

Heavy Fixed Cost Risk

Amougou et al. (2022) discuss the fixed costs associated with run-of-river hydropower plants, highlighting that these costs include civil works and electromechanical equipment. This distinction is critical for understanding the financial structure of hydropower projects, because fixed costs have a significant impact on the overall economic viability and risk assessment of such investments. The study also emphasizes the significance of optimizing design to reduce the levelized cost of energy (LCOE), which is heavily influenced by these fixed costs. By providing a cost-effective design methodology, the reference addresses the inherent risks associated with the unpredictability of power generation in run-of-river systems, allowing for more informed decision-making in hydropower project development.

Fixed cost risk refers to the inability of a hydropower project to adjust its fixed operating and capital costs in response to changes in market conditions. Hydropower plants require significant fixed costs, such as maintenance, staff, and infrastructure, which do not fluctuate with output. For lenders, the concern is that even if the hydropower plant is not generating revenue due to factors such as low water levels or seasonal variations, it will still have to cover these fixed costs. This could lead to cash flow problems and an inability to service debt.

As per the survey, the average risk in Heavy Fixed Cost Risk scores is 3.5 out of 5. A Heavy Fixed Cost Risk score of 3.5 out of 5 suggests a moderate to high level of risk related to the impact of high fixed costs on the profitability of the hydropower project. This score indicates that while the project is exposed to significant fixed cost pressures, it is not necessarily at imminent risk of financial distress. However, these fixed costs should be managed carefully to ensure that they do not negatively impact profitability, particularly during periods of low revenue or operational disruptions.

Mitigation

From a banker's perspective, hydropower projects should focus on revenue diversification to stabilize income, such as exploring alternative streams like grid balancing services or integrating hybrid renewable solutions like solar and wind. Operational efficiency can be enhanced by controlling costs, optimizing maintenance, and outsourcing non-essential functions. Flexible financing structures, such as debt refinancing and alternative financing options like green bonds, can reduce financial pressure. Dynamic pricing strategies and securing power purchase agreements (PPAs) will help stabilize revenue. Risk hedging through financial instruments and insurance coverage ensures financial security, while modular expansion and contingency planning can maintain stability during periods of low production. Also, Optimization of expenses can effectively be achieved by appointing a qualified Operations Auditor.

Weak Regulation-Related Risk

Urban et al. (2015) provide valuable insights into the relationship between hydropower projects and social sustainability, particularly focusing on Chinese-funded dams in Ghana and Cambodia. This study is crucial for lenders as it highlights the empirical gaps in understanding the social impacts of hydropower projects, which can lead to weak regulatory frameworks and increased investment risks. By utilizing an environmental justice perspective, the authors emphasize the need for improved social sustainability frameworks and policies that align with international standards. The article suggests that lenders should advocate for the implementation of social benchmarking and enhanced social policies to mitigate risks associated with weak regulations. Furthermore, it underscores the importance of established guidelines from organizations such as the International Hydropower Association (IHA) and the International Finance Corporation (IFC), which provide frameworks for assessing the social and environmental performance of hydropower projects. By adhering to these guidelines, lenders can better navigate the complexities of financing hydropower initiatives, ensuring compliance with international standards and minimizing potential risks associated with social and environmental impacts. In summary, this reference serves as a critical resource for lenders seeking to understand and mitigate the risks associated with weak regulation in hydropower projects by advocating for enhanced social sustainability practices and adherence to established international guidelines.

As per the survey, the average risk in Weak Regulation Risk scores is 3.4 out of 5. A Weak Regulation Risk score of 3.375 out of 5 suggests moderate risk due to ineffective policy enforcement and regulatory uncertainty in the hydropower sector. This score indicates that while regulatory issues are a concern, they are not the most critical risk facing the project at this time. However, regulatory weaknesses could still have significant implications, especially in the long term, affecting project operations, profitability, and compliance costs.

Mitigation

From a banker's perspective, engaging proactively with regulators is key to shaping stable frameworks and staying ahead of potential regulatory shifts. Regular monitoring of policy changes ensures that the project remains compliant. Legal and compliance strategies, such as establishing a legal team and conducting internal audits, reduce the risk of non-compliance and reputational damage. A robust risk management framework, including contingency planning and hedging against regulatory risks, can protect the project from unforeseen costs. Strengthening stakeholder relationships through community engagement and transparency helps mitigate risks, while leveraging external partnerships with NGOs and industry peers ensures environmental and social responsibility, particularly in weak regulatory environments.

(It is important for the lenders to examine how carefully, and honestly environmental studies have been carried out; how often public consultations were held during the feasibility and construction phases to make the local communities well-informed about the benefit and challenges of the project. This will help avoid public disruptions during the construction and operations. The support of local government is equally vital. Projects get their support if local compliance is met. Lenders are recommended to meet local government authorities before making find decisions on financing. Lenders must thoroughly review all compliance related legal documents to ensure all environmental and regulatory requirements are met).

Dr. Ram Prasad Dhital, chairperson of the Electricity Regulation Commission (ERC) explains that Nepal's electricity sector is primarily regulated by the Electricity Act of 2049, which shifted electricity from being a public good (under the 2041 Act) to a licensed business. With the introduction of the Hydropower Act, electricity became a tradable commodity, with market entry based on a first-come, first-served principle. Initially, the market was a monopoly, but later evolved into a monopsony, where the government was the sole buyer of electricity. The Tariff Fixation Committee was given the responsibility to set consumer tariffs. The Nepal Electricity Authority (NEA) initially controlled the market, and the ERC was created to move the market toward greater competition. Despite these efforts, the sector faces ongoing challenges, including:

(1) Issues in institutional management,
2) Promoters exiting projects by selling shares (IPOs) once they are completed,
3) Lack of uniformity in the market,
4) A regulator with limited authority, and
5) Environmental concerns. The ERC's main role is to set cost benchmarks and assess whether the NEA's reported costs or the tariffs to the consumers are accurate.

Madhun Sudhan Adhikari, member of the ERC notes that there are few investment opportunities in Nepal, with hydropower being the key sector attracting growing attention. To improve the situation, Adhikari suggests:

1) Assessing the expectations of equity holders, who face high risks in financing projects,
2) Addressing regulatory issues, such as the lack of proper guidelines for IPO issuance and the weak regulatory power ("a snake without teeth"),
3) Investigating whether auditors focus solely on the financial aspects of hydropower projects,
4) Examining how promoters fund large rights issuances in the market.

Adhikari emphasizes that the ERC should concentrate on: establishing a cost-check mechanism and setting cost benchmarks, conducting thorough due diligence on the money invested by promoters, and resolving issues related to the NEA.

Transmission Line Risk

Transmission line risk in hydropower means the risk that electricity generated cannot be delivered to the buyer because transmission lines are not built on time, are insufficient in capacity, or face technical/political delays. In Nepal, this is a common problem since hydropower projects often finish construction before transmission lines are ready, causing power to go to waste and developers to lose revenue, which then affects their ability to repay bank loans.

A Transmission Line Risk Score of **4.25/5** shows that banks face a very high risk of power not reaching the market, which could block revenue and loan repayment. This pushes lenders to demand stronger safeguards, closer monitoring, and possibly higher financing costs before supporting the project.

Mitigation

Banks minimize this risk by checking whether transmission line projects are planned and financed alongside the hydropower project, and by pressing for coordination between developers, NEA, and the government. They often require project timelines to be aligned with transmission infrastructure or include contractual provisions that make the government or buyer responsible for delays. Some lenders also prefer projects close to existing transmission corridors or push for joint financing of both generation and transmission. In simple terms, banks manage transmission line risk by ensuring power plants are connected to the grid on time, holding responsible parties accountable, and choosing projects with secure evacuation routes for electricity. Also, transmission line risk arises due to delay by NEA to get substations ready, sufficient transmission line costs are not included in the project cost, the developers start TL feasibility study and environmental clearance process too late, late commencement of construction of TL, social and environmental factors for transmission lines are ignored. This needs to be scrutinized during the DD)

Insurance Risk

As per the survey, the average risk in Insurance Risk scores is 4.25 out of 5. An Insurance Risk score of 4.25 out of 5 indicates a high risk associated with the reluctance of insurance companies to provide adequate coverage for hydropower projects. This risk primarily arises from climate-related risks and the challenges of insuring large infrastructure projects in an uncertain or rapidly changing environment. The reluctance of insurers to cover hydropower projects could significantly affect the financial stability and risk management of the project.

Mitigation Approach

Selecting insurance and reinsurance partners with a good reputation and credentials is the most imp way to mitigate this risk. The developers should be advised to explore better options. Finding a reinsurer for hydropower projects has become increasingly difficult, leading to a sharp rise in insurance premiums. The developers alone cannot take the entire insurance burden, otherwise it can make the project financially not feasible. Such a model unfairly penalizes the developers without any fault. It is already too late to think about devising risk-sharing insurance mechanisms acceptable to the lenders, developers and government and flexible insurance structures to keep hydropower projects financially viable).

Besides the risks mentioned above from the lender’s perspective, looking holistically, there are other risks in hydropower in the context of Nepal, which are explained below:

Cross-border Transmission Risk

Since export of energy to India (and lately Bangladesh) has been constantly increasing and the transmission capacity is limited, it creates several risks for Nepal if the number of cross border TLs are not increased from several places along the border. Also, since there is a global trend of using energy as a potential weapon to settle geopolitical conflicts (like in Ukraine and Europe), the long-term stability of bilateral and trilateral agreements, pricing structure remains doubtful.

Local Cooperation to Build and Operate: Community opposition often instigated and fueled by political actors; land rights disputes and displacement and settlement are major risks in large hydropower projects.

Construction Delay and Cost Overrun Risk: Hydropower projects are prone to poor cost forecasting and construction delays.

CHAPTER VI: COST PER MW

Based on the key informant's interview responses cost per MW for Run-of-the-River (ROR) type projects has increased from NRs. 16 crores per MW, NRs. 20 crores per MW currently, as shown in Table 2.

Table 2: Cost per MW ROR

	10 years ago,	5 years ago,	Current
Cost per MW ROR (Crores, NRS)	16	18	20

According to the key informant interviews (KIIs) with Independent Power Producers (IPPs), the cost per MW of Run-of-River (ROR) hydropower projects has increased from NPR 16 crore to NPR 20 crore over the past decade. This increase raises important considerations for lenders when assessing project financing and associated risks. This upward trend means lenders may need to adjust their financial assessments to account for the higher costs involved in financing such projects.

Lenders should be cautious and take these factors into account when evaluating potential projects, ensuring that financial models reflect the increased costs and potentially lower energy production. Based on the secondary source of data from thirty hydropower, this study estimate the cost per MW:

Table 3: Cost per MW

Hydropower	Amount	KWH	MG	Cost per megawatt
87 MW Seti river-3	17890000000	87000	87	220,850,000.00
Upper Sankhuwa Khola Hydropower Project (USKHP)	7880000000	40000	40	197,000,000.00
Daraundi river in Gorkha municipality-13	2200000000	9840	9.84	223,577,235.77
Upper Tamakoshi	89420000000	456000	456	196,096,491.23
Sanjeen Upper	NA	14800	14.8	149,900,000.00
Arun Valley Company	NA	9940	9.94	221,000,000.00
Sanima Mai Hydropower	4375000000	29000	29	150,862,068.97
United Modi	1770000000	10500	10.5	169,000,000.00
Super Dordi Hydropower Project Kha (SDHPK)	10390000000	54000	54	192,410,000.00
Mandu Hydropower Ltd	3990000000	22000	22	181,000,000.00
Arun 3 Hydropower	144000000000	900000	900	160,000,000.00
Nyadi Hydropower	6600000000	30000	30	220,000,000.00

Dordi Khola Jal Bidyut Company Ltd.	NA	12000	12	224,500,000.00
Balephi Hydropower Ltd	NA	36000	36	169,000,000.00
Liberty Energy Company (Upper Dordi "A" HEP)	NA	25000	25	185,000,000.00
Pan Himalaya Energy Ltd.	15604000000	77000	77	203,000,000.00
Nilgiri Khola Hydropower Companay-N1	6400000000	38000	38	168,000,000.00
Maya Khola Hydroelectric Project	NA	14900	14.9	201,000,000.00
Kalanga Hydro Pvt. Ltd.	4355000000	15330	15.33	284,000,000.00
Dynamic hydropower energy private ltd	7000000000	42000	42	167,000,000.00
Swet-Ganga Hydropower and Construction Ltd.	6372000000	28100	28.1	226,761,565.84
Upper Solu Electric Company Ltd	5000000000	23500	23.5	213,000,000.00
Chhyangdi Hydropower Ltd.	443000000	6000	6	197,000,000.00
Shiva Shree Hydropower ltd	4033000000	22200	22.2	136,000,000.00
Puwa Khola-1 Hydropower Pvt. Ltd.	3675000000	21000	21	175,000,000.00
Happy Energy Private Limited	8234000000	40000	40	206,000,000.00
Expert Hydro Investment Private Limited	9600000000	44520	44.52	215,630,000.00
Samriddhi Energy Ltd.	41609000000	216000	216	192,630,000.00
DARAMKHOLA HYDRO ENERGY LIMITED	2150000000	9600	9.6	224,000,000.00
Average		0		195,490,253.86

6.1 Holistic Interpretation of the Dataset

6.1.1 Cost Efficiency of Hydropower Projects

- On average, developing 1 MW of hydropower in Nepal costs about NPR 195 million.
- However, there is a large variation: the cost per MW ranges from around NPR 136 million (very efficient) to NPR 284 million (very expensive).
- This shows that hydropower development is highly context-dependent, shaped by scale, geography, and construction challenges.

6.1.2 Economies of Scale

- Large-scale projects (hundreds of MW capacity) generally have lower costs per MW.
    - Bigger projects spread fixed costs (e.g., transmission lines, tunnels, dams) over more output.
- Smaller projects (below 50 MW) tend to have higher unit costs, as they cannot fully exploit economies of scale.

- This suggests that from an investment standpoint, larger projects are more cost-effective per unit of electricity produced.

6.1.3 Benchmark for Future Projects

- With an average cost of ~NPR 195 million/MW, this figure can serve as a benchmark for evaluating new hydropower proposals.
- Projects with unit costs much higher than the average may face financial viability challenges unless supported by subsidies, concessional loans, or special incentives.
- Conversely, projects that can deliver significantly lower costs per MW demonstrate strong investment attractiveness.

Overall Takeaway:
Nepal’s hydropower sector shows strong economies of scale, with larger projects delivering cheaper electricity generation costs per MW. However, the variation in unit costs reveals the influence of local geography, project management capacity, and financing structure. For future planning, an average benchmark of NPR 180–200 million/MW can guide both investors and policymakers, while also stressing the need to control risks that push some projects far above this level.

CHAPTER VII: BANKING PROSPECTS AND CHALLENGES

The hydropower sector in Nepal faces multifaceted challenges, particularly from the perspectives of the Electricity Regulatory Commission (ERC), Independent Power Producers (IPPs), and lenders. The ERC struggles with issues related to market transformation, regulatory authority, and cost benchmarking. Similarly, IPPs grapple with structural inefficiencies in Power Purchase Agreements (PPAs), licensing delays, bureaucratic hurdles and the absence of forward-looking policies. Lenders are confronted with risks stemming from inadequate data, flawed due diligence processes that constrain identification of technical and financial issues, and gaps in environmental and social governance frameworks. These factors may expose lenders to reputational risks and potential non-performing assets.

7.1 Banking and Financial Dynamics in Hydropower Development

Banks have moved away from funding smaller projects, and personal guarantee requirements have become an issue for securing funding. As per FGDs with IPPS “In developed countries, interest rates tend to be lower during the construction phase and higher during the operational phase of projects. However, in Nepal, it would be more advantageous for power producers if banks charged lower interest rates during the construction period”. Additionally, there are no hedging facilities available in Nepal to manage financial risks. For large-scale projects, foreign banks are needed, as Nepali banks are unable to provide sufficient funding for such large projects.

7.2 Banking Challenges in Hydropower Financing Amid Export Aspirations

As per FGDs with Bankers, there is no reliable and constantly updated comprehensive database for hydropower projects, which creates a significant gap between feasibility studies and the actual reality of project implementation. This lack of reliable data poses a challenge for project financing. There are also issues with the DDA process. Currently, power producers or borrowers themselves carry out the DDA, which may lead to biased reports that favor their interests. To ensure transparency and objectivity, banks should take the initiative to conduct due diligence independently rather than relying on reports prepared by the project developers.

CHAPTER VIII: KEY FINDINGS AND RECOMMENDATIONS

This chapter encompasses the key outcomes of the study, presenting a summary of findings, conclusion, recommendations, and the way forward. It synthesizes insights from both qualitative and quantitative analyses, reflecting the perspectives of banks, financial institutions, independent power producers, and regulators.

8.1. Summary of the Findings

The hydropower industry is a risky industry as per the above-mentioned risk assessment above. As per survey, the overall attractiveness of the hydropower industry is 3.67 out of 5. Despite being risky, respondents argued that being a clean energy source, it is an attractive investment instrument. Consider hydropower as an enabler of competitive advantage when discussing Nepal's hydropower prospects. Among the top four lending sectors, hydro is one of the most prominent. Nepal has enormous potential for an installed capacity of 35,000 MW. 15,000 MW of projects are already prepared for PPA and awaiting the conclusion at the NEA. Nepal is also competitive in terms of cost, price, growth, and exports. Therefore, "Hydropower remains Nepal's strongest pathway to achieving sustainable economic growth and prosperity." If the government makes provisions for exporting to the power producer, it will create a win-win situation. As per FGDs with IPPs, foreign investors are willing to finance at a single-digit interest rate. With a vast and growing market for clean energy in India and interest from other neighboring countries willing to enter power purchase agreements at INR 6 per unit, Nepal has a significant potential to expand its electricity exports).

8.2 Conclusion

Nepal's hydropower sector is a cornerstone for achieving long-term economic prosperity, regional energy influence, and environmental sustainability. Despite inherent risks—climate risk, regulatory uncertainty, buyer concentration, market fluctuations, transmission line delays, and financing constraints—these challenges can be mitigated through stable policies, strategic infrastructure investment, and stakeholder collaboration. By opening power exports to private players, implementing transparent pricing mechanisms, strengthening regulatory clarity, and leveraging international financing, Nepal can unlock over 28,000 MW of hydropower potential by 2035.

A holistic approach combining public-private collaboration, diversified energy sources, and robust financial safeguards will allow Nepal not only to meet domestic energy needs but also to establish itself as a leading clean energy provider in South Asia. If policies and investments are aligned strategically, hydropower can drive national development, attract low-cost financing, ensure energy security, and create a win-win scenario for both the government and independent power producers, ultimately transforming Nepal's energy landscape and economic trajectory.

From a banking perspective, Nepal's hydropower sector presents a mix of high and moderate risks, with Climate, Hydrology, and Equity Risks being the most critical due to their impact on cash flow and loan repayment. Moderate risks like Insurance and Transmission Line Risks highlight the need for financial safeguards and infrastructure readiness, while lower risks such as Market and Technology Risks offer opportunities for growth. Overall, with careful due diligence, structured financing, and risk mitigation measures—including resilient infrastructure, strong PPAs, and investor-friendly policies—banks can manage these risks and view hydropower as an attractive, sustainable investment opportunity.

The findings of this study also resonate with the Triple Bottom Line (TBL) framework, which emphasizes the integration of financial, social, and environmental considerations in assessing sustainability. From the perspective of banks and financial institutions, risks in hydropower financing are not limited to financial constraints such as asset–liability mismatches and exposure limits, but also extend to environmental concerns, climate change impacts, and social challenges including community displacement and stakeholder conflicts. This alignment underscores that effective risk assessment in hydropower financing requires a holistic approach that goes beyond financial metrics to also account for long-term environmental sustainability and social acceptability.

8.3 Recommendations

It can be viewed from two different perspectives, which is explained below:

8.3.1 Lender's Perspective

From the perspective of lenders, the following key insights and recommendations have emerged based on Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs):

Transparent and Stable Regulations

Bankers emphasize the need for Nepal to adopt transparent and consistent policies for hydropower development. These should include stabilizing regulatory frameworks, reform of Power Purchase Agreements (PPAs), and Policies must promote long-term financial sustainability, minimize operational uncertainties, and attract investments in both hydropower and complementary energy sectors like solar power. Concerns were raised about the electricity bill currently under discussion in parliament, reflecting widespread discontent among IPPs regarding its potential impact.

Enhanced Feasibility Studies and Data Access

To better evaluate the viability of hydropower projects, lenders recommend creating a comprehensive, publicly accessible and dynamic database of hydropower projects.

Balanced Development of Hydropower and Solar Energy

While hydropower remains a cornerstone of Nepal's economic growth, bankers suggest diversifying the energy portfolio by investing in solar power development. This dual approach could help mitigate seasonal fluctuations in hydropower generation, creating a more reliable and competitive energy market. Integrating solar energy alongside hydropower would strengthen Nepal's energy sustainability and market resilience.

Nepal's policy landscape poses both risks and opportunities for hydropower development and power exports:

- **Financing Policies:** Hydropower projects are exempt from requiring collateral under Bank and Financial Institutions (BFIs) project financing rules. Additionally, the Nepal Rastra Bank's (NRB) policy of allocating 10% of total loan disbursement to the energy sector has supported capital formation for investors. However, some provision of Personal gurantee and share pledge are in provision.
- **Operational Challenges:** Power producers face a maximum operational period of 30 years following renewal, and although VAT exemptions for producers in certain items were announced in the budget, their size and implementation remain inadequate.
- **Lack of Stakeholder Engagement:** The absence of a clear stakeholder engagement policy creates uncertainty, especially regarding the status of shareholders after the completion of hydropower projects Build-Own-Operate-Transfer (BOOT) period.
- **Clarity in Policy:** There is a pressing need for well-defined policies to provide transparency and predictability, especially as Nepal positions itself to export power to neighboring markets.

These insights highlight the critical importance of stable regulations, data-driven project evaluation, and diversified energy development in shaping Nepal's energy sector and maximizing its potential in the regional energy market.

8.3.2 Forward-looking Policy and Government Support

Hydropower represents a vital green asset for Nepal, with the potential to transform the nation into a prosperous economy through sustainable energy development. Flexible and forward-looking policies are crucial not only to support hydropower development but also to secure international financing at lower costs. Key insights and recommendations from Independent Power Producers (IPPs) include the following:

Strong Government Support for Policy Alignment

The government must align its policies and actions with a long-term vision for hydropower development. For example, Nepal's imposition of a 292% customs duty on cement imports spurred the growth of the domestic cement industry. Similarly, well-crafted initiatives and favorable policies targeting hydropower could significantly bolster the sector while improving the national economy.

Non-Discriminatory Pricing Policy

IPPs advocate for the adoption of a fair and transparent electricity pricing policy, like India's "black box" model, which ensures impartiality and eliminates bias towards specific developers. Such a mechanism in Nepal would promote equitable pricing and build trust among stakeholders. In this context, the "black box" model refers to a pricing system where the calculation and determination of electricity rates are kept transparent and impartial, without favoring any specific developer or party. It operates by ensuring that all factors influencing the pricing are clear, making the process fair for all stakeholders involved. By adopting a similar model, IPPs (Independent Power Producers) in Nepal aim to foster trust and promote a more balanced, non-biased electricity pricing policy, ensuring that rates are determined objectively without manipulation or influence from certain developers or external interests.

Opening Power Export to the Private Sector

IPPs recommend that the government allow private sector participation in power exports. By enabling private players to trade electricity across borders, the reliance on Power Purchase Agreements (PPAs) could be reduced, creating more opportunities for power producers to access international markets, particularly given the high demand in neighboring countries like India.

Reform of the PPA Framework

The current PPA structure in Nepal resembles a loan deed rather than a true market-based agreement. IPPs suggest that the government reform PPAs to better reflect real market dynamics, ensuring fairness and financial viability for all parties involved.

Streamlining the Licensing Process

Delays in granting licenses for hydropower projects are a major bottleneck. IPPs urge the government to expedite and simplify the licensing process, establishing a transparent and efficient system to foster investor confidence and minimize project delays.

Clearing the IPO Backlog

The backlog of Initial Public Offerings (IPOs) at the Securities Board of Nepal (SEBON) is a significant obstacle for hydropower producers seeking to access capital markets. Clearing this backlog should be prioritized, enabling power producers to meet their financial obligations and enhance liquidity in the sector.

Incorporating Escalation Rates in PPAs

The absence of escalation clauses in current PPAs leaves hydropower producers vulnerable to inflation and rising costs. IPPs recommend including inflation-adjustment clauses or escalation rates in PPAs to ensure the long-term financial sustainability of projects, especially over their 30-year operational lifespans.

Flexible Policies for International Financing

To attract global investments at lower interest rates, IPPs emphasize the need for hydropower to be treated as a "green asset." Policies should align with international standards, providing flexibility and fostering investor confidence. This approach would reduce financing costs while supporting Nepal's broader economic development goals.

Encouraging Private Sector Participation in Power Exports

Expanding provisions for private sector involvement in cross-border electricity trading is essential. By doing so, Nepal can reduce dependence on domestic PPAs and capitalize on regional energy demand, particularly in markets like India.

By implementing these recommendations, Nepal can create a more supportive environment for hydropower development, attract foreign investment, and establish itself as a key energy player in the region, ensuring long-term economic growth and energy security.

8.4 Way Forward

Nepal's hydropower sector has immense potential to drive sustainable economic growth, energy security, and regional competitiveness, but realizing this potential requires a multi-dimensional strategy. First, infrastructure development must be prioritized, with particular focus on reliable transmission lines to ensure timely evacuation of electricity and integration with domestic and cross-border markets. Strengthening technical expertise and domestic industrial capacity is equally critical to support project execution, maintenance, and innovation.

Policy reforms are central to fostering investment. Nepal should adopt transparent, stable, and forward-looking policies, including clear licensing procedures, streamlined regulatory frameworks, and reforms to the Power Purchase Agreement (PPA) structure to reflect true market dynamics. Recognizing hydropower as a "green asset" can attract international financing at lower costs, while incorporating escalation clauses in PPAs can protect projects against inflation and cost escalation over their 30-year operational life.

Private sector engagement should be expanded, particularly in cross-border power exports, reducing dependency on domestic PPAs and leveraging growing regional demand for clean energy, especially in India. Transparent, non-discriminatory pricing mechanisms, such as India's "black-box" model, would ensure fairness and build trust among stakeholders. Additionally, integrating solar energy alongside hydropower can mitigate seasonal fluctuations in energy generation, creating a more reliable and competitive energy market.

Financial strategies must also be enhanced. Coordinated efforts between banks, multilateral agencies (World Bank, IFC, ADB), and private investors can provide long-term, low-cost financing. Escrow accounts, government guarantees, and international insurance mechanisms should be utilized to reduce operational and financial risks. Collaborative engagement among the government, IPPs, and investors is essential to ensure timely project execution and maximize sector potential.

In the short term, Nepal must overcome challenges such as limited access to capital, bureaucratic hurdles, infrastructure deficits, and the currency peg that limits independent monetary policy. Addressing these through strategic reforms, improved capital mobilization, and policy coordination will help the country convert its comparative advantage in hydropower into a sustainable competitive edge, positioning Nepal as a regional energy hub.

REFERENCES

Aryal, S., Ghimire, S., Tiwari, S., Baaniya, Y., & Pandey, V. P. (2024). Evolution and future prospects of hydropower sector in Nepal: A review. *Heliyon, 10*(10), 1-18. https://doi.org/10.1016/j.heliyon.2024.e31139

Asian Development Bank [ADB] (2023). *ADB and world bank join forces for sustainable development of Nepal's hydropower sector.* https://www.adb.org/news/adb-world-bank-join-forces-sustainable-development-nepal-hydropower-sector

Asian Development Bank [ADB] (n. d.). *Development coordination.* https://www.adb.org/sites/default/files/linked-documents/43281-013-nep-dc.pdf

Bangladesh Power Development Board (2023). *Annual report 2022-23.* https://bpdb.portal.gov.bd/sites/default/files/files/bpdb.portal.gov.bd/page/771c9a89_a06c_4c2f_9b8c_699d17ed769a/2024-01-03-06-02-dda85c69e3462d6de89b6486edd08779.pdf

Baurzhan, S., Jenkins, G. P., & Olasehinde-Williams, G. (2021). The economic performance of hydropower dams supported by the World Bank Group, 1975–2015. *Energies, 14*(9), 2673. https://doi.org/10.3390/en14092673

Bhatta, R. P. (2017). Hydropower development in Nepal - Climate change, impacts and implications. Renewable Hydropower Technologies. http://dx.doi.org/10.5772/66253

Bishwakarma, M. B. (2020). *Hydropower and environment: An experience from Khimti I hydropower project, Nepal.* http://dx.doi.org/10.1201/9781003078722-24

Braeckman, J. P., Markkanen, S., & Seega, N. (2022). Financiers' perceptions of risk in relation to large hydropower projects. *Environmental Research: Infrastructure and Sustainability, 2*(1), 015006. https://doi.org/10.1088/2634-4505/ac4e70

Chaudhary, S. (2024). *Hydropower investment by commercial banks exceeds regulatory requirements.* https://www.nepsetrading.com/blog/hydropower-investment-by-commercial-banks-exceeds-regulatory-requirements

Chaulagain, D., Ray, R. L., Yakub, A. O., Same, N. N., Jong, J. P., Roh, W., Suh, D., Lim, J., & Huh, J. (2025). Impact of climate change on hydrological patterns and implications for hydroelectric power generation in Khimti river basin, Nepal. *Discover Applied Sciences, 7,* 1-21. https://doi.org/10.1007/s42452-025-07304-7

Coro Strandberg (2009). *Triple bottom line and structured decision-making.* https://corostrandberg.com/wp-content/uploads/2009/12/industry-canada-sdm-case study.pdf

De Oliveira, J. A. P., dos Santos, R. A., & Rodrigues, R. (2025). Socioeconomic impacts of renewable energy plants through the lens of the triple bottom line: Evidence from

Brazilian municipalities. *Sustainability, 17*(11), 4864. https://www.mdpi.com/2071 1050/17/11/4864

Ehrlich, M. (2010). *Estimation of foreign exchange exposure for public-private partnership infrastructure projects* (Published PhD Thesis). Nanyang Technological University. https://dr.ntu.edu.sg/server/api/core/bitstreams/6dd41d65-abe4-436a-a761-7c139bd6e5cc/content

Elkington, J. (1994). Toward the sustainable corporation: Win-win-win business strategies for sustainable development. *California Management Review, 36*(2), 90–100. https://doi.org/10.2307/41165746

Elkington, J. (1997). *Cannibals with forks: The triple bottom line of 21st century business.* Capstone.

Elkington, J. (2018). 25 years ago, I coined the phrase "triple bottom line." Here's why I'm giving up on it. *Harvard Business Review.* https://hbr.org/2018/06/25-years-ago-i-coined the-phrase-triple-bottom-line-heres-why-im-giving-up-on-it

Equity Nepal (2025). *NMB bank leads financing of NPR 5.35 billion bajra Madi hydropower project*. https://equitynepal.com/2025/05/11/30930/

Financial Notices (2025). *NMB bank leads financial closure of 24.8 mw bajra Madi hydropower project; Marks another milestone in sustainable energy financing.* https://www.financialnotices.com/news/57209.phtml

Ghimire, H. R. (2021). Spatio-temporal analysis of hydropower projects with terrestrial environmentally sensitive areas of Nepal. https://doi.org/10.21203/rs.3.rs-228325/v1

Hekel, J. D. (2016). *The future battery of South Asia: Nepal power investment summit 2016.* http://jameshekel.com/index.php/category/regulatory-reform/

Herath, H. M. K. A., Prabodanie, R. R., & Wijewicrama, M. T. M. T. (2021). Environmental and social impact of a mini-hydropower plant based on Sudu Ganga in Sri Lanka. *Ruhuna Journal of Science, 12*(1), 40. https://doi.org/10.4038/rjs.v12i1.99

Kuhlman, T., & Farrington, J. (2010). What is sustainability? *Sustainability, 2*(11). 3436-3448. https://doi.org/10.3390/su2113436

Kuikel, B., Maemura, Y., & Ozawa, K. (2023). Management of foreign exchange risk for build-ownoperate-transfer hydropower projects in Nepal: A good-for-all approach. *Journal of Infrastructure Systems, 29*(2). https://doi.org/10.1061/JITSE4.ISENG-2149

Li, H., Xu, B., Arzaghi, E., Abbassi, R., Chen, D., Aggidis, G. A., Zhang, J., & Patelli, E. (2020). Transient safety assessment and risk mitigation of a hydroelectric generation system. *Energy, 196.* https://doi.org/10.1016/j.energy.2020.117135

Liu, R., & Luo, Z. (2023). Application of digital intelligent construction in the field of water conservancy and hydropower engineering. *Journal of Physics: Conference Series, 2565*(1). https://doi.org/10.1088/1742-6596/2565/1/012025

Luu, C., Meding, J. v., & Kanjanabootra, S. (2017). Balancing costs and benefits in Vietnam's hydropower industry: A strategic proposal. *International Journal of Disaster Resilience in the Built Environment, 8*(1), 27-39. https://doi.org/10.1108/ijdrbe-05-2016-0018

Meng, Y., Liu, J., Leduc, S., Mesfun, S., Kraxner, F., Mao, G., Qi, W., & Wang, Z. (2020). Hydropower production benefits more from 1.5°c than 2 °c climate scenario. *Water Resources Research, 56*(5). https://doi.org/10.1029/2019wr025519

Ministry of Energy, Water resources and Irrigation (2025). *Power plants: Hydro (More than 1MW).* https://doed.gov.np/license/54

Ministry of Finance (2025). *Bangladesh economic review (Archive).* https://mof.gov.bd/site/page/44e399b3-d378-41aa-86ff-8c4277eb0990/Bangladesh-Economic-Review

Ministry of Power (n. d.). *Power sector at a glance all India.* https://powermin.gov.in/en/content/power-sector-glance-all-india

Nepal Economic Forum (2014). *Hydropower development in Nepal.* https://media.thuprai.com/book/pdfs/Hydropower_Development_in_Nepal.pdf

Nepal Rastra Bank [NRB] (2010). *Unified directives: Issues by Nepal rastra bank to the licensed banks and financial institutions, 2010.* https://www.nrb.org.np/contents/uploads/2019/12/Directives-Unified-_Directives-_2067-_English.pdf

Nepal Rastra Bank [NRB] (2022). *Monetary policy for 2022/23.* https://www.nrb.org.np/contents/uploads/2022/08/Monetary-policy-in-English-2022_23-Full-text.pdf

Nepal Rastra Bank [NRB] (2024). *Financial stability report.* https://www.nrb.org.np/contents/uploads/2024/06/FSR-2022_23.pdf

Nepal Rastra Bank [NRB] (2025). *Key financial indicators.* https://www.nrb.org.np/category/key-financial-indicators/

Nepal Rastra Bank [NRB] (2025a). *Unified directives 2081.* https://www.nrb.org.np/contents/uploads/2025/01/UD-2081-ABC-Final-Upload-3.pdf

Nepal Rastra Bank [NRB] (2025b). *Foreign exchange rates.* https://www.nrb.org.np/forex/

Nepal, A., Khanal, V., & Maelah, R. (2021). Relative importance of risks in hydropower projects and project finance in Nepal. *Journal of Advanced Academic Research, 8*(1), 1-21. https://doi.org/10.3126/jaar.v8i1.38409

Nepal, A., Maelah, R., & Khanal, V. (2023). Role of domestic banking and financial institutions in project finance: Insights from hydropower sector in Nepal. *Journal of Advanced Academic Research, 10*(2), 1-21. http://dx.doi.org/10.3126/jaar.v10i2.60189

Niroula, S., Kafle, N., Chitrakar, S., & Thapa, B. S. (2024). Green hydrogen production from surplus hydroelectric power: A case study in Nepal. *International Journal of Hydrogen Energy, 92,* 527-534. https://doi.org/10.1016/j.ijhydene.2024.10.296

Oyerinde, G., Wisser, D., Hountondji, F. C. C., Odofin, A. J., Lawin, A. E., Afouda, A., … & Diekkrüger, B. (2016). Quantifying uncertainties in modeling climate change impacts on hydropower production. *Climate, 4*(3), 34. https://doi.org/10.3390/cli4030034

P.C., S., Pun, I., Talchabhadel, R., & Kshetri, D. (2021). The role of glaciers in hydropower production in Nepal. *Journal of Asian Energy Studies, 5*(1), 1-13, doi:10.24112/jaes.050001

Pandey, L. N., & Patodiya, P. K. (2023). Hydropower development in Nepal: Achievements and opportunities. *A Bi-annual South Asian Journal of Research & Innovation, 10*(2), 61-68. https://doi.org/10.3126/jori.v10i2.71847

Parsa, V. A., & Salehi, E. (2016). Spatio-temporal analysis and simulation pattern of land use/cover changes, case study: Naghadeh, Iran. *Journal of Urban Management, 5*(2), 43-51. https://doi.org/10.1016/j.jum.2016.11.001

Pokhrel, P. R. (2017). *Number one in the world*. https://www.prasashan.com/2017/06/25/197896/

Rand, J. (2018). Overlooked trade-offs of environmentally protective hydropower operation: Impacts to ancillary services and greenhouse gas emissions. *River Research and Applications, 34*(9), 1123-1131. https://doi.org/10.1002/rra.3354

Reuter (2025). *Nepal begins first power exports to Bangladesh via India's grid.* https://www.reuters.com/business/energy/nepal-begins-first-power-exports-bangladesh-via-indias-grid-2025-06-16/

Reuters (2025). *Nepal begins first power exports to Bangladesh via India's grid.* https://www.reuters.com/business/energy/nepal-begins-first-power-exports-bangladesh-via-indias-grid-2025-06-16/#:~:text=June%2016%20(Reuters)%20%2D%20Nepal,facilitator%20of%20regional%20electricity%20trading.

Shaktawat, A., & Vadhera, S. (2021). Risk management of hydropower projects for sustainable development: A review. *Environment, Development and Sustainability, 23*, 45–76. https://doi.org/10.1007/s10668-020-00607-2

Subedi, K. D. (2018). Funding gap in hydropower projects of Nepal: Does internal finance matter? *The Saptagandaki Journal, 9,* 34-52. https://doi.org/10.3126/sj.v9i0.20879

Sustainable Finance Department. (2022). *Guidelines on Environmental & Social Risk Management (ESRM) for Banks and Financial Institutions in Bangladesh.* Bangladesh Bank.

Swanson, A. R., & Sakhrani, V. (2023). Value–risk calculator for blended finance: A systems perspective of the nachtigal hydropower project. *Sustainability, 15*(13), 10357. https://doi.org/10.3390/su151310357

Tiwari, G. (2024). Green banking initiatives: Policy and practices in commercial banks of Nepal. *Intelligence Journal of Multidisciplinary Research, 3*(1), 119–134. https://doi.org/10.3126/ijmr.v3i1.65481

Tuladhar, S. (2015). *Perceptions and reality: An analysis on hydropower financing in Nepal.* https://nepaleconomicforum.org/perceptions-and-reality-an-analysis-on-hydropower-financing-in-nepal/

Urban, F., Nordensvard, J., Siciliano, G., & Li, B. (2015). Chinese overseas hydropower dams and social sustainability: The Bui dam in Ghana and the Kanchay dam in Cambodia. *Asia & The Pacific Policy Studies, 2*(3), 573-589. https://onlinelibrary.wiley.com/doi/full/10.1002/app5.103

Urban, F., Nordensvärd, J., Siciliano, G., & Li, B. (2015). Chinese overseas hydropower dams and social sustainability: The Bui dam in Ghana and the Kamchay dam in Cambodia. *Asia & The Pacific Policy Studies, 2*(3), 573-589. https://doi.org/10.1002/app5.103

Warren, D. (2025). *Hydropower in Nepal: A path toward or away from sustainability.* https://www.researchgate.net/publication/391808840_Hydropower_in_Nepal_A_Path_Toward_or_Away_from_Sustainability

Water and Energy Commission Secretariat (2017). *Electricity demand forecast report (2015-2040).* https://giwmscdnone.gov.np/media/pdf_upload/05%20Electricity%20Demand%20Forecast%20Report%20(2015-2040)%202073-10_slxdxv9.pdf

Water and Energy Commission Secretariat (2024). *Energy sector synopsis 2024.* http://wecs.gov.np/source/ESR_2024.pdf

Williams, J. (2025). Exploring the socio-environmental impacts of hydropower in Nepal. ResearchGate. https://www.researchgate.net/publication/391675363_Exploring_the_Socio Environmental_Impacts_of_Hydropower_in_Nepal

World Bank Group (2019). *Nepal infrastructure sector assessment: Private sector solutions for sustainable infrastructure development*. Washington, DC: World Bank. https://documents1.worldbank.org/curated/en/685161568039416684/pdf/Nepal-Infrastructure-Sector-Assessment-Private-Sector-Solutions-for-Sustainable-Infrastructure-Development.pdf

World Bank. (2017). *Better Hydro: Compendium of case studies 2017.* World Bank. https://documents.worldbank.org/curated/en/247261519658051630/pdf/Better-Hydro Compendium-of-Case-Studies-2017.pdf

Yang, P. (2024). Hydropower. *Renewable Energy.* https://link.springer.com/chapter/10.1007/978-3-031-49125-2_4