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Financial Risk Assessment of Hydropower Projects Developed by Independent Power Producers in Nepal

By

Sneha Neopane

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A THESIS

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I hereby declare that the thesis entitled "**Financial Risk Assessment of Hydropower Projects Developed by Independent Power Producers in Nepal**", submitted to the Department of Civil Engineering in partial fulfillment of the requirements for the degree of Master of Science in Engineering in Construction Management, is a record of original work done under the guidance of Asst. Prof. Mahendra Raj Dhital. This thesis contains only work completed by me except for the consulted material, which has been duly referenced and acknowledged.

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AHP	Analytic Hierarchy Process
AIJ	Aggregation of Individual Judgments
ALOP	Advance Loss of Profits
BI	Business Interruption
BOOT	Build-Own-Operate-Transfer
CAR	Construction All Risks
CI	Consistency Index
CR	Consistency Ratio
CVI	Content Validity Index
DOED	Department of Electricity Development
DSCR	Debt Service Coverage Ratio
EAR	Erection All Risks
EPC	Engineering, Procurement and Construction
FRI	Financial Risk Index
GLOF	Glacial Lake Outburst Flood
IDC	Interest During Construction
IDA	International Development Association
IFC	International Finance Corporation

IHA	International Hydropower Association
IPP	Independent Power Producer
KII	Key Informant Interview
MCDM	Multi-Criteria Decision Making
MIGA	Multilateral Investment Guarantee Agency
MS	Mitigation Score
MW	Megawatt
NEA	Nepal Electricity Authority
NEPSE	Nepal Stock Exchange
NERC	Nepal Electricity Regulatory Commission
OECD	Organization for Economic Co-operation and Development
PAR	Property All Risks
PDA	Power Development Agreement
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
RI	Random Consistency Index
RII	Relative Importance Index
SPV	Special Purpose Vehicle
WECS	Water and Energy Commission Secretariat

CHAPTER 1: INTRODUCTION

1.1 Background

Nepal is endowed with an estimated 83,000 MW of theoretical hydropower potential, of which approximately 45,000 MW is technically feasible and 42,000 MW economically viable (Water and Energy Commission Secretariat, 2019). Despite this resource endowment, only 3,416 MW has been developed as of 2082 B.S. which is less than 8% of technically feasible capacity (Nepal Electricity Authority [NEA], 2082 B.S. (2025–26 A.D.))The structural transformation of Nepal's electricity sector from a state-dominated model toward private investment, formalized through the Electricity Act of 1992 and revised in 2018, has positioned Independent Power Producers (IPPs) as the dominant force in hydropower development. IPPs now account for 64% of total installed generation capacity, with 204 projects under operation, 130 under construction with financial closure concluded, and 135 at various stages of development (Nepal Electricity Authority [NEA], 2025).

IPP-led projects in Nepal are financed through project finance structures in which a Special Purpose Vehicle (SPV) ring-fences project assets and cash flows from sponsor balance sheets. Projects typically operate with debt-to-equity ratios of 70:30 to 75:25 and concession periods of 25 to 35 years, with revenues tied exclusively to Power Purchase Agreements (PPAs) with NEA as the sole off-taker (Esty, 2003). Nepal's rugged terrain, monsoon-dominated hydrology, multi-agency regulatory framework, and shallow domestic financial markets together create a financial risk environment that is materially more challenging than international benchmarks (Neupane, 2014). Ansar et al. (2014), in a global analysis of 245 large dam projects, documented median construction cost overruns of 96% and schedule overruns of 44% , a pattern corroborated for Nepal's small hydropower context. (Bhattarai, et al., 2024).

Nepal's government targets 15,000 MW of installed capacity by 2030 and aspires to become a major electricity exporter to India and Bangladesh. Achieving this requires sustained private investment at scale, yet no systematic, quantitative financial risk assessment framework exists for Nepal's IPP hydropower sector. Existing studies remain largely qualitative (Neupane, 2014), and while the Analytic Hierarchy Process (AHP) has been widely applied for risk prioritization in hydropower globally (Wang, et al., 2018; Patel, et al., 2021), no AHP-based financial risk framework has been validated for Nepal's IPP context. This study directly addresses that gap.

1.2 Statement of the Problem

Nepal's IPP hydropower sector lacks a systematic, quantitative framework for identifying, prioritizing, and measuring the financial risks that threaten project viability. This absence creates three interconnected problems.

First, without a validated prioritization of financial risk factors, investors, developers, and lenders lack a common evidence-based reference for understanding which risks are most consequential in Nepal's specific context. Reliance on generic international frameworks or informal practitioner knowledge inadequately reflects Nepal's distinctive institutional, hydrological, and financial market conditions (Bhattarai, et al., 2024), elevating risk premiums and deterring investment in a sector that requires sustained private capital mobilization.

Second, no composite Financial Risk Index exists for Nepal's IPP sector. While composite risk indices are established tools in infrastructure investment governance internationally (Organisation for Economic Co-operation and Development [OECD], 2008), their absence in Nepal's hydropower context means that policymakers cannot monitor risk trends, evaluate the impact of regulatory changes, or communicate aggregate risk conditions to international investors in a standardized format, a gap that directly undermines Nepal's ability to mobilize the capital required to achieve its 15,000 MW installed capacity target by 2030 (Nepal Electricity Regulatory Commission [NERC], 2021).

Third, the effectiveness of the mitigation instruments currently deployed in Nepal's IPP transactions like PPAs, PDAs, EPC contracts, O&M contracts, syndicated credit facilities, insurance, and financial hedging has never been empirically assessed. Bhattarai et al. (2024) observe that despite the widespread use of these instruments in Nepal's project finance transactions, their practical contribution to reducing financial risk exposure at the project level remains poorly understood, and the residual financial risk that persists after all instruments are applied is entirely unknown. This prevents informed decisions about where mitigation coverage needs strengthening and where new instruments are needed.

1.3 Research Questions

The following research questions guide the empirical investigation:

1. Which financial risk factors and categories are most critical for IPP-developed hydropower projects in Nepal, and how do they rank in terms of relative importance?
2. What is the aggregate level of financial risk faced by IPP-developed hydropower projects in Nepal, as measured by a composite Financial Risk Index?
3. How effective are the existing risk mitigation instruments in reducing financial risk exposure for Nepal's IPP-developed hydropower projects, and what is the level of residual financial risk after mitigation?

1.4 Research Objectives

1.4.1 Primary Objective

The primary objective of this study is to assess the financial risk of Hydropower projects developed by Independent Power Producers in Nepal.

1.4.2 Specific Objectives

The specific objectives of this study are as follows.

1. To prioritize the financial risk factors affecting IPP-developed hydropower projects in Nepal.
2. To develop a composite Financial Risk Index (FRI) of IPP-developed hydropower projects in Nepal.
3. To evaluate the effectiveness of existing risk mitigation instruments for Nepal's IPP-developed hydropower projects, and to quantify the residual financial risk after mitigation.

1.5 Significance of the Study

This study makes several distinct contributions to scholarship and practice in the domain of hydropower project finance and infrastructure risk management.

From a scholarly perspective, it produces the first empirically validated, AHP-based financial risk prioritization framework specifically designed for Nepal's IPP hydropower context, filling a documented gap in the Nepal-specific infrastructure finance literature. It advances the methodological integration of AHP and KII for composite index construction in infrastructure risk assessment, providing a replicable analytical template for similar studies in comparable emerging market contexts. The study also contributes to the growing body of evidence on the gap between nominal availability of risk mitigation instruments and their practical effectiveness, a dimension of risk management research that remains underdeveloped in the developing country infrastructure literature.

From a practitioner perspective, the AHP-derived priority weights provide developers and lenders with an evidence-based, Nepal-specific risk ranking that can inform due diligence processes, risk-adjusted return requirements, and contingency budgeting. The composite FRI provides a standardized, communicable metric of aggregate financial risk that can anchor negotiations between investors, lenders, and government counterparties, and serve as a benchmark for monitoring changes in the risk environment over time. The mitigation effectiveness assessment and Residual FRI identify specific gaps in the current risk management architecture, providing a targeted basis for instrument development and capacity building.

From a policy perspective, the study provides quantitative evidence for regulatory reform priorities, particularly the dominant role of delays in government approvals and licensing as a financial risk driver that can inform the Electricity Regulatory Commission, the Department of Electricity Development, and the Ministry of Energy, Water Resources and Irrigation in prioritizing institutional capacity development and regulatory streamlining. The identification of the residual risk gap i.e., the financial risk that persists despite existing mitigation provides a quantitative basis for government decisions about enhanced guarantee mechanisms, viability gap funding, and other public-private risk sharing arrangements.

1.6 Scope and Limitations

1.6.1 Scope

This study is focused on the financial risk environment of hydropower projects developed by Independent Power Producers in Nepal. The scope encompasses all stages of the IPP project lifecycle, development, financing, construction, commissioning, and operations as sources of financial risk. However, the primary focus is on risks with material financial consequences across the full project lifecycle rather than purely operational or technical considerations. Geographically, the study focuses on Nepal's national IPP hydropower sector without disaggregation by river basin, project size, or technology type (run-of-river versus storage). The study reflects conditions as of the data collection period (2024–2025) and is intended as a cross-sectional assessment rather than a longitudinal tracking study.

1.6.2 Limitations

Several methodological and contextual limitations should be acknowledged in interpreting the findings of this study. The AHP and KII analyses rely on expert and key informant judgment from panels of five respondents each, which is consistent with established practice for sector-specific expert elicitation but limits the statistical diversity of perspectives captured. The findings are context-specific to Nepal's IPP sector and may not be directly generalizable to other sectors or geographic contexts. The FRI, Mitigation Score, and Residual FRI are point-in-time assessments that may shift as Nepal's regulatory environment and financial markets evolve. The equal-interval classification bands applied to the indices are methodologically convenient but not statistically derived from the data. Despite these limitations, the study represents a significant methodological advance over the qualitative risk assessments that have previously characterized Nepal's IPP hydropower financial risk literature.

CHAPTER 2: LITERATURE REVIEW

2.1 Infrastructure Finance and the Evolution of IPP Models

Infrastructure investment in the energy and water sectors is a foundational determinant of economic development in low- and middle-income countries (Calderón & Servén, 2008). Against a backdrop of constrained public fiscal resources, the Independent Power Producer (IPP) model emerged from the 1990s electricity sector reform wave as a mechanism for attracting private capital into power generation previously dominated by state utilities (Grimsey & Lewis, 2002; Delmon, 2017). The IPP model structures a private sector project company, typically a Special Purpose Vehicle (SPV) that enters into long-term Power Purchase Agreements with state utilities (Esty, 2003; Finnerty, 1996). By fiscal year 2081/82 B.S., IPPs accounted for 64% of Nepal's installed hydropower capacity (Nepal Electricity Authority [NEA], 2025), reflecting the country's heavy reliance on this model.

Despite the theoretical appeal of IPPs, empirical evidence from developing countries consistently documents implementation challenges. Nepal-specific studies by Neupane (2014) and Bhattarai et al.(2024) document how sequential multi-agency licensing timelines extend development by three to five years, directly inflating pre-construction financing costs. Bhattarai et al. (2024) identify contractor program delays and rework costs as primary drivers of cost overruns in Nepal's small hydropower projects, reinforcing the finding that construction-phase risk is the dominant financial risk category in this context.

2.2 Project Finance as the Financing Modality for Hydropower IPPs

Project finance is defined as a method of funding in which the lender looks primarily to revenues generated by a single project, both as the source of repayment and as security for the exposure (Esty, 2003). IPP hydropower transactions in Nepal are structured under project finance arrangements with debt-to-equity ratios typically of 70:30 to 75:25 and concession periods of 25–35 years (Nepal Electricity Authority [NEA], 2082 B.S. (2025–26 A.D.); Nepal Rastra Bank [NRB], 2025). The Debt Service Coverage Ratio (DSCR) is the central financial health metric; a DSCR below 1.2 typically triggers covenant breach (Yescombe, 2013). The leverage-heavy structures of hydropower IPPs mean modest deviations in revenue or cost assumptions can disproportionately erode DSCR, making financial risk identification essential (Esty, 2003; Finnerty, 1996).

Nepal's project finance environment is structurally shaped by thin domestic capital markets, limited long-tenor debt availability, and the absence of a deep domestic bond market (Neupane, 2014). Nepal Rastra Bank (2025) directed lending provisions mandate commercial bank allocation to productive sectors including hydropower, but domestic banks' capacity is constrained by relatively short loan tenors, high non-performing loan ratios, and limited project finance expertise. These structural factors amplify delays in financial closure and contribute to elevated interest rate risk for IPP developers.

2.3 Financial Risk in Infrastructure Projects: Theoretical Frameworks

The risk management literature for infrastructure projects provides rich theoretical and empirical work on risk identification, categorization, allocation, and mitigation. Grimsey and Lewis (2002) provide a foundational taxonomy organizing infrastructure risks into macro-level risks (political, legal, economic, social), meso-level risks (organizational and relationship), and micro-level risks (construction, operation, revenue). This taxonomy underpins the five-category framework employed in this study. Esty (2003) demonstrates that project finance loan credit risk differs fundamentally from corporate loans due to non-recourse debt structure, long tenors, and heightened sensitivity to project-specific events.

Ansar et al. (2014) empirically analyzed 245 large dams globally, finding actual construction costs exceeded estimates by a median of 96% and schedule overruns averaged 44%. Flyvbjerg (2009) attributes this systematic bias to 'optimism bias' and 'strategic misrepresentation' in project appraisal. In Nepal specifically, Bhattarai et al. (2024) corroborate these findings using a Relative Importance Index (RII) analysis on small hydropower projects, identifying rework cost (RII = 0.579) and contractor program delay as the most influential factors, directly validating the global infrastructure cost overrun literature in Nepal's context. Delmon (2017) and Yescombe (2013) provide comprehensive project finance risk allocation frameworks relevant to Nepal's concession-based hydropower sector.

2.4 Nepal's Hydropower Sector and the IPP Financial Risk Environment

Nepal holds an estimated 83,000 MW of theoretical hydropower potential, of which 45,000 MW is technically feasible and 42,000 MW economically viable (Nepal Electricity Authority, 2082 B.S.). As of Kartik–Poush 2082 B.S., only 3,416.19 MW has been developed (Nepal Electricity Authority, 2082 B.S.), with 204 IPP-owned projects operational, 130 under construction, and 135 in various development stages (Nepal Electricity Authority [NEA], 2025). Nepal's regulatory framework has evolved under the Electricity Act 2018 and the Nepal Electricity Regulatory Commission (NERC) established in 2017, though persistent structural challenges remain.

Pandey et al. (2023) document how sequential multi-agency approvals (spanning the Department of Electricity Development, Ministry of Forests and Environment, Department of Mines and Geology, provincial governments, and local authorities) extend project development timelines by three to five years, directly inflating pre-construction financing costs. The World Bank identifies Nepal's transmission infrastructure gaps as a critical constraint on IPP financial performance: commissioned generating capacity unable to evacuate power earns no revenue while bearing full debt service obligations, creating a structural revenue risk unique to Nepal's grid development context (World Bank, 2020). Neupane (2014) identifies limited long-tenor debt and structural financing constraints as defining challenges for Nepal's IPPs. Shrestha et al. (2015) provide evidence of climate change impacts on Nepal's hydropower generation potential, finding increasing inter-annual variability in river discharge that threatens the reliability of energy yield projections underlying project financial models.

2.5 Identification of Financial Risk Factors from Literature

Drawing on the comprehensive review above, 33 financial risk factors were identified as potentially relevant to IPP-developed hydropower projects in Nepal. These factors are presented in Table 2.1 with the sources from where they were identified.

Table 2.1 Financial Risk Factors Identified from Literature Review

S.N.	Financial Risk Factor	Key Literature References
1	Construction time overrun	Ansar et al. (2014); Flyvbjerg (2009); Bhattarai et al. (2024)
2	Interest rate fluctuation	Finnerty (1996); Yescombe (2013); Neupane (2014)
3	Adverse geological condition	Ansar et al. (2014); Kumar & Katoch (2016); Bhattarai et al. (2024)
4	Tariff renegotiation risk at handover	Pandey et al. (2023); Delmon (2017)
5	Delays in financial closure	Neupane (2014); Finnerty (Finnerty, 1996); Yescombe (2013)
6	Delays in government approvals and licensing	Pandey et al. (2023); World Bank (2020); Department of Electricity Development (2022)
7	Hydrological variability and climate change	International Hydropower Association (2021); Kumar & Katoch (2016); Shrestha et al. (2015)
8	High insurance premium	Finnerty (1996); Bhattarai et al. (2024); Multilateral Investment Guarantee Agency (2013)
9	Macroeconomic instability	North (1990); Guasch et al. (2006); World Bank (2020)
10	Environmental compliance and mitigation cost	International Finance Corporation (2015); Neupane (2014); Asian Development Bank (2015)
11	Disputes and legal settlements	Grimsey & Lewis (2002); Delmon (2017); North (1990)
12	Currency exchange fluctuation	Finnerty (1996); Yescombe (2013); Neupane (2014)
13	Operation and maintenance cost escalation	International Hydropower Association (2021); Yescombe (2013); Bhattarai et al. (2024)

14	Insufficient financial audit and monitoring	North (1990); Grimsey & Lewis (2002); Ika et al. (2012)
15	Equity exit risk	Delmon (2017); Yescombe (2013); Neupane (2014)
16	Off-taker risk (PPA and payment risk)	Grimsey & Lewis (2002); Delmon (2017); Nepal Electricity Authority (2025)
17	Inflation-induced cost escalation	Grimsey & Lewis (2002); Yescombe (2013); Bhattarai et al. (2024)
18	Errors in financial forecasting and data assumptions	Ansar et al. (2014); Flyvbjerg (2009); Pandey et al. (2023)
19	Transmission line construction delay	World Bank (2020); Nepal Electricity Authority (2024); Neupane (2014)
20	Financial system crisis	North (1990); Neupane (2014); World Bank (World Bank, 2020)
21	Social mitigation and compensation cost	International Finance Corporation (2015); World Bank (2020); Asian Development Bank (2015)
22	Lack of government guarantees	Delmon (2017); Pandey et al. (2023); World Bank (2020)
23	Contract termination or cancellation	Grimsey & Lewis (2002); Delmon (2017); Bhattarai et al. (2024)
24	Design and professional services cost escalation	Ansar et al. (2014); Flyvbjerg (2009); Grimsey & Lewis (2002)
25	Client inability to service debt	Esty (2003); Yescombe (2013); Finnerty (1996)
26	Market demand changes	Grimsey & Lewis (2002); Delmon (2017); World Bank (2020)
27	Inadequate investing capital	Neupane (2014); World Bank (2020); Bhattarai et al. (2024)
28	Corporate governance risk	North (1990); Ika et al. (2012); Pandey et al. (2023)
29	High occupational safety and health expenses	International Finance Corporation (2015); Bhattarai et al. (2024);

		International Hydropower Association (2021)
30	Weak financial market	Neupane (2014); North (1990); World Bank (2020)
31	Permit and license expenditure	Department of Electricity Development (2022); Pandey et al. (2023); Neupane (2014)
32	High taxation risk	World Bank (2020); Delmon (2017); Bhattarai et al. (2024)
33	Force majeure risk	Finnerty (1996); Delmon (2017); Yescombe (2013)

Table 2.1 reveals that construction-related cost risks (time overrun, O&M escalation, inflation, and design cost escalation) appear with high frequency across the cited literature, consistent with Ansar et al.'s (2014) and Bhattarai et al.'s (2024) empirical documentation of construction-phase dominance in infrastructure financial outcomes. Regulatory and institutional risks are particularly prominent in Nepal-specific literature, reflecting the country's multi-agency licensing complexity (Neupane, 2014; Bhattarai, et al., 2024; Department of Electricity Development [DOED], 2022). Hydrological and climate risks emerge increasingly from the Himalayan-focused literature (Kumar & Katoch, 2016; Shrestha, et al., 2015), while financing risks are well-documented in both global project finance texts (Esty, 2003; Finnerty, 1996; Yescombe, 2013) and Nepal-specific assessments (Neupane, 2014).

2.6 Categorization of Financial Risk Factors

The 33 identified financial risk factors were organized into five thematic categories, following the taxonomy of Grimsey and Lewis (2002) as adapted for the energy and hydropower sector by Delmon (2017) and Yescombe (2013). Table 2.2 presents the categories with the factors included under them.

Table 2.2 Categorized Financial Risk Factors

S.N.	**Risk Category**	**Financial Risk Factors**
1	**Cost-Related Risks**	Design and professional services cost escalation
		Construction time overrun

		Operation and maintenance cost escalation
		Inflation-induced cost escalation
		Environmental compliance and mitigation cost
		Social mitigation and compensation cost
		High occupational safety and health expenses
		High insurance premium
2	**Revenue and Market Risks**	Market demand changes
		Tariff renegotiation risk at handover
		Off-taker risk (PPA and payment risk)
		Hydrological variability and climate change
		High taxation risk
		Transmission line construction delay
3	**Financing Risks**	Interest rate fluctuation
		Currency exchange fluctuation
		Weak financial market
		Financial system crisis
		Macroeconomic instability
		Inadequate investing capital
		Equity exit risk
		Client inability to service debt
		Delays in financial closure
4	**Regulatory and Institutional Risks**	Lack of government guarantees
		Delays in government approvals and licensing
		Insufficient financial audit and monitoring
		Corporate governance risk

		Errors in financial forecasting and data assumptions
5	**External Risks**	Permit and license expenditure
		Adverse geological condition
		Disputes and legal settlements
		Contract termination or cancellation
		Force majeure risk

2.6.1 Cost-Related Risks

Cost-related financial risks are the most extensively documented risk category in Nepal's hydropower literature. Construction time overrun is universally identified as the most consequential cost risk, with Ansar et al. (2014) documenting median cost overruns of 96% and schedule overruns of 44% across 245 large dams globally. In Nepal's context, Bhattarai et al. (2024) corroborate this through RII analysis, identifying rework cost (RII = 0.579) and delayed contractor program approval as the dominant cost and schedule risk drivers respectively. Pandey et al. (2023) note that Nepal's challenging terrain, monsoon-season construction interruptions, and remote site access amplify construction cost uncertainty well above international benchmarks. International Finance Corporation Performance Standards (2015) and Asian Development Bank (2015) requirements have substantially escalated environmental compliance and social mitigation costs for projects financed by international development institutions, creating budgetary obligations that domestic-only feasibility assessments historically underestimate. Pandey et al. (2023) document insurance premium escalation as a specific cost challenge for Nepal's IPPs, attributed to growing international reinsurer risk consciousness about Himalayan geological and climate hazards.

2.6.2 Revenue and Market Risks

Nepal's revenue risk environment for IPP hydropower is primarily shaped by two structural factors: transmission infrastructure deficits and hydrological variability. The World Bank (2020) and Nepal Electricity Authority (2024) document a persistent and widening gap between installed generation capacity and available transmission evacuation capacity, creating a structural revenue risk that is uniquely severe in Nepal relative to international benchmarks. Pandey et al. (2023) identify transmission line delays as a primary cause of IPP revenue shortfalls, noting cases where commissioned plants operated at materially below-capacity for extended periods due to NEA's inability to absorb output. Shrestha et al. (Shrestha et al., 2015) and the International Hydropower Association (2021) document that climate change is materially altering Himalayan hydrological regimes, increasing inter-annual flow variability and introducing growing uncertainty into long-term energy yield projections. The tariff renegotiation risk at handover is Nepal-specific: as documented by Neupane (2014), the BOOT concession structure returns the project to NEA at nominal cost after the initial PPA term, requiring renegotiation under potentially unfavorable terms without the investor protection mechanisms present during the initial development phase.

2.6.3 Financing Risks

Nepal's financing risk environment is characterized by structural constraints in its domestic financial system. Neupane (2014) provides a Nepal-specific analysis of financing constraints, identifying limited long-tenor debt availability, elevated interest rate volatility, and the absence of a domestic capital market for project bond issuance as the defining structural financing challenges for Nepal's IPPs. Nepal Rastra Bank (2025) monetary policy communications confirm that domestic interest rates have been subject to significant volatility, with base rates fluctuating materially over recent years in response to macroeconomic conditions. Bhattarai et al. (2024) identify delays in financial closure as a recurrent challenge attributable to Nepal's thin banking syndication market and limited experienced project finance legal practitioners. North (1990) provides the theoretical institutional economics framework for understanding how the weakness of Nepal's financial market institutions amplifies financial system crisis risk and constrains the development of equity exit mechanisms for IPP investors.

2.6.4 Regulatory and Institutional Risks

Regulatory and institutional risk is significant in Nepal's IPP hydropower sector, driven overwhelmingly by delays in government approvals and licensing. Pandey et al. (2023) document that Nepal's multi-agency sequential approval process adds significantly to project development timelines, with each additional year directly inflating pre-construction financing costs through interest during construction accumulation. Department of Electricity Development (2022) annual reports confirm that average time from survey license application to generation license issuance substantially exceeds statutory timelines for most IPP projects. North (1990) provides the theoretical grounding for understanding how weak institutional frameworks (including inadequate rule of law, corruption, and bureaucratic inefficiency) systematically elevate regulatory risk in developing country infrastructure investment. Ika et al. (2012) identify governance quality and institutional capacity as critical success factors for development projects in low-income countries, a finding directly applicable to Nepal's IPP regulatory environment.

2.6.5 External Risks

Nepal's geologically active Himalayan setting creates an elevated external risk environment for hydropower development. Ansar et al. (2014) and Kumar and Katoch (2016) document the disproportionate financial consequences of unexpected ground conditions in tunnel and underground works, the most common civil work type in Nepal's run-of-river IPP projects. Bhattarai et al. (2024) document that adverse geological conditions are frequently encountered during tunnel excavation in Nepal's middle hill terrain, creating cost escalations that significantly exceed EPC contract contingencies. Force majeure risks (including seismic events, glacial lake outburst floods (GLOFs), and extreme rainfall events) are particularly material in Nepal following the 2015 Gorkha earthquake, which directly affected multiple hydropower projects under construction or operation. Bhattarai et al. (2024) note that force majeure provisions in Nepal's PPAs and concession agreements have been strengthened following the 2015 earthquake, but insurance coverage gaps and disputes over event classification continue to create financial uncertainty.

2.7 Existing Risk Mitigation Instruments in Nepal's IPP Hydropower Sector

Risk mitigation in Nepal's IPP hydropower sector relies on an interconnected set of contractual, financial, and insurance instruments that collectively form the risk management architecture of project finance transactions. The seven primary mitigation instruments identified in the KII survey for this study (Power Purchase Agreement (PPA), Power Development Agreement (PDA), Syndicated Credit Facilities

Agreement, Engineering, Procurement and Construction (EPC) Contract, Operation and Maintenance (O&M) Contract, Insurance Mechanisms, and Financial Hedging) are reviewed below, drawing exclusively on Nepal-specific studies, government reports, and sector assessments. Table 2.3 summarizes the mapping between mitigation instruments and the financial risk factors they primarily address.

Table 2.3 Risk Mitigation Instruments and Primary Financial Risks Addressed

S.N.	Mitigation Instrument	Primary Financial Risks Addressed
1	Power Purchase Agreement (PPA)	Off-taker risk; Tariff renegotiation risk; Revenue uncertainty; Hydrological variability
2	Power Development Agreement (PDA)	Delays in government approvals; Regulatory and policy risk; Contract termination; Lack of government guarantees; Tariff renegotiation
3	Syndicated Credit Facilities Agreement	Client inability to service debt; Delays in financial closure; Interest rate fluctuation; Inadequate investing capital; Weak financial market; Financial system crisis; Equity exit risk
4	Engineering, Procurement and Construction (EPC) Contract	Construction time overrun; Design and professional services cost escalation; Inflation-induced cost escalation; Adverse geological condition; High insurance premium
5	Operation and Maintenance (O&M) Contract	Operation and maintenance cost escalation; Adverse geological condition; Environmental compliance cost; High insurance premium
6	Insurance Mechanisms	Adverse geological condition; Force majeure risk; High insurance premium; Construction time overrun; Hydrological variability; Contract termination
7	Financial Hedging Instruments	Interest rate fluctuation; Currency exchange fluctuation; Client inability to service debt; Macroeconomic instability; Weak financial market; Inadequate investing capital

2.7.1 Power Purchase Agreement (PPA)

The Power Purchase Agreement is the foundational revenue-security instrument in Nepal's IPP hydropower sector. Under the PPA framework, NEA is contractually obligated to purchase electricity at a predetermined tariff for the duration of the concession period, typically 25–35 years. The PPA directly mitigates off-taker risk, tariff renegotiation risk, and revenue uncertainty by providing contractual certainty of revenue streams required for debt service. Pandey (2023) document that Nepal's PPA framework, while providing a degree of revenue certainty, has structural weaknesses including limited payment guarantee mechanisms and insufficient provisions for generation curtailment compensation. NEA's Annual Report (2024/25) confirms that current PPAs incorporate capacity payment provisions for projects affected by transmission bottlenecks, partially addressing the revenue risk from transmission delays, though payment delays from NEA remain a persistent concern for IPP developers.

2.7.2 Power Development Agreement (PDA)

The Power Development Agreement is a government-to-project company agreement that provides the overarching legal and regulatory framework for hydropower project development in Nepal, supplementing the PPA by addressing development risk, government obligations, and dispute resolution mechanisms. The PDA is granted by the Government of Nepal through the Department of Electricity Development and establishes the project's concession terms, land access rights, and applicable regulatory conditions. Pandey et al. (2023) emphasize that the PDA is critical for addressing political risk and regulatory change risk, as it creates legally enforceable government obligations regarding license continuity, access to land and water resources, and repatriation of investor proceeds. In Nepal, the PDA also governs the tariff renegotiation process at handover and provides the legal basis for government guarantee arrangements. DOED (2022) documents the evolution of PDA provisions in Nepal, noting that enhanced stabilization clauses and dispute resolution mechanisms have been progressively incorporated to reduce regulatory risk for private investors.

2.7.3 Syndicated Credit Facilities Agreement

Syndicated credit facilities represent the primary debt financing mechanism for large IPP hydropower projects in Nepal, wherein a lead arranger bank structures and distributes project debt among a consortium of domestic commercial banks and, in some cases, development finance institutions. The syndication structure is governed by a credit facilities agreement that specifies covenants, security arrangements, drawdown conditions, and lender rights. Nepal Rastra Bank's directed lending regulations require commercial banks to allocate a portion of their loan portfolios to productive sectors including hydropower, creating a mandated supply of project debt that supports syndication. Pandey et al. (2023) document that Nepal's syndicated credit market for hydropower is characterized by high floating interest rates (typically base rate plus spread), limited maximum tenors (generally 15–20 years against project lives of 25–35 years), and inadequate long-tenor domestic bond market alternatives. The credit facilities agreement incorporates DSCR covenants (typically minimum 1.2x), financial reporting requirements, and restriction covenants that provide lender protection against client inability to service debt and financial system risk. Bhattarai et al. (2024) identify delays in syndication as a primary cause of financial closure delays in Nepal, attributing these to complex inter-creditor negotiations, varying bank due diligence standards, and limited experienced project finance legal expertise.

2.7.4 Engineering, Procurement and Construction (EPC) Contract

The EPC contract is the primary contractual instrument for managing construction-phase financial risks in hydropower projects. Under a lump-sum, fixed-price EPC structure, the contractor assumes responsibility for design, procurement, construction, and commissioning at an agreed total price and within a specified schedule, providing the project company with certainty of construction cost and timeline exposure. EPC contracts in Nepal's hydropower sector typically incorporate liquidated damages provisions for schedule delay, performance guarantees for installed capacity and energy yield, and defects liability periods, creating financial accountability structures that partially transfer construction time overrun and cost escalation risks to the contractor. Bhattarai et al. (2024) analyze EPC contract performance on small hydropower projects in Nepal, finding that contractor program delays and rework costs are the most common financial risk materializations, with EPC contracts providing only partial financial protection due to contractor claims, limited contractor financial capacity, and gaps in contract enforcement. Pandey et al. (2023) note that many Nepalese IPP projects use hybrid contract structures rather than fully fixed-price EPC arrangements due to the limited number of contractors with both technical capability and financial capacity for full EPC lump-sum commitments, which reduces the risk-transfer effectiveness of the contractual structure.

2.7.5 Operation and Maintenance (O&M) Contract

The O&M contract governs the post-commissioning management and maintenance of hydropower facilities, transferring operational cost risk from the project company to a specialist operator when structured as a fixed-fee or performance-based arrangement. In Nepal, O&M contracts for IPP hydropower projects have evolved significantly, with increasing adoption of long-term performance-based contracts that align operator incentives with plant availability and energy output targets. Bhattarai et al. (2024) document that O&M cost management is a critical performance dimension for Nepal's small and medium hydropower projects, with sedimentation-induced turbine wear, spare parts procurement constraints, and trained operator availability being primary O&M cost escalation drivers in Nepal's remote mountain terrain. Nepal Electricity Authority (2023) identifies inadequate O&M provisions as a contributing factor to performance degradation in older IPP projects, underscoring the financial importance of robust O&M contractual arrangements.

2.7.6 Insurance Mechanisms

Insurance is a foundational risk transfer instrument in hydropower project finance, providing financial compensation for specified loss events in exchange for premium payments. Nepal's IPP hydropower sector employs multiple insurance products, including Construction All Risks (CAR) insurance covering damage to works under construction, Erection All Risks (EAR) insurance for electromechanical equipment, Advance Loss of Profits (ALOP) insurance providing delay-in-start-up coverage, and operational Property All Risks (PAR) and Business Interruption (BI) insurance. Political risk insurance and investment guarantee products from multilateral providers including MIGA (World Bank Group's Multilateral Investment Guarantee Agency) and the Asian Development Bank's investment guarantee facility are available for eligible IPP transactions in Nepal to cover non-commercial risks such as contract repudiation, expropriation, and currency transfer restrictions (Multilateral Investment Guarantee Agency [MIGA], 2013).

2.7.7 Financial Hedging Instruments

Financial hedging instruments, including interest rate swaps, currency forward contracts, cross-currency swaps, and inflation-linked financial products, provide contractual protection against adverse movements in financial market variables that affect project cash flows and debt service capacity. In Nepal's IPP context, financial hedging is employed primarily for interest rate and currency exchange risk management. Pandey et al. (2023) document that interest rate hedging in Nepal's hydropower sector is limited by the shallow domestic derivatives market and the absence of a liquid interest rate swap market in Nepalese rupees, though fixed-rate financing from development finance institutions (such as the World Bank's IDA, ADB, or bilateral lenders) provides a functional substitute for interest rate risk management on the portion of project debt denominated in foreign currency. Currency hedging for the import component of construction costs (primarily electromechanical equipment) is documented as a significant financial management challenge for Nepal's IPPs, as forward contract tenors available in Nepal's market are typically limited to less than 12 months, inadequate for the 3–7 year construction timelines of larger hydropower projects. Nepal Rastra Bank (2025) notes ongoing efforts to develop Nepal's foreign exchange derivatives market, though structural limitations in domestic market depth constrain the availability of adequate hedging instruments. Bhattarai et al. (2024) identify inadequate hedging of import cost currency exposure as a contributing factor to construction cost overruns in several Nepalese IPP projects.

2.8 The Analytic Hierarchy Process (AHP): Methodological Review

The Analytic Hierarchy Process, developed by Saaty (1980), is a structured multi-criteria decision-making methodology that decomposes complex decisions into a hierarchy of goals, criteria, and sub-criteria. Experts provide pairwise comparison judgments on Saaty's 1–9 fundamental ratio scale. This scale assigns numerical values to verbal judgments of relative importance, as presented in Table 2.4

Table 2.4 Saaty's Fundamental Scale of Absolute Numbers

Intensity of Importance	**Definition**
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very Strong Importance

9	Extreme Importance
2, 4, 6, 8	Intermediate Values
Reciprocals	Inverse comparisons

Priority weights are derived from the pairwise comparison matrices using the principal eigenvector method, as originally specified by Saaty (1980). For a given n × n pairwise comparison matrix A, the priority vector w is the normalized principal eigenvector corresponding to the largest eigenvalue λ_{max} of the matrix. The computational procedure involves the following steps:

1. Construct the pairwise comparison matrix A, where each element a_{ij} represents the relative importance of factor i over factor j.
2. Normalize the matrix by dividing each element by the sum of its column.
3. Compute the priority vector (local weights) as the row average of the normalized matrix.
4. Calculate λ_{max} as the average of the ratio of the weighted sum vector to the priority vector.
5. Compute the Consistency Index (CI) and Consistency Ratio (CR) as

Consistency Ratio Calculation and Threshold

A fundamental methodological requirement of AHP is that pairwise comparison matrices must satisfy an acceptable level of logical consistency. In practice, some inconsistency is inevitable and acceptable in complex multi-factor comparisons, but excessive inconsistency indicates arbitrary or random judgments that undermine the validity of derived weights.

The Consistency Ratio (CR) is computed for using the following formulas:

<u>Step 1: Calculate the Consistency Index (CI)</u>

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Where, λ_{max} is the principal eigenvalue of the comparison matrix and n is the matrix size (number of factors compared).

Step 2: Calculate the Consistency Ratio (CR)

$$CR = \frac{CI}{RI}$$

Where, RI is the Random Consistency Index for a matrix of size n, representing the average CI of randomly generated reciprocal matrices of the same size. The RI values used in this study follow Saaty's (1980) standard table, as reproduced in Table 2.5.

Table 2.5 Random Consistency Index (RI) Values by Matrix Size (Saaty, 1980)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

A CR value of ≤ 0.10 is considered acceptable in AHP applications (Saaty, 1980), indicating that the pairwise comparison matrix is sufficiently consistent to serve as a valid basis for weight derivation. In this study, all consensus matrices for both category-level and factor-level comparisons were verified to satisfy the CR < 0.10 requirement. This consistency validation provides important assurance of the methodological integrity and reliability of the derived priority weights.

AHP has been widely applied to hydropower and infrastructure risk prioritization. Wang et al. (2018) applied AHP for large hydropower projects in China; Kumar and Katoch (2016) applied it to run-of-river projects in the Himalayan region; Patel et al. (2021) applied it to hydropower risk management; and Sridharan et al. (2021) examined hydropower risk in the South Asian context. Hwang et al. (2013) applied AHP to PPP risk prioritization in Singapore, providing a methodological parallel for the present Nepal-focused study. AHP's flexibility, transparency, and adaptability to expert judgment under data scarcity make it particularly well-suited to Nepal's IPP hydropower context, where comprehensive historical financial data is not systematically available.

2.9 Chi-Square Test of Significance in AHP Studies

The Chi-Square Goodness-of-Fit test is a non-parametric statistical procedure used to determine whether an observed frequency distribution differs significantly from a theoretically expected distribution (Pearson, 1900). In its classical formulation, the test statistic is computed as the sum of squared differences between observed (O) and expected (E) frequencies, each divided by the expected frequency:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

The resulting statistic follows a chi-square distribution with degrees of freedom equal to k − 1, where k is the number of categories. If the computed χ^2 exceeds the critical value, which implies that the p-value is below the chosen significance level (conventionally $\alpha = 0.05$), it leads to rejection of the null hypothesis of no difference between observed and expected distributions (Cochran, 1952).

In the context of multi-criteria decision-making (MCDM) and AHP-based research, the chi-square test has been employed as a methodological validation tool to assess whether expert-derived priority weights reflect genuine discriminative judgment or approximate a random, uniform distribution. If experts were indifferent among all criteria, AHP weights would be approximately equal (i.e., uniformly distributed at 1/k each); a statistically significant departure from this uniform expectation confirms that the expert panel has produced a meaningful, non-arbitrary prioritization (Ho, 2008; Vaidya & Kumar, 2006). This application of the chi-square test provides an objective, statistical basis for validating the quality and discriminative power of AHP outputs, which is particularly important in studies where the number of expert respondents is small and the credibility of findings depends on demonstrating that the weights are not a product of random or indifferent judgment.

Several AHP-based infrastructure and energy risk studies have adopted significance testing to corroborate expert-derived results. Wang et al. (2018) applied chi-square tests to validate AHP priority weights for large hydropower project risks in China, confirming that the non-uniform weight distributions were statistically significant and not attributable to chance. Patel et al. (2021) employed a similar approach in their review of hydropower risk management, using statistical validation to strengthen the credibility of expert-elicited priority structures. In the infrastructure finance literature more broadly, Ho (2008) noted in a comprehensive review of AHP applications that statistical validation of weight distributions is an underutilized but methodologically sound practice that enhances the rigor of expert-judgment-based priority assessments.

2.10 Key Informant Interview (KII): Methodological Review

Key Informant Interview is a qualitative data collection technique in which in-depth interviews are conducted with purposively selected individuals whose professional experience makes them uniquely positioned to provide contextually grounded insights. KII has been employed extensively in development-oriented infrastructure research and sector assessment contexts where specialized, context-dependent knowledge is required. In hydropower and energy sector research, KII is employed to capture practitioner perspectives on risk materialization and institutional dynamics not accessible through documentary sources alone.

The combination of KII with structured Likert-scale assessments (as employed in this study for likelihood and mitigation effectiveness ratings) represents a hybrid approach that captures both qualitative practitioner knowledge and the quantitative precision required for index construction. This approach is consistent with composite indicator construction guidelines (Organisation for Economic Co-operation and Development [OECD], 2008) and with established practice in infrastructure risk assessment instruments documented by Grimsey and Lewis (2002) and Delmon (2017), who similarly employ expert-rated Likert assessments for risk likelihood and impact in infrastructure project contexts.

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CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Methodology

The research methodology follows a structured approach. The first step before starting the actual research process was to identify the research concept, based on the identification of problems which then highlighted the need for this research. The objectives for this research were set, which defined the study's scope and purpose. The research objectives were based on the research questions. Next, a research design was developed which included the development of a research flowchart. The research flowchart acts as the roadmap that guides the research process by outlining the key concepts, variables, and their relationships. The flowchart further guided the process of data collection as well as data analysis. The data collection phase involved gathering the relevant data from primary and secondary sources. The collected data was then processed, analyzed and then interpreted to get a meaningful result. The findings are presented and their implications are critically examined in the results and discussion phase. The study ends with conclusions and recommendations that highlight the main lessons learnt and offer ideas for further research. The literature study was done in all the phases and it served as a theoretical foundation for the process, and the consultation with the supervisor guaranteed the quality and usefulness of the research. Figure 3.1 shows the general methodology used in this research.

3.2 Research Approach

This study adopts a mixed-methods research approach, combining quantitative and qualitative data collection and analysis procedures within a single integrated design. The mixed-methods approach is appropriate for this study because neither a purely quantitative nor a purely qualitative approach would be sufficient to address all three research objectives. Quantitative procedures are required to derive numeric priority weights, compute composite indices, and produce statistically comparable results, while qualitative procedures are required to capture the contextual knowledge, professional judgment, and experiential insights of practitioners that cannot be obtained from secondary data or structured surveys alone (Creswell & Creswell, 2018).

The quantitative component of the study is dominant and comprises two main procedures. First, the Analytic Hierarchy Process (AHP) is applied to pairwise comparison data collected from five domain experts to produce quantitative priority weights for financial risk categories and individual risk factors. Second, numerical scores collected through the Key Informant Interview (KII) instrument are used to compute the composite Financial Risk Index (FRI), the Mitigation Score (MS), and the Residual FRI. These indices are expressed on a continuous 0–1 scale and classified against defined interpretation bands, producing quantitative outputs that can be benchmarked and communicated to investors, lenders, and policymakers.

The qualitative component is embedded within the KII instrument design and data collection process. Although KII ratings are ultimately converted to numerical scores, the semi-structured interview format allowed five key informants to elaborate on their ratings, explain contextual factors influencing their assessments, and provide practitioner insights that enrich the interpretation of the quantitative results. This qualitative dimension ensures that the numerical outputs are grounded in the practical realities of Nepal's IPP hydropower sector rather than abstracted from it.

3.3 Research Design

Research design is the blueprint for conducting the study. It is a strategy developed to address the research questions. It involves developing a research path by identifying the major variables, defining the population, and selecting the sampling methods. The research flowchart illustrated in Figure 3.2 gives a clear picture of the research design of this study.

The overall research process is divided into three interconnected stages aligned with the study objectives:

Identification and Prioritization of Financial Risk Factors (Objective 1)

The study begins with an extensive literature review to identify and categorize relevant financial risk factors. These factors are then validated through industry experts to ensure contextual relevance to hydropower projects in Nepal. Subsequently, the Analytical Hierarchy Process (AHP) is applied to determine the relative importance of each risk factor and category. A consistency check is performed using the Consistency Ratio ($CR < 0.1$) to ensure reliability of expert judgments. If the consistency condition is not satisfied, responses are revised. The final outputs of this stage include relative weights of risk categories and factors which give the priority rankings of financial risks

Quantification of Financial Risk (Objective 2)

To assess the severity of identified risks, Key Informant Interviews (KII) are conducted with experts using a structured Likert-scale questionnaire. Experts provide likelihood scores for each risk factor, which are then aggregated to compute the Financial Risk Index (FRI). This index reflects the overall exposure level of each financial risk based on its probability of occurrence.

Assessment of Mitigation Measures and Residual Risk (Objective 3)

Parallel to risk identification, mitigation instruments are identified through literature review and expert inputs. Using KII, experts evaluate the effectiveness of mitigation measures for each risk factor. Based on these responses a Mitigation Score is calculated to quantify the strength of each mitigation strategy. The Mitigation Score is integrated with the Financial Risk Index to derive the Residual Financial Risk Index, representing the remaining risk after applying mitigation measures.

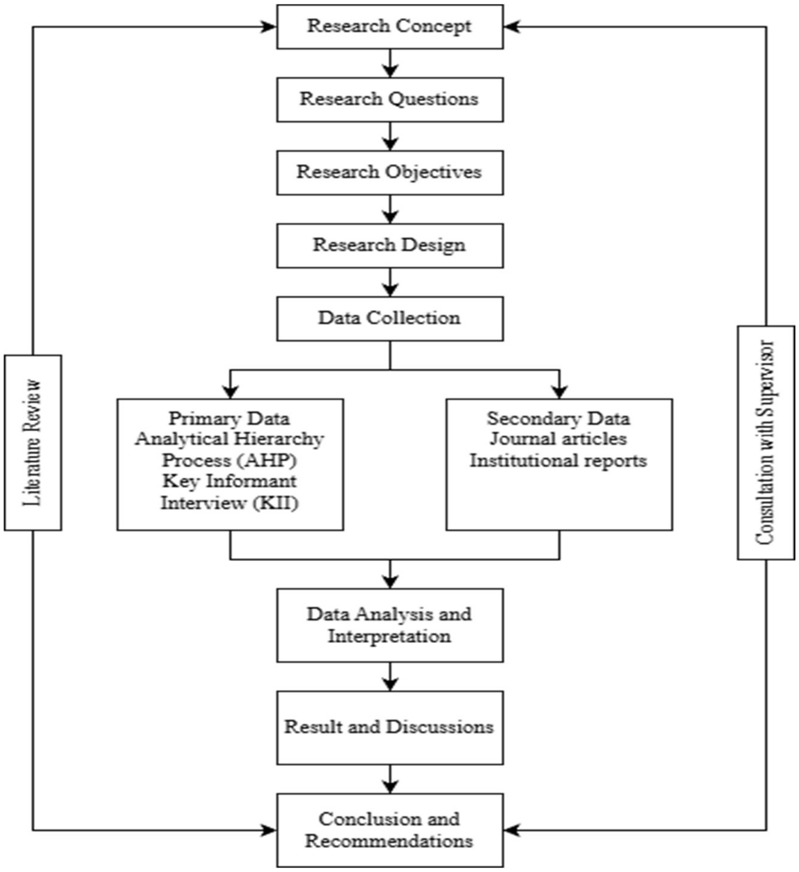


Figure 3.1 Research Methodology

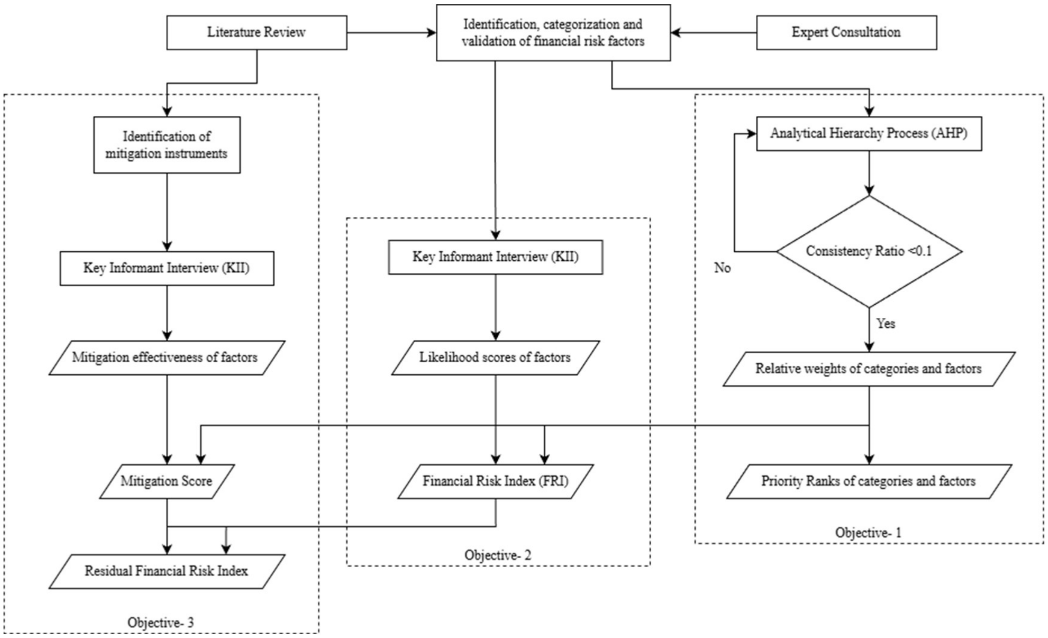


Figure 3.2 Research Flowchart

3.4 Study Area

The study area is Nepal's Independent Power Producer (IPP) hydropower sector, encompassing all privately developed hydropower projects that operate under Power Purchase Agreements (PPAs) with the Nepal Electricity Authority (NEA) under a Build-Own-Operate-Transfer (BOOT) concession framework.

Geographically, IPP hydropower projects are distributed across Nepal's diverse hydrological and topographical zones, spanning the high Himalayan region in the north, the mid-hill zone, and the Siwalik foothills. The majority of currently operational and under-development IPP projects are run-of-river schemes located in the mid-hill river systems, including the Trishuli, Marsyangdi, Tamakoshi, Sun Koshi, and Karnali river basins, as well as their numerous tributaries. These projects typically range in installed capacity from 1 MW to 500 MW, are financed through project finance structures with debt-to-equity ratios of 70:30 to 75:25, and operate under concession periods of 25 to 35 years. The study does not focus on a single project or geographic sub-region but treats the entire national IPP sector as the unit.

3.5 Study Population, Sampling and Sample Size

The study population comprises professionals with direct and substantive engagement in the development, financing, regulation, or operation of IPP hydropower projects in Nepal. This population spans three distinct professional groups: private sector IPP developers and project sponsors, financial sector professionals including bankers and investment analysts involved in hydropower project financing, and public sector professionals in institutions directly responsible for hydropower regulation, power procurement, and sector oversight, including the Nepal Electricity Authority (NEA) and the Department of Electricity Development (DOED). Given the specialized nature of IPP project finance and the limited number of professionals with the requisite depth of experience in Nepal's sector, the study population is inherently small and geographically concentrated, with the majority of relevant professionals based in Kathmandu.

This study employs purposive sampling in which participants are deliberately selected on the basis of specific criteria relevant to the research objectives rather than through random selection (Creswell & Creswell, 2018). Purposive sampling is appropriate for this study because the research requires respondents with highly specialized knowledge of IPP project finance, risk management, and sector operations in Nepal, knowledge that is not uniformly distributed across the general population of hydropower professionals but is concentrated in a small subset of experienced senior practitioners. Random sampling from the broader population of hydropower professionals would risk including respondents whose experience does not extend to the financial risk dimensions central to this study, thereby compromising the quality and credibility of the expert judgments on which the AHP and KII analyses depend.

The expert validation panel comprised five respondents. A panel of five is consistent with established practice in expert-based risk factor validation studies in infrastructure research, where a majority rule threshold (consensus among at least three of five experts) provides a defensible and replicable decision criterion for factor retention (Hwang, et al., 2013).

The AHP expert panel also comprised five respondents. AHP literature consistently demonstrates that panels of five to eight carefully selected domain experts produce reliable and stable priority weights, and that increasing panel size beyond this range yields diminishing returns in weight stability when members are homogeneous in expertise (Saaty & Peniwati, 2013). Individual administration of pairwise comparison matrices to each expert independently ensures that each judgment reflects the expert's own assessment without anchoring effects from group discussion.

The KII key informant panel comprised five respondents. In qualitative and mixed-methods research, purposive samples for key informant interviews are typically small, as the objective is depth and credibility of insight rather than statistical representativeness (Kumar, 2007). Five key informants with senior-level, direct IPP experience in Nepal were judged sufficient to provide the practitioner-based likelihood and mitigation effectiveness assessments required for the FRI, MS, and Residual FRI computations, particularly given the convergence of responses observed across informants during data collection

3.6 Data Collection

3.6.1 Primary Data Collection

Primary data for this study were collected through two structured instruments administered to separate panels of purposively selected respondents: an Analytical Hierarchy Process (AHP) questionnaire and a Key Informant Interview (KII).

The first primary data collection instrument was the AHP pairwise comparison questionnaire, administered to a panel of five domain experts to elicit comparative judgments about the relative importance of financial risk categories and individual risk factors. The instrument presented all required pairwise comparisons using Saaty's nine-point fundamental scale, and was administered individually to prevent group anchoring effects and ensure the independence of each expert's judgments.

The second primary data collection instrument was the Key Informant Interview (KII) questionnaire, structured in two modules and administered to five key informants with direct IPP project experience in Nepal. Module 1 collected likelihood ratings for each of the 29 validated financial risk factors on a 1–5 Likert scale, while Module 2 collected effectiveness ratings for seven identified risk mitigation instruments across all 29 factors. KII sessions were conducted through individual semi-structured interviews lasting approximately 60 to 90 minutes each, allowing informants to elaborate on their ratings and provide contextual insights where appropriate. The AHP and KII questionnaire instruments are shown in Appendix 4, 7-8 respectively.

3.6.2 Secondary Data Collection

Secondary data were collected through a systematic review of published literature, sector reports, policy documents, and regulatory frameworks relevant to financial risk in hydropower project finance and Nepal's IPP sector specifically. Secondary data served two distinct purposes in this study: first, to identify the initial population of candidate financial risk factors through a structured review of the academic and grey literature; and second, to identify the existing risk mitigation instruments currently available and employed in Nepal's IPP hydropower sector.

The secondary data sources utilized in this study comprised four main categories. The first category consisted of peer-reviewed academic journal articles in infrastructure finance, project risk management, energy economics, and hydropower development, accessed through databases including Scopus, Web of Science, and Google Scholar. The second category consisted of grey literature including reports and working papers published by multilateral institutions (World Bank, Asian Development Bank, International Finance Corporation, International Hydropower Association) and national bodies (Nepal Electricity Authority, Water and Energy Commission Secretariat, Department of Electricity Development). The third category comprised Nepal-specific policy and regulatory documents, including the Electricity Act (2018), the Electricity Regulation (2018), and NEA annual and quarterly reports. The fourth category included project-level documentation such as publicly available project information memoranda, environmental impact assessments, and sector assessments for specific IPP projects in Nepal.

Secondary data collection followed a structured protocol designed to ensure comprehensiveness and reproducibility. For the identification of financial risk factors, the literature review encompassed studies published between 1990 and 2024, using a combination of keyword searches (financial risk, hydropower, IPP, project finance, developing countries, Nepal) and citation tracking to identify seminal and recent contributions. For the identification of mitigation instruments, the review was specifically focused on Nepal's hydropower sector, prioritizing documents describing the contractual, financial, and insurance structures commonly employed in Nepali IPP transactions. All identified secondary sources are cited in the References section of this thesis.

3.7 Data Analysis

3.7.1 Prioritization of Financial Risk Factors

Thematic Synthesis and Content Analysis

Prior to the primary data collection phases, a systematic thematic and content analysis of the existing academic literature, sector reports, and policy documents was conducted to identify and organize the financial risk factors relevant to IPP-developed hydropower projects in Nepal. Published studies, multilateral institution reports, and Nepal-specific hydropower sector assessments were reviewed and coded thematically to extract risk factors, which were then categorized into five broad thematic groupings based on their nature and financial implications. This process produced an initial inventory of 33 candidate financial risk factors, the full list of which is presented in Table 2.1, and their subsequent categorization into five risk categories is presented in Table 2.2. The thematic and content analysis findings from the literature directly informed the design of the expert validation instrument and served as the input to the AHP pairwise comparison exercise described in the sub-sections that follow.

Validation of Financial Risk Factors

The validation rule applied in this study was that a factor was retained if at least three out of five experts (i.e., a majority of $\geq 60\%$) judged it to be relevant. This threshold was selected to ensure that the retained factors reflected broad expert consensus while avoiding the exclusion of factors recognized as significant by the majority of the expert panel. Factors receiving fewer than three expert validations were excluded from further analysis on the grounds that they lacked sufficient expert-endorsed relevance to Nepal's specific IPP hydropower context. The demographic information of the experts for factor validation is shown in Appendix 1 and the complete report of validation from the five experts is documented in Appendix 2.

The application of this validation rule resulted in the retention of 29 financial risk factors and the exclusion of 4 factors. The 29 validated factors, distributed across the five risk categories, formed the basis for all subsequent analyses.

Analytical Hierarchy Process

A separate panel of five hydropower sector professionals with direct experience in IPP project development, investment, and management was recruited for the AHP pairwise comparison exercise. The demographic information of the experts for AHP Analysis is shown in Appendix 3.

The AHP hierarchy for this study was structured across three levels:

- Goal Level (Level 1): Prioritization of Financial Risk Factors in IPP-Developed Hydropower Projects in Nepal.
- Criteria Level (Level 2): Five financial risk categories (Cost-Related Risks, Revenue and Market Risks, Financing Risks, Regulatory and Institutional Risks, and External Risks) serving as the primary decision criteria.
- Sub-Criteria Level (Level 3): The 29 validated financial risk factors, distributed under their respective risk categories, serving as sub-criteria within each category's comparative judgment.

This three-level hierarchy enabled the derivation of both category-level weights (from Level 2 comparisons) and factor-level weights within each category (from Level 3 comparisons), which were subsequently combined through multiplication to yield global priority weights for all 29 risk factors on a common scale summing to unity.

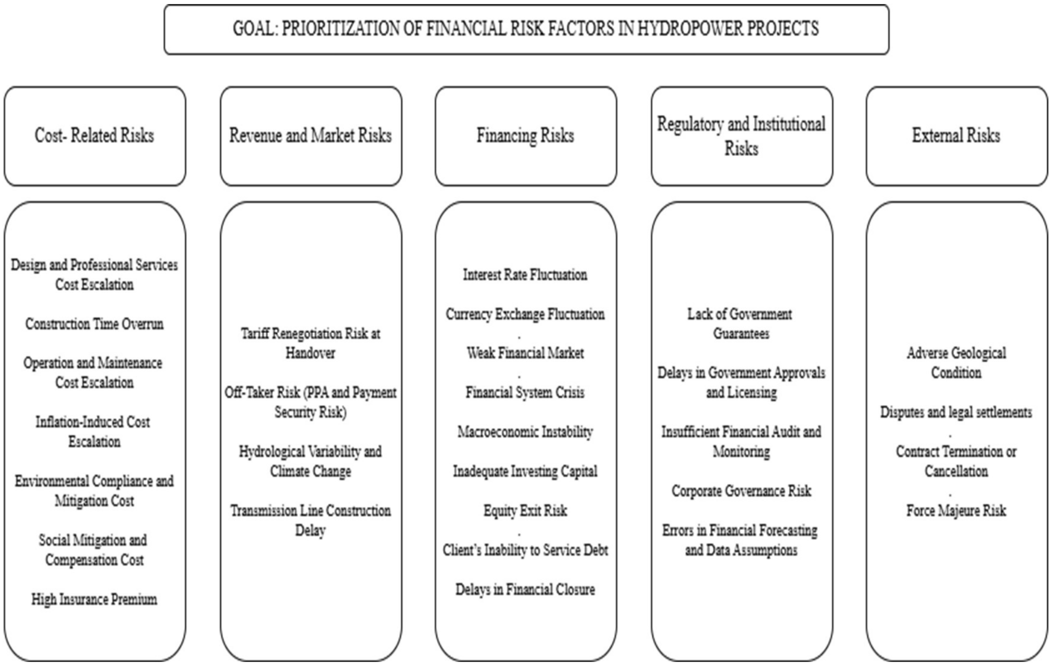


Figure 3.3AHP Hierarchy

For each pairwise comparison matrix at the category and sub-category levels, structured questionnaires in the form of pairwise comparison matrices were distributed to each expert individually. The detailed questionnaire administered to the experts is shown in Appendix 4. The questionnaires were accompanied by detailed instructions explaining the AHP methodology, the meaning of the comparison scale, and illustrative examples to ensure uniform interpretation of the scaling convention. Priority weights were derived from the pairwise comparison matrices using the principal eigenvector method, as originally specified by Saaty (1980).

The global priority weight of each factor was computed by multiplying its local weight within the category (derived from Level 3 comparisons) by the weight of the corresponding category (derived from Level 2 comparisons):

Global Weight = Local Weight × Category Weight

This multiplicative aggregation ensures that the global weights reflect both the relative importance of the risk category and the relative importance of the factor within that category, producing a unified hierarchical weighting structure that sums to unity across all 29 factors.

Aggregation of Individual Judgments

Given that the AHP was administered to five individual experts, individual pairwise comparison matrices needed to be aggregated into a single consensus matrix before deriving priority weights. This study employed the Aggregation of Individual Judgments (AIJ) approach using the geometric mean method, as recommended by Saaty and Peniwati (2013) for group AHP applications.

The geometric mean aggregation was applied element-wise to the individual comparison matrices: for each element position (i, j) in the consensus matrix, the aggregated value was computed as the geometric mean of the corresponding values across all n expert matrices:

$$a_{\mathrm{ij}} = \sqrt[n]{a_{\mathrm{ij}}{}^{1} \times a_{\mathrm{ij}}{}^{2} \times \ldots \times a_{\mathrm{ij}}{}^{n}}$$

The geometric mean is preferred over the arithmetic mean for aggregating ratio-scale AHP judgments because it preserves the reciprocal property of pairwise comparison matrices and is less sensitive to extreme values in individual expert judgments. The resulting consensus matrix was then used as the basis for all eigenvector calculations and consistency testing.

The Consistency Ratio (CR) was computed for each pairwise comparison matrix and the calculation of CR for all the six matrices in this study is documented in Appendix 5.

Chi-Square test of Attributes

To validate that the AHP-derived priority weights reflect genuine expert discrimination rather than random or indifferent assignment, a Chi-Square Goodness-of-Fit test was applied to the six (one for category, and five for factors within categories) AHP priority weight distributions.

For each dataset, the null hypothesis (H_0) states that all items carry equal weight (1/k, where k is the number of items), while the alternative hypothesis (H_1) states that at least one weight differs significantly from this uniform expectation. The significance level adopted is $\alpha = 0.05$.

AHP weights are proportions summing to 1.00. To convert them to frequencies, each weight was multiplied by a scaling factor N = 100, yielding an observed frequency $O_i = W_i \times 100$ for each item i. The expected frequency under H_0 is $E_i = 100/k$ for all items.

3.7.2 Development of the Financial Risk Index (FRI)

The Financial Risk Index (FRI) was constructed as a weighted composite of the normalized likelihood scores for each financial risk factor, with weights derived from the AHP analysis. The FRI integrates the importance of each risk factor (as measured by AHP priority weights) with the probability of its occurrence (as assessed by key informants), yielding a single composite metric that reflects both the structural significance and the empirical likelihood of financial risk materialization across the 29 factors.

Five key informants were selected using purposive, criterion-based sampling. Selection criteria emphasized breadth and depth of practical engagement with hydropower project finance, risk management, and operational management across the full project lifecycle. The specific criteria applied in informant selection were:

- Minimum of 10 years of professional experience in Nepal's hydropower sector.
- Direct involvement in at least one IPP hydropower project in a senior technical, financial, or management role.
- Familiarity with the financial management, risk allocation, and contractual arrangements characteristic of Nepal's IPP project finance structure.
- Exposure to multiple project development stages, from pre-feasibility and financing through construction and operations.

The demographic information of the key informants is presented in Appendix 6. The informant panel represents diverse professional trajectories within Nepal's hydropower sector, spanning roles in civil engineering, project management, investment, and contract administration.

KII Instrument Design

The KII instrument consisted of a structured questionnaire administered in individual semi-structured interview settings. The detailed questionnaire administered to the key informants is shown in Appendix 7. Key informants were asked to rate the likelihood of occurrence of each of the 29 validated financial risk factors over the typical lifecycle of an IPP hydropower project in Nepal. Ratings were provided on a five-point Likert scale anchored as follows:

Table 3.1 Likelihood Rating Scale for KII

Score	**Verbal Descriptor**	**Normalized Value**
1	Very Unlikely	0.20
2	Unlikely	0.40
3	Moderately Likely	0.60
4	Likely	0.80
5	Very Likely	1.00

Financial Risk Index (FRI) Formula

The FRI is defined by the following formula:

$$FRI = \sum_{i} (W_i \times L_i^{norm})$$

Where:

- W_i = global priority weight of risk factor i, derived from the AHP analysis ($\Sigma W_i = 1$)
- L_i^{norm} = normalized likelihood score for risk factor i, computed as the arithmetic mean of key informant ratings divided by 5 (the maximum possible rating)
- The summation is taken over all (i = 1, 2, ..., 29) validated financial risk factors

The FRI is bounded between 0 and 1. A value of 0 would indicate that all risk factors are assessed as having zero likelihood of occurrence (hypothetically impossible given the current sector environment), while a value of 1 would represent a scenario in which all risk factors are assessed as having maximum likelihood (Very Likely) and receive equal maximum importance weight. The interpretation of FRI values follows the classification scheme presented in Table 3.2.

Table 3.2 Financial Risk Index (FRI) Interpretation Scale

FRI Value Range	**Risk Classification**
0.0 – 0.2	Very Low Risk
0.2 – 0.4	Low Risk
0.4 – 0.6	Moderate Risk
0.6 – 0.8	High Risk
0.8 – 1.0	Very High Risk

The classification boundaries in Table 3.2 are defined by equal-interval partitioning of the [0, 1] index range, consistent with standard practice in composite index construction (OECD, 2008). Each class represents a qualitatively distinct level of financial risk exposure, from Very Low Risk (where identified risk factors are assessed as having very low probability of materialization relative to their importance) to Very High Risk (where high-importance risk factors are also assessed as having very high likelihood of occurrence).

3.7.3 Computation of the Mitigation Score (MS) and Residual Financial Risk Index

KII Instrument Design

The same set of five key informants as interviewed for the development of FRI were asked to assess the effectiveness of currently available risk mitigation instruments in reducing the financial impact of each of the 29 risk factors, again on a five-point Likert scale. The detailed questionnaire administered to the key informants is shown in Appendix 8.

Table 3.3 Mitigation Effectiveness Rating Scale for KII

Score	**Verbal Descriptor**	**Normalized Value**
1	Not Effective	0.20

2	Slightly Effective	0.40
3	Moderately Effective	0.60
4	Highly Effective	0.80
5	Very Effective	1.00

The normalization of Likert scale scores was performed by dividing each raw score by the maximum possible score (5), mapping all scores to the [0, 1] interval. The average normalized likelihood and mitigation effectiveness scores across the five key informants were computed for each risk factor.

Mitigation Score (MS)

The Mitigation Score (MS) quantifies the aggregate effectiveness of existing risk mitigation instruments across all 29 financial risk factors, weighted by the global importance of each factor as derived from the AHP. It is computed as:

$$MS = \sum_{i} (W_i \times E_i^{norm})$$

Where:

- W_i = global priority weight of risk factor i (from AHP)
- E_i^{norm} = normalized mitigation effectiveness score for risk factor i, computed as the arithmetic mean of key informant ratings divided by 5

The MS is similarly bounded between 0 and 1, where 0 indicates a complete absence of effective mitigation for any risk factor and 1 represents perfect mitigation effectiveness across all factors. The interpretation scale for the MS is presented in Table 3.4.

Table 3.4 Mitigation Score (MS) Interpretation Scale

MS Value Range	**Effectiveness Classification**
0.0 – 0.2	Not Effective

0.2 – 0.4	Slightly Effective
0.4 – 0.6	Moderately Effective
0.6 – 0.8	Highly Effective
0.8 – 1.0	Very Effective

The MS provides a sector-level assessment of the adequacy of the current risk management toolkit. A high MS would indicate that the existing package of contractual provisions, financial instruments, insurance products, and institutional support mechanisms effectively reduces financial risk exposure, while a low MS would signal a systemic gap between the financial risks faced by Nepal's IPP sector and the protection afforded by available mitigation instruments.

Residual Financial Risk Index

The Residual Financial Risk Index (FRI_residual) integrates the pre-mitigation financial risk (captured in the FRI) with the mitigation effectiveness (captured in the MS) to derive a composite measure of the financial risk exposure that persists after the application of existing mitigation instruments. It represents the 'net' or 'residual' financial risk facing Nepal's IPP hydropower sector and provides a direct measure of the degree to which current risk management instruments are sufficient to reduce financial risk to manageable levels.

The FRI_residual is computed factor by factor, using both the normalized likelihood score and the normalized mitigation effectiveness score for each factor, combined with AHP weights:

$$FRI\_residual = \sum_{i} (W_i \times L_i^{norm} \times (1 - E_i^{norm})$$

Where:

- W_i = global AHP weight of risk factor i
- L_i^{norm} = normalized likelihood score for risk factor i
- E_i^{norm} = normalized mitigation effectiveness score for risk factor i

- $(1 - E_i^{norm})$ = the residual risk proportion after mitigation, representing the fraction of risk not addressed by existing instruments

The term $(1 - E_i^{norm})$ is the key innovation of the Residual FRI formulation. For a factor with perfect mitigation effectiveness ($E_i^{norm} = 1.0$), the residual contribution to FRI is zero, indicating complete risk neutralization. For a factor with zero mitigation effectiveness ($E_i^{norm} = 0$), the residual contribution equals the full pre-mitigation contribution ($W_i \times L_i^{norm}$). For intermediate effectiveness values, the residual contribution is proportionally reduced.

The FRI_residual uses the same classification bands as the FRI (Table 3.2), enabling direct comparison of pre and post-mitigation risk levels. The absolute reduction (FRI − FRI_residual) and percentage reduction [(FRI − FRI_residual) / FRI × 100] are reported as measures of aggregate mitigation effectiveness across the sector.

3.8 Research Matrix

Table 3.5 presents the research matrix of this study, summarizing the alignment between research objectives, data sources, data collection methods, analytical tools, and expected outputs for each stage of the research.

Table 3.5 Research Matrix

Research Objective	**Sub-stage**	**Data Source**	**Data Collection**	**Data Analysis**	**Expected Output**
Objective 1: To prioritize financial risk factors affecting IPP-developed hydropower projects in Nepal	Stage 1: Identification	Academic literature; World Bank/ADB reports; NEA annual reports; Nepal-specific hydropower studies	Systematic literature review	Thematic synthesis and content analysis	Categorized financial risk factors
	Stage 2: Validation	5 senior hydropower professionals	Dichotomous expert validation questionnaire	Majority rule: retention if >= 3/5 experts agree	Validated financial risk factors
	Stage 3: Prioritization	Separate panel of 5 IPP sector experts	AHP pairwise comparison questionnaire	AHP: eigenvector method; geometric mean AIJ; CR less than 0.10; Chi-square test	Local and global priority weights; ranked risk factors and categories
Objective 2: To develop a composite Financial Risk Index (FRI) for IPP-developed	Single stage	5 key informants with direct IPP project experience in Nepal	KII: structured Likert questionnaire	FRI = Sum of (Wi x Li_norm); weighted composite index	Composite FRI (0-1); sector financial risk classification on five-band scale

hydropower projects in Nepal					
Objective 3: To evaluate the effectiveness of existing risk mitigation instruments and quantify residual financial risk	Stage 1: Instrument identification from literature	Academic literature and Nepal-specific hydropower sector reports and policy documents	Systematic literature review focused on Nepal hydropower sector mitigation instruments	Thematic review and synthesis	Identified Mitigation Instruments
	Stage 2: Effectiveness assessment	Same 5 key informants, assessing the mitigation instruments	KII: structured Likert questionnaire	MS = Sum of (Wi x Ei_norm); FRI_residual = Sum of [Wi x Li_norm x (1-Ei_norm)]	Composite Mitigation Score (five-band scale); Residual FRI; % risk reduction

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Prioritization of Financial Risk Factors Affecting IPP-Developed Hydropower Projects in Nepal

This section presents the results of the Analytic Hierarchy Process (AHP) analysis conducted to achieve the first research objective. Results are reported at three levels: category-level priority weights, factor-level local and global weights within each category, and the overall global ranking of all 29 factors. The section concludes with the chi-square validation of the AHP prioritization hierarchy.

4.1.1 Prioritization of Financial Risk Categories

Table 4.1 presents the derived priority weights and rankings of the financial risk categories.

Table 4.1 Priority Weights and Rankings of Financial Risk Categories

Rank	**Financial Risk Category**	**Priority Weight**
1	Cost-Related Risks	0.3606
2	Regulatory and Institutional Risks	0.2517
3	Revenue and Market Risks	0.1844
4	Financing Risks	0.1422
5	External Risks	0.0611

The category-level pairwise comparison matrix yielded a Consistency Ratio (CR) of 0.0106, well within the acceptable threshold of 0.10 (Saaty, 1980), confirming the logical consistency of the aggregated expert judgments at the category level. A chi-square goodness-of-fit test ($N = 100$) applied to the five category weights returned $\chi^2 = 25.671$ ($p\text{-value} = 3.69 \times 10^{-5} < 0.05$). This result confirms that the category weight distribution is statistically non-uniform: the experts did not assign equal importance to all five categories, and the observed concentration of weight in Cost-Related and Regulatory risks is unlikely to have arisen by chance.

Cost-Related Risks attained the highest priority weight of 0.3606. This finding signifies that, in the collective judgment of the AHP panel, project cost dynamics, including construction cost overruns, operation and maintenance escalation, and compliance-related expenditures, represent the most critical financial risk domain for Nepal's IPP hydropower sector. This result is consistent with the characteristics of run-of-river and storage hydropower projects in Nepal, where the combination of difficult terrain, remote site access, extended construction timelines, and complex resettlement obligations creates exceptional cost uncertainty.

Regulatory and Institutional Risks ranked second with a priority weight of 0.2517, reflecting the significant influence that governance quality, approval processes, and institutional framework exert on hydropower project financial outcomes. Nepal's regulatory environment for hydropower is characterized by multi-agency licensing requirements, frequent changes in regulatory policy, and limited transparency in government decision-making, all of which create material financial risks for IPP developers. The relatively high weighting of this category, second only to Cost-Related Risks, underscores expert recognition that institutional and governance factors are not merely background conditions but active sources of financial loss.

Revenue and Market Risks ranked third with a weight of 0.1844. This category captures the financial risks associated with electricity off-take, hydrological variability, and infrastructure connectivity. The prominence of this category reflects Nepal's electricity market structure, in which Nepal Electricity Authority (NEA) acts as the sole off-taker under Power Purchase Agreements (PPAs), creating significant counterparty concentration risk. Furthermore, Nepal's hydropower generation is highly sensitive to seasonal hydrological variability and the accelerating effects of climate change on glacial and rainfall patterns, both of which affect revenue predictability.

Financing Risks ranked fourth with a weight of 0.1422. Although financing-related factors such as interest rate fluctuation, currency exchange risk, and difficulties in achieving financial closure are inherently significant in capital-intensive infrastructure projects, the panel's relatively lower weighting of this category compared to cost and regulatory risks suggests that expert perception attributes primary financial risk to operational and institutional factors rather than to capital market conditions alone. Nonetheless, Nepal's underdeveloped domestic financial markets, high dependence on development finance institutions, and limited access to long-tenor debt remain important structural vulnerabilities.

External Risks received the lowest priority weight of 0.0611, encompassing geological hazards, force majeure events, contractual disputes, and legal settlements. While these risks are acknowledged as material in absolute terms, particularly given Nepal's seismic activity and challenging geological conditions, the expert panel's judgment reflects that such risks, while potentially severe, occur with lower frequency and are often partially addressed through insurance and contractual provisions compared to the systemic risks captured in higher-ranked categories.

4.1.2 Prioritization of Financial Risk Factors within Categories

Within each risk category, pairwise comparisons among constituent risk factors yielded local priority weights that reflect the relative importance of each factor within its category.

Cost-Related Risk Factors

Table 4.2 presents the local priority weights for the seven Cost-Related Risk factors.

Table 4.2 Priority Weights of Cost-Related Risk Factors

Rank	Risk Factor	Weight
1	Construction Time Overrun	0.3741
2	Operation and Maintenance Cost Escalation	0.1599
3	Social Mitigation and Compensation Cost	0.1398
4	Environmental Compliance and Mitigation Cost	0.1111
5	Inflation-Induced Cost Escalation	0.0887
6	High Insurance Premium	0.0749
7	Design and Professional Services Cost Escalation	0.0516

The pairwise comparison matrix for Cost-Related Risk factors yielded a Consistency Ratio (CR) of 0.0104, well below the acceptable threshold of 0.10, confirming the logical coherence of expert judgments. The chi-square goodness-of-fit test (N = 100) returned $\chi^2 = 49.458$ (p-value = $6.038 \times 10^{-9} < 0.05$), which confirms that the weight distribution is statistically non-uniform and reflects genuine expert prioritization.

Construction Time Overrun emerged as the dominant factor within Cost-Related Risks, capturing a weight of 0.3741. This outcome is attributable to the multi-dimensional financial consequences of construction delays in hydropower projects, which include escalated labor and material costs, extended debt servicing periods without corresponding revenue generation, potential PPA default penalties, and loss of investor confidence. In Nepal, delays are exacerbated by seasonal flooding, supply chain disruptions in remote terrain, community resettlement disputes, and protracted permit renewals. A single year of construction delay can increase total project costs by 15–25% through interest during construction (IDC) accumulation. This finding is strongly corroborated by Ansar et al. (2014), whose global study of large hydropower projects found that actual costs exceeded appraisal estimates by an average of 96%, with schedule overruns being the dominant driver.

Operation and Maintenance (O&M) Cost Escalation ranked second within the category, with a weight of 0.1599. Nepal's hydropower projects face pronounced O&M cost uncertainty due to high sedimentation loads in Himalayan rivers, which cause accelerated turbine erosion, the necessity of specialized maintenance expertise often imported at premium cost, and the high elevation and remoteness of many project sites. The long operational lifespans of hydropower plants (typically 30–50 years) mean that even modest annual escalation in O&M costs compounds significantly over the project lifecycle. Bhattarai et al. (2024) specifically identified O&M cost escalation as a persistent financial challenge for run-of-river projects in Nepal, attributing it to the underestimation of sediment-related wear in feasibility studies.

Social Mitigation and Compensation Cost ranked third (0.1398), reflecting the growing significance of community relations and resettlement costs. Community opposition to land acquisition and resettlement, combined with increasingly assertive demands for local employment, infrastructure development, and equity participation, have materially elevated the social cost of hydropower development.

Environmental Compliance and Mitigation Cost (weight: 0.1111) reflects the increasing rigor of Nepal's environmental impact assessment requirements and the financial burden of implementing environmental management plans. Costs associated with fish passage facilities, minimum flow maintenance, biodiversity offset programs, and debris management have grown substantially with tightening compliance standards from both national regulators and international lenders (particularly IFC Performance Standards and Equator Principles). The remaining cost factors. Inflation-Induced Cost Escalation, High Insurance Premium, and Design and Professional Services Cost Escalation, each received lower weights, though they collectively contribute to the aggregate cost risk burden of the sector.

Revenue and Market Risk Factors

Table 4.3 presents the local priority weights for the four Revenue and Market Risk factors.

Table 4.3 Priority Weights of Revenue and Market Risk Factors

Rank	**Risk Factor**	**Weight**
1	Transmission Line Construction Delay	0.4580
2	Hydrological Variability and Climate Change	0.3634
3	Tariff Renegotiation Risk at Handover	0.1240
4	Off-Taker Risk (PPA and Payment Security Risk)	0.0546

The Revenue and Market pairwise comparison matrix produced a Consistency Ratio of 0.0196 ($CR < 0.10$), confirming acceptable consistency. The chi-square test yielded $\chi^2 = 44.072$ (p-value = $1.457 \times 10^{-9} < 0.05$), confirming that the local weights reflect a statistically significant non-uniform prioritization.

Transmission Line Construction Delay received the highest weight within the Revenue and Market category (0.4580). This result highlights a structural vulnerability in Nepal's electricity infrastructure that is distinct from the project itself: even a fully operational hydropower plant cannot generate revenue if transmission connectivity is absent or delayed. Nepal's topography makes transmission line construction technically challenging and expensive, and the NEA's financial constraints and procurement limitations have historically caused significant transmission project delays that have materially affected IPP cash flows. The Chilime, Middle Marsyangdi, and Upper

Tamakoshi projects all experienced periods of delayed generation revenue attributable to transmission infrastructure constraints. Pandey et al. (2023) specifically documented transmission delay as the most consequential post-construction financial risk for Nepal's IPP sector, noting that developers bear full debt service obligations with no offsetting revenue during grid connection delays.

Hydrological Variability and Climate Change ranked second within the Revenue category (weight: 0.3634). Nepal's run-of-river hydropower plants are particularly sensitive to inter-annual and seasonal variability in river discharge, which directly determines annual energy generation and PPA compliance. Bhattarai et al. (2024) confirmed that hydrological variability represents the dominant revenue-side financial risk for run-of-river IPPs in Nepal, with observed generation shortfalls of 20–40% in drought years relative to design energy estimates.

Tariff Renegotiation Risk at Handover (weight: 0.1240) captures the financial uncertainty associated with the transition from the construction-phase PPA tariff to the post-handover tariff under Nepal's build-own-operate-transfer (BOOT) concession framework. Upon transfer to the Government of Nepal or NEA, tariff renegotiation may result in rates significantly lower than those assumed in original financial models, potentially jeopardizing project financial viability for investors in late-stage ownership. Off-Taker Risk (weight: 0.0546), while ranked lowest in this category, captures the credit and payment reliability risk associated with NEA as the primary off-taker, a concern underscored by historical payment delays and NEA's chronic financial losses.

Financing Risk Factors

Table 4.4 presents the local priority weights for the nine Financing Risk factors.

Table 4.4 Priority Weights of Financing Risk Factors

Rank	Risk Factor	Weight
1	Client's Inability to Service Debt	0.2599
2	Delays in Financial Closure	0.2248
3	Financial System Crisis	0.1202
4	Macroeconomic Instability	0.0919

5	Interest Rate Fluctuation	0.0889
6	Inadequate Investing Capital	0.0827
7	Currency Exchange Fluctuation	0.0606
8	Weak Financial Market	0.0435
9	Equity Exit Risk	0.0275

The Financing Risk pairwise comparison matrix produced a Consistency Ratio of 0.0250 ($CR < 0.10$). The chi-square test returned $\chi^2 = 45.836$ ($p\text{-value} = 2.554 \times 10^{-7} < 0.05$), confirming a statistically significant non-uniform weight distribution across the nine financing risk factors.

Within Financing Risks, Client's Inability to Service Debt ranked first with a weight of 0.2599. This factor encapsulates the project company's capacity to meet its debt service obligations, principal repayment and interest, from operational cash flows, as measured by the Debt Service Coverage Ratio (DSCR). In Nepal's hydropower IPP sector, debt service capacity is threatened by the combination of high leverage ratios (typically 70:30 debt-equity), variable generation revenues, and fixed or semi-fixed O&M and debt servicing costs. Projects with DSCR falling below lender minimum thresholds (typically 1.2x) trigger covenant violations that can lead to renegotiation, penalty charges, or restructuring. Grimsey and Lewis (2002) identified debt serviceability as the central financing risk in project-financed infrastructure globally, a finding directly applicable to Nepal’s context given its highly leveraged IPP structures.

Delays in Financial Closure ranked second (weight: 0.2248), reflecting the complex, multi-party process of assembling financing involving multiple domestic banks under Nepal Rastra Bank regulations, potential DFI co-financing, and inter-creditor negotiations.

Financial System Crisis (weight: 0.1202) and Macroeconomic Instability (weight: 0.0919) reflect systemic financial environment risks. Nepal's banking sector is characterized by relatively high non-performing loan ratios, limited long-tenor lending capacity, and vulnerability to liquidity pressures, while the broader macroeconomic environment faces challenges including high remittance dependency, volatile inflation, and foreign exchange reserve adequacy concerns. Interest Rate Fluctuation (weight:

0.0889) and Inadequate Investing Capital (weight: 0.0827) complete the principal financing risk factors, with Currency Exchange Fluctuation, Weak Financial Market, and Equity Exit Risk ranked lower but still constituting meaningful components of the overall financing risk landscape.

Regulatory and Institutional Risk Factors

Table 4.5 presents the local priority weights for the five Regulatory and Institutional Risk factors.

Table 4.5 Priority Weights of Regulatory and Institutional Risk Factors

Rank	Risk Factor	Weight
1	Delays in Government Approvals and Licensing	0.4998
2	Corporate Governance Risk	0.1794
3	Insufficient Financial Audit and Monitoring	0.1540
4	Lack of Government Guarantees	0.1026
5	Errors in Financial Forecasting and Data Assumptions	0.0641

The Regulatory and Institutional Risk matrix produced a Consistency Ratio of 0.0266 ($CR < 0.10$). The chi-square test yielded $\chi^2 = 60.194$ (p-value = $2.641 \times 10^{-12} < 0.05$), the highest chi-square value of any within-category test, confirming an exceptionally concentrated non-uniform weight distribution dominated by a single factor.

The Regulatory and Institutional Risk category is dominated by Delays in Government Approvals and Licensing, which received a local weight of 0.4998, nearly half the entire category weight. This reflects expert consensus that the regulatory approval process is the single most critical institutional bottleneck in Nepal's IPP hydropower sector. Hydropower project development in Nepal requires licenses and approvals from multiple agencies including the Department of Electricity Development (DOED), Department of Forests, Department of Mines and Geology, local governments, and NEA for grid interconnection. The fragmented, sequential nature of these approvals, combined with procedural ambiguities and political uncertainty, creates a regulatory risk environment that directly translates into project cost escalation and investment delay. Awojobi and Jenkins (2016) documented regulatory delay as a primary driver of cost overruns in developing-country infrastructure across Asia and Africa, while Esty (2003) noted that multi-agency licensing in emerging economies consistently represents the most significant institutional risk in project-financed energy investments.

Corporate Governance Risk ranked second within the category (weight: 0.1794), acknowledging that IPP project companies in Nepal are frequently established as special-purpose vehicles with complex ownership structures involving multiple promoters, institutional investors, and local development partners. Governance deficiencies, including inadequate board oversight, lack of transparency in related-party transactions, weak financial reporting standards, and promoter conflicts of interest, create financial risks that affect lender confidence, investor relations, and ultimately project financial performance. The prevalence of promoter-managed project companies without professional management practices amplifies this risk.

Insufficient Financial Audit and Monitoring (weight: 0.1540) reflects the recognized weakness in financial oversight mechanisms for Nepal's IPP sector. Independent technical audits, concurrent financial monitoring, and post-completion audits are often inadequate relative to international standards, creating information asymmetries between project companies, lenders, and regulators. Lack of Government Guarantees (weight: 0.1026) and Errors in Financial Forecasting and Data Assumptions (weight: 0.0641) round out the category, with both factors reflecting structural gaps in risk allocation and analytical rigor in project development.

External Risk Factors

Table 4.6 presents the local priority weights for the four External Risk factors.

Table 4.6 Priority Weights of External Risk Factors

Rank	Risk Factor	Weight
1	Adverse Geological Condition	0.4676
2	Contract Termination or Cancellation	0.2360
3	Disputes and Legal Settlements	0.1672
4	Force Majeure Risk	0.1292

The External Risk matrix yielded the lowest Consistency Ratio of all six matrices at 0.0029 ($CR < 0.10$), reflecting a high degree of expert agreement. The chi-square test returned $\chi^2 = 27.598$ (p-value = $4.411 \times 10^{-6} < 0.05$), confirming that Adverse Geological Condition is rated significantly more important than the other external factors.

Adverse Geological Condition dominated the External Risk category with a weight of 0.4676. Nepal's complex geological setting, characterized by active tectonic uplift, unstable rock formations, high groundwater tables, and elevated seismicity, creates significant uncertainty in civil works execution. Geological surprises during tunnel excavation, foundation preparation, and dam construction are among the most financially costly events in hydropower project histories globally, with cost escalations of 20–50% attributable to unexpected geological conditions in several Himalayan projects. In Nepal, the 2015 Gorkha earthquake and associated aftershocks demonstrated the potential for sudden, catastrophic geological events that can affect projects at both construction and operational stages. This finding aligns with Flyvbjerg et al. (2003), whose study of major infrastructure projects identified geological risk as the most severe source of unplanned cost escalation in mountain and underground construction.

Contract Termination or Cancellation (weight: 0.2360) represents the risk of PPA termination, concession cancellation, or contractor default. Force majeure provisions in PPAs and concession agreements provide partial protection but often leave gaps, particularly for events that do not clearly satisfy contractual force majeure definitions. Disputes and Legal Settlements (weight: 0.1672) and Force Majeure Risk (weight: 0.1292) complete the category, both representing event-driven financial risks that are difficult to manage through conventional risk mitigation instruments.

4.1.3 Global Priority Weights and Overall Ranking of Financial Risk Factors

The integration of category-level and factor-level AHP weights through multiplication yields global priority weights that enable a unified ranking of all 29 validated financial risk factors on a common scale summing to unity. Table 4.7 presents the complete global ranking.

Table 4.7 Global Priority Weights and Rankings of All Financial Risk Factors

Global Rank	Financial Risk Factor	Category	Global Weight
1	Construction Time Overrun	Cost-Related	0.1349
2	Delays in Government Approvals and Licensing	Regulatory and Institutional	0.1258
3	Transmission Line Construction Delay	Revenue and Market	0.0844
4	Hydrological Variability and Climate Change	Revenue and Market	0.0670
5	Operation and Maintenance Cost Escalation	Cost-Related	0.0577
6	Social Mitigation and Compensation Cost	Cost-Related	0.0504
7	Corporate Governance Risk	Regulatory and Institutional	0.0451
8	Environmental Compliance and Mitigation Cost	Cost-Related	0.0401
9	Insufficient Financial Audit and Monitoring	Regulatory and Institutional	0.0388
10	Client's Inability to Service Debt	Financing	0.0370
11	Inflation- Induced Cost Escalation	Cost-Related	0.0320
12	Delays in Financial Closure	Financing	0.0320
13	Adverse Geological Condition	External	0.0286
14	High Insurance Premium	Cost-Related	0.0270
15	Lack of Government Guarantees	Regulatory and Institutional	0.0258
16	Tarrif Renegotiation Risk at Handover	Revenue and Market	0.0229
17	Design and Professional Services Cost Escalation	Cost-Related	0.0186

18	Financial System Crisis	Financing	0.0171
19	Errors in Financial Forecasting and Data Assumptions	Regulatory and Institutional	0.0161
20	Contract Termination or Cancellation	External	0.0144
21	Macroeconomic Instability	Financing	0.0131
22	Interest Rate Fluctuation	Financing	0.0126
23	Inadequate Investing Capital	Financing	0.0118
24	Disputes and Legal Settlements	External	0.0102
25	Off-Taker Risk	Revenue and Market	0.0101
26	Currency Exchange Fluctuation	Financing	0.0086
27	Force Majeure Risk	External	0.0079
28	Weak Financial Market	Financing	0.0062
29	Equity Exit Risk	Financing	0.0039
Total			**1.0000**

The global ranking reveals that the top five risks. Construction Time Overrun (0.1349), Delays in Government Approvals and Licensing (0.1258), Transmission Line Construction Delay (0.0844), Hydrological Variability and Climate Change (0.0670), and Operation and Maintenance Cost Escalation (0.0577), collectively account for 47.48% of the total decision weight. This concentration of risk priority in a relatively small number of factors has important practical implications for risk management resource allocation: interventions targeting these five factors would address nearly half of the expert-assessed financial risk burden.

It is also significant that the top ten factors span all five risk categories, with Cost-Related Risks contributing four factors (Construction Time Overrun, O&M Cost Escalation, Social Mitigation and Compensation Cost, Environmental Compliance and Mitigation Cost), Regulatory and Institutional Risks contributing three (Delays in Government Approvals, Corporate Governance Risk, Insufficient Financial Audit and

Monitoring), Revenue and Market Risks contributing two (Transmission Line Construction Delay, Hydrological Variability), and Financing Risks contributing one (Client's Inability to Service Debt). This cross-category distribution within the top tier of risks underscores the multi-dimensional nature of financial risk in Nepal's IPP hydropower sector and the inadequacy of risk management frameworks that address only one or two risk domains.

4.2 Development of the Composite Financial Risk Index (FRI)

4.2.1 Likelihood Assessment by Key Informants

Key informants assigned likelihood scores to each of the 29 validated financial risk factors based on their professional experience with IPP hydropower projects in Nepal. The arithmetic mean of individual KII responses was used to compute the average likelihood score for each factor. Table 4.8 presents the normalized likelihood scores alongside their global AHP weights and FRI contributions.

Table 4.8 Normalized Likelihood Scores and FRI Contributions of Risk Factors

Global Rank	**Financial Risk Factor**	**Normalized Likelihood**	**FRI Contribution**
1	Construction Time Overrun	0.9600	0.1295
2	Delays in Government Approvals and Licensing	0.9200	0.1157
3	Transmission Line Construction Delay	0.8000	0.0676
4	Hydrological Variability and Climate Change	0.7200	0.0482
5	Operation and Maintenance Cost Escalation	0.8400	0.0484
6	Social Mitigation and Compensation Cost	0.8400	0.0423
7	Corporate Governance Risk	0.7200	0.0325
8	Environmental Compliance and Mitigation Cost	0.6800	0.0272
9	Insufficient Financial Audit and Monitoring	0.5600	0.0217
10	Client's Inability to Service Debt	0.5600	0.0207

11	Inflation- Induced Cost Escalation	0.7600	0.0243
12	Delays in Financial Closure	0.5600	0.0179
13	Adverse Geological Condition	0.7200	0.0206
14	High Insurance Premium	0.7200	0.0194
15	Lack of Government Guarantees	0.7600	0.0196
16	Tarrif Renegotiation Risk at Handover	0.7600	0.0174
17	Design and Professional Services Cost Escalation	0.6000	0.0112
18	Financial System Crisis	0.3200	0.0055
19	Errors in Financial Forecasting and Data Assumptions	0.5200	0.0084
20	Contract Termination or Cancellation	0.7600	0.0110
21	Macroeconomic Instability	0.4400	0.0058
22	Interest Rate Fluctuation	0.8000	0.0101
23	Inadequate Investing Capital	0.8000	0.0094
24	Disputes and Legal Settlements	0.6400	0.0065
25	Off-Taker Risk	0.8000	0.0081
26	Currency Exchange Fluctuation	0.8800	0.0076
27	Force Majeure Risk	0.6800	0.0054
28	Weak Financial Market	0.4800	0.0030
29	Equity Exit Risk	0.4400	0.0017
Total		**20.0400**	**0.7667**

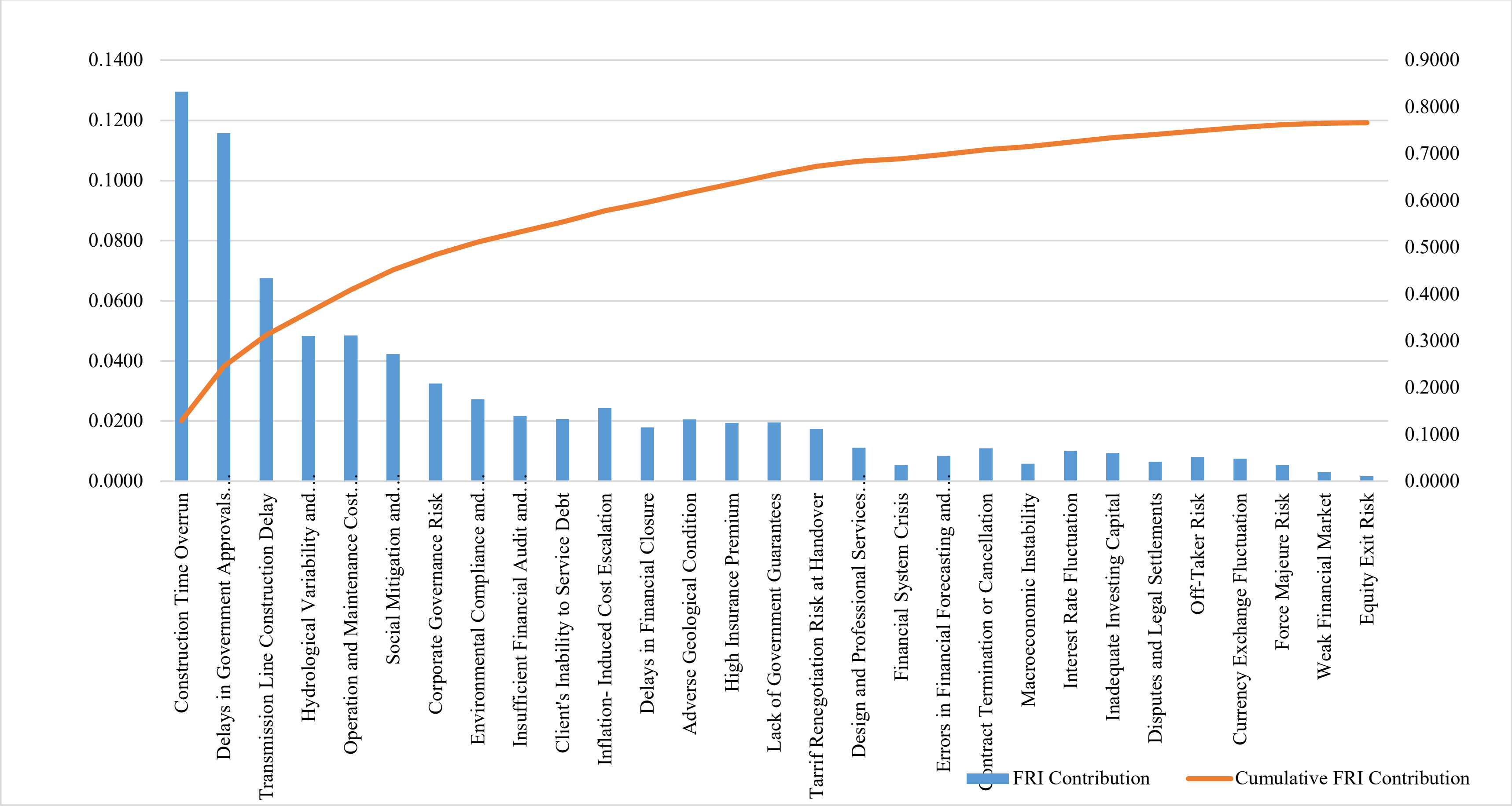


Figure 4.1 FRI Contribution of Individual Risk Factors and Cumulative FRI (Without Mitigation)

The likelihood assessment reveals that key informants perceive a high probability of materialization across the majority of the top-ranked financial risk factors. Construction Time Overrun received the highest normalized likelihood score of 0.96, indicating an expert consensus that this risk is considered almost certain to materialize to some degree in IPP hydropower projects in Nepal. This assessment is consistent with the empirical record of hydropower construction in Nepal, where virtually all major projects have experienced construction delays relative to their original schedule. The 480 MW Upper Tamakoshi Hydroelectric Project, one of Nepal's flagships IPP ventures, experienced delays of several years beyond its original commissioning target, while numerous smaller run-of-river projects have similarly overrun their construction schedules.

Delays in Government Approvals and Licensing was assigned the second-highest likelihood score (0.92), reflecting deep expert conviction that bureaucratic and regulatory delays are a near-inevitable feature of hydropower project development in Nepal's current institutional environment. This near-certainty of regulatory delay, combined with the second-highest global AHP weight, results in the second-largest individual FRI contribution of 0.1157, making this factor a critical driver of overall financial risk.

Currency Exchange Fluctuation received the highest likelihood score (0.88) among factors outside the top two, despite ranking only 26th in global importance weight. This finding suggests that while currency risk is considered universally prevalent, reflecting Nepal's persistent current account deficits and foreign exchange volatility, its financial impact per unit of occurrence is moderated by its lower strategic weight in the hierarchy. Interest Rate Fluctuation, Inadequate Investing Capital, Off-Taker Risk, and Transmission Line Construction Delay each received likelihood scores of 0.80, reflecting strong expert assessment that these conditions are frequently encountered in Nepal's hydropower project environment.

Notably, Financial System Crisis received a relatively low likelihood score of 0.32, consistent with expert judgment that while Nepal's banking sector faces structural vulnerabilities, a systemic financial crisis of the kind that would severely impair project financing is considered relatively uncommon rather than routine. Macroeconomic Instability (0.44) and Equity Exit Risk (0.44) similarly received moderate-to-low likelihood scores, suggesting expert assessment that while these risks exist, they manifest with less regularity than operational, regulatory, or infrastructure-related risks.

4.2.2 Composite Financial Risk Index Value and Interpretation

The aggregation of all 29 weighted likelihood contributions yields a composite Financial Risk Index (FRI) of 0.7667. According to the interpretation scale developed for this study, this value falls within the 'High Risk' band (0.6–0.8), as shown in Table 4.9.

Table 4.9 FRI Interpretation Scale and Computed Value

FRI Range	Risk Interpretation	Status
0.0 – 0.2	Very Low Risk	
0.2 – 0.4	Low Risk	
0.4 – 0.6	Moderate Risk	
0.6 – 0.8	High Risk	FRI = 0.7667
0.8 – 1.0	Very High Risk	

An FRI of 0.7667 positions Nepal's IPP hydropower sector at the upper end of the High Risk band, approaching the threshold of Very High Risk (0.80). This finding carries several important implications. First, it confirms that financial risk in Nepal's IPP hydropower sector is not merely a theoretical concern but a present and material challenge with measurable aggregate magnitude. Second, the proximity to the Very High Risk threshold indicates that the sector's financial risk environment is severe, with relatively limited margin before aggregate risk conditions would be considered extreme. Third, the FRI provides a quantitative benchmark that can be used by investors, lenders, and policymakers to calibrate risk appetite, pricing, and mitigation requirements.

The category-level decomposition of the FRI reveals that Cost-Related Risks contribute the largest share of the overall index at 0.3025 (approximately 39.5% of the total FRI), followed by Regulatory and Institutional Risks at 0.1980 (25.8%), Revenue and Market Risks at 0.1412 (18.4%), Financing Risks at 0.0816 (10.6%), and External Risks at 0.0434 (5.7%). These proportions closely mirror the AHP category weights, as would be expected given that likelihood scores across factors did not vary dramatically enough to significantly alter the relative contribution ordering established by the AHP.

The FRI of 0.7667 is particularly significant when contextualized within Nepal's hydropower development ambitions. The government has set a target of developing 15,000 MW of hydropower by 2030, which will require billions of dollars of private investment from both domestic and international sources. An FRI at the upper end of the High Risk band suggests that without substantial improvements in risk management frameworks and mitigation effectiveness, achieving these investment targets will be challenging. The FRI provides a concrete and communicable metric that can anchor discussions between the government, regulators, lenders, and investors about the specific interventions needed to reduce financial risk to levels compatible with broad-based private investment.

4.3 Evaluation of Mitigation Effectiveness and Residual Financial Risk

4.3.1 Composite Mitigation Score

The computed composite Mitigation Score is 0.3124, which falls within the 'Slightly Effective' band (0.2–0.4) of the interpretation scale, as shown in Table 4.10.

Table 4.10 Mitigation Score Interpretation Scale and Computed Value

Score Range	Effectiveness Interpretation	Status
0.0 – 0.2	Not Effective	
0.2 – 0.4	Slightly Effective	MS = 0.3124
0.4 – 0.6	Moderately Effective	
0.6 – 0.8	Highly Effective	
0.8 – 1.0	Very Effective	

A composite Mitigation Score of 0.3124 indicates that the aggregate package of risk mitigation instruments currently employed in Nepal's IPP hydropower sector is assessed by experienced practitioners as only slightly effective. This represents a significant finding: despite the wide range of contractual provisions, financial instruments, government support mechanisms, and insurance products that are nominally available to hydropower developers, their realized effectiveness in reducing financial risk is limited. This gap between the nominal availability of mitigation tools and their actual effectiveness in reducing financial risk has profound implications for project finance structuring, investment decision-making, and policy development.

4.3.2 Factor-Level Mitigation Effectiveness Analysis

The factor-level analysis of mitigation effectiveness reveals substantial variation across the 29 risk factors, with certain risks benefiting from relatively effective mitigation instruments while others remain poorly addressed by available measures. Table 4.11 presents the mitigation effectiveness scores for all 29 factors.

Table 4.11 Mitigation Effectiveness Scores by Risk Factor

Rank	Financial Risk Factor	Mitigation score
1	Construction Time Overrun	0.0443
2	Delays in Government Approvals and Licensing	0.0403
3	Transmission Line Construction Delay	0.0220
4	Hydrological Variability and Climate Change	0.0155
5	Operation and Maintenance Cost Escalation	0.0271
6	Social Mitigation and Compensation Cost	0.0151
7	Corporate Governance Risk	0.0042
8	Environmental Compliance and Mitigation Cost	0.0091
9	Insufficient Financial Audit and Monitoring	0.0124
10	Client's Inability to Service Debt	0.0148
11	Inflation- Induced Cost Escalation	0.0067
12	Delays in Financial Closure	0.0149
13	Adverse Geological Condition	0.0069
14	High Insurance Premium	0.0108
15	Lack of Government Guarantees	0.0052
16	Tarrif Renegotiation Risk at Handover	0.0096

17	Design and Professional Services Cost Escalation	0.0078
18	Financial System Crisis	0.0027
19	Errors in Financial Forecasting and Data Assumptions	0.0052
20	Contract Termination or Cancellation	0.0036
21	Macroeconomic Instability	0.0005
22	Interest Rate Fluctuation	0.0076
23	Inadequate Investing Capital	0.0089
24	Disputes and Legal Settlements	0.0018
25	Off-Taker Risk	0.0064
26	Currency Exchange Fluctuation	0.0043
27	Force Majeure Risk	0.0028
28	Weak Financial Market	0.0009
29	Equity Exit Risk	0.0012
Total		**0.3124**

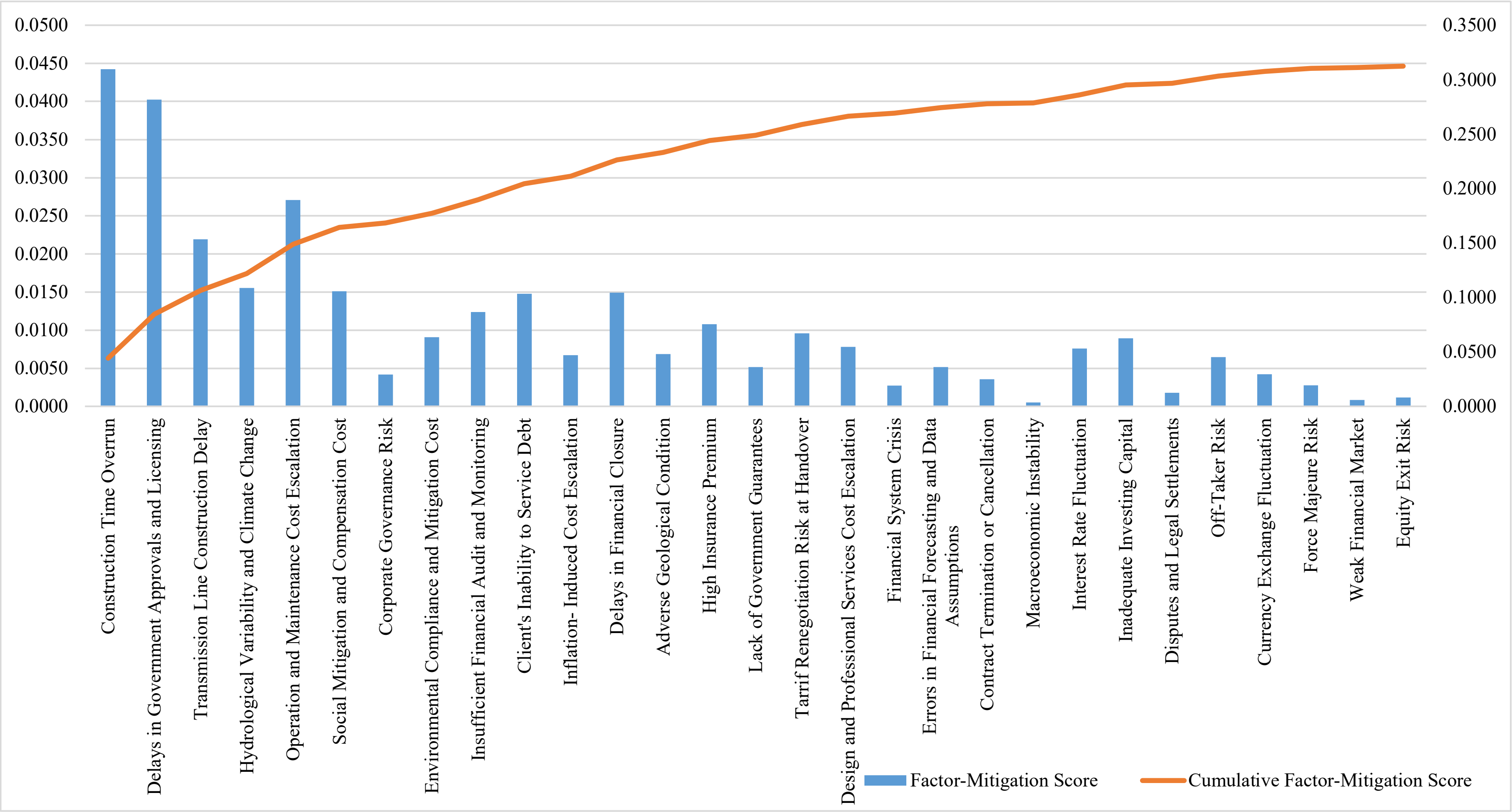


Figure 4.2 Factor-Wise Mitigation Score and Cumulative Mitigation Score

Figure 4.2 presents the factor-level mitigation scores as a combined bar and cumulative line chart, with factors arranged in order of global AHP priority (highest to lowest weight from left to right). The bar component represents the individual weighted mitigation score for each factor (computed as the product of the AHP global weight and the normalized mitigation effectiveness score) while the cumulative line traces the running total of mitigation scores, reaching 0.3124 at the rightmost factor, which represents the composite Mitigation Score. The visual distribution of bar heights reveals immediately that the mitigation contributions are heavily concentrated in the first few high-weight factors, particularly Construction Time Overrun (0.0443) and Delays in Government Approvals and Licensing (0.0403), which together account for 27.1% of the total mitigation score despite being the two factors where mitigation is most urgently needed. The relatively flat profile of bars from factor 7 onwards reflects the diminishing individual mitigation contributions of lower-weight factors, even where their normalized effectiveness is comparatively higher.

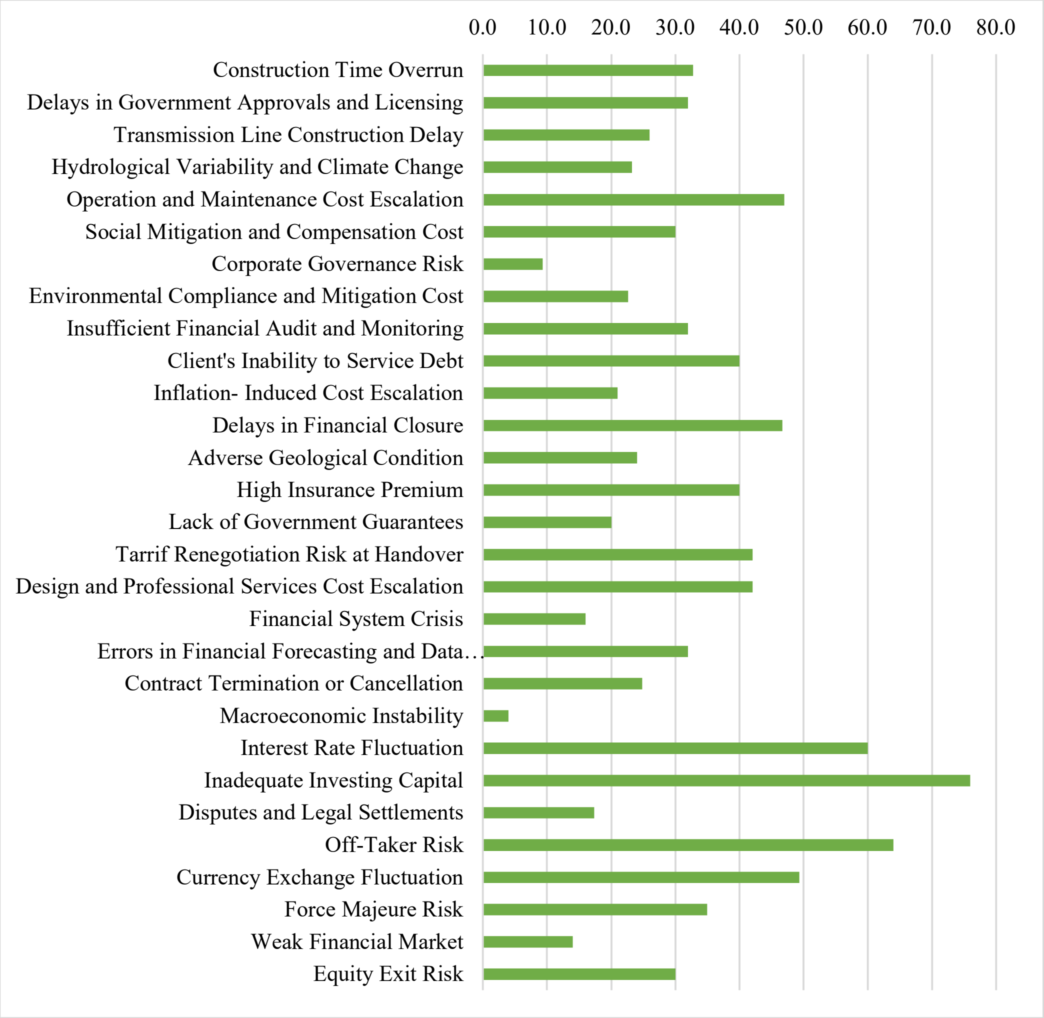


Figure 4.3 Percentage Mitigation by Risk Factor

Figure 4.3 presents the percentage mitigation for each factor, defined as the proportion of each factor's unmitigated FRI contribution that is reduced by available instruments, arranged in the same global AHP priority order. This chart reveals a striking pattern: the highest-weight factors at the left of the chart (Construction Time Overrun at 32.8%, Delays in Government Approvals at 32.0%, Transmission Line Construction Delay at 26.0%) achieve only modest to moderate mitigation percentages, while several lower-weight factors on the right achieve substantially higher mitigation: Inadequate Investing Capital (76.0%), Off-Taker Risk (64.0%), Interest Rate Fluctuation (60.0%), and Currency Exchange Fluctuation (49.3%). This inverse relationship between factor importance and mitigation effectiveness is a structurally significant finding: the most financially consequential risks are among the least well-mitigated, while the more effectively mitigated risks carry relatively lower AHP weights. The bar for Macroeconomic Instability is barely visible (4.0%), confirming that this systemic risk is essentially unaddressed by available project-level instruments. Corporate Governance Risk (9.3%) similarly shows minimal mitigation, consistent with the near-absence of governance enforcement mechanisms in Nepal's current IPP regulatory framework (Ika, et al., 2012; North, 1990). The pattern illustrated in Figure 4.3 thus quantitatively demonstrates the mismatch between where mitigation capacity currently exists and where it is most critically needed, providing a direct visual foundation for the risk-mitigation gap analysis presented in Section 4.5.4.

The highest mitigation effectiveness scores were recorded for Inadequate Investing Capital (0.76), Off-Taker Risk (0.64), and Interest Rate Fluctuation (0.60). The effectiveness of mitigation for Inadequate Investing Capital reflects the availability of structured equity mobilization mechanisms, including Nepal's public listing of hydropower project shares on the Nepal Stock Exchange (NEPSE), the use of promoter group financing arrangements, and the growing availability of hybrid equity instruments (Nepal Electricity Authority [NEA], 2025). The relatively high mitigation score for Off-Taker Risk acknowledges the role of the Government of Nepal's guarantee arrangements and the partial payment guarantee mechanisms under the PPA framework, alongside political risk insurance products from multilateral providers such as the Multilateral Investment Guarantee Agency (Multilateral Investment Guarantee Agency [MIGA], 2013) and the Asian Development Bank (Asian Development Bank [ADB], 2015). Interest Rate Fluctuation achieved a mitigation effectiveness of 60%, reflecting the availability of fixed-rate lending from development finance institutions and partial interest rate arrangements documented by Pandey et al.(2023).

In contrast, Corporate Governance Risk (9.3%) and Macroeconomic Instability (4.0%) received the lowest mitigation effectiveness scores, indicating that current instruments are largely ineffective in addressing these risk dimensions. The near-zero effectiveness score for Macroeconomic Instability reflects the structural and systemic nature of Nepal's macroeconomic challenges, which are largely beyond the control of individual project companies and for which no adequate project-level mitigation tools exist. The low score for Corporate Governance Risk suggests that while governance improvement frameworks exist in principle, their practical implementation in Nepal's IPP project company environment is severely limited, consistent with findings on institutional quality in developing country infrastructure markets (North, 1990; Ika et al., 2012). Critically, the two highest-weight factors (Construction Time Overrun and Delays in Government Approvals and Licensing) achieved only 32.8% and 32.0% effectiveness respectively. Given that these two factors alone account for approximately 26% of the total FRI, their limited mitigation effectiveness represents a fundamental structural weakness in Nepal's hydropower risk management framework, as also noted by Bhattarai et al. (2024) and Shrestha et al. (2015) in their assessments of Nepal's IPP sector challenges.

4.3.3 Residual Financial Risk Index

The computed Residual FRI is 0.5239, which falls within the 'Moderate Risk' band (0.4–0.6). The transition from High Risk (FRI = 0.7667) to Moderate Risk (FRI_residual = 0.5239) represents a reduction of 0.2428 units, or approximately 31.67%, attributable to the aggregate effect of existing mitigation instruments. Table 4.12 summarizes the three key risk metrics and their interpretations.

Table 4.12 Summary of Financial Risk Metrics

Metric	**Value**	**Band**	**Interpretation**
Financial Risk Index (FRI)	0.7667	0.6 – 0.8	High Risk
Mitigation Score (MS)	0.3124	0.2 – 0.4	Slightly Effective
Residual FRI (FRI_residual)	0.5239	0.4 – 0.6	Moderate Risk
Absolute Risk Reduction	0.2428		31.67% Reduction

The Residual FRI of 0.5239 occupies the upper portion of the Moderate Risk band, positioned closer to the High Risk threshold (0.60) than to the lower boundary (0.40). Several important interpretations emerge from this finding.

First, the 31.67% risk reduction achieved through existing mitigation instruments, while non-trivial, is insufficient to move Nepal's IPP hydropower financial risk from High to Low risk territory. To achieve a Low Risk classification (FRI_residual < 0.40), the aggregate mitigation effectiveness would need to reduce the FRI by approximately 47.8%, substantially more than the 31.67% currently achieved. This gap represents the quantified inadequacy of the current risk mitigation architecture and provides a concrete target for policy and practice improvement.

Second, the Residual FRI of 0.5239 is particularly concerning given that it represents the post-mitigation risk level, the irreducible financial risk exposure that persists even after all available mitigation instruments have been applied. This residual exposure must be priced into investment returns, debt service coverage ratios, and financial model contingencies. A Residual FRI at the upper end of the Moderate Risk band implies that project financial models must incorporate substantial risk premiums, conservative sensitivity analyses, and robust contingency budgets to maintain financial viability.

Third, the contrast between the FRI (High Risk = 0.7667) and the Residual FRI (Moderate Risk = 0.5239) quantitatively demonstrates that current mitigation instruments do provide some meaningful protection but are collectively insufficient. This finding contradicts two possible extreme positions: that mitigation instruments are wholly ineffective (in which case FRI_residual would equal FRI) or that they are adequate to bring risk to acceptable levels (in which case FRI_residual would fall in the Low Risk band). The empirical reality lies between these extremes, pointing to a sector that has developed some risk management capacity but requires substantial enhancement.

4.3.4 Factor-Level Residual Risk Analysis

The factor-level analysis of residual risk reveals which specific risk factors remain most critical after mitigation and therefore represent the highest-priority targets for improved risk management. Table 4.13 presents the residual FRI contributions of all the factors alongside their mitigation-related risk reduction.

Table 4.13 Residual FRI Contributions of Risk Factors

Rank	**Financial Risk Factors**	**FRI Contribution**		**Percentage Mitigation**
		Without Mitigation	**With Mitigation**	
1	Construction Time Overrun	0.1295	0.0870	32.8000

2	Delays in Government Approvals and Licensing	0.1157	0.0787	32.0000
3	Transmission Line Construction Delay	0.0676	0.0500	26.0000
4	Hydrological Variability and Climate Change	0.0482	0.0370	23.2000
5	Operation and Maintenance Cost Escalation	0.0484	0.0257	47.0000
6	Social Mitigation and Compensation Cost	0.0423	0.0296	30.0000
7	Corporate Governance Risk	0.0325	0.0295	9.3333
8	Environmental Compliance and Mitigation Cost	0.0272	0.0211	22.6667
9	Insufficient Financial Audit and Monitoring	0.0217	0.0148	32.0000
10	Client's Inability to Service Debt	0.0207	0.0124	40.0000
11	Inflation- Induced Cost Escalation	0.0243	0.0192	21.0000
12	Delays in Financial Closure	0.0179	0.0095	46.6667
13	Adverse Geological Condition	0.0206	0.0156	24.0000
14	High Insurance Premium	0.0194	0.0117	40.0000
15	Lack of Government Guarantees	0.0196	0.0157	20.0000
16	Tarrif Renegotiation Risk at Handover	0.0174	0.0101	42.0000
17	Design and Professional Services Cost Escalation	0.0112	0.0065	42.0000
18	Financial System Crisis	0.0055	0.0046	16.0000
19	Errors in Financial Forecasting and Data Assumptions	0.0084	0.0057	32.0000

20	Contract Termination or Cancellation	0.0110	0.0082	24.8000
21	Macroeconomic Instability	0.0058	0.0055	4.0000
22	Interest Rate Fluctuation	0.0101	0.0040	60.0000
23	Inadequate Investing Capital	0.0094	0.0023	76.0000
24	Disputes and Legal Settlements	0.0065	0.0054	17.3333
25	Off-Taker Risk	0.0081	0.0029	64.0000
26	Currency Exchange Fluctuation	0.0076	0.0038	49.3333
27	Force Majeure Risk	0.0054	0.0035	35.0000
28	Weak Financial Market	0.0030	0.0026	14.0000
29	Equity Exit Risk	0.0017	0.0012	30.0000
Total		**0.7667**	**0.5239**	**31.6721**

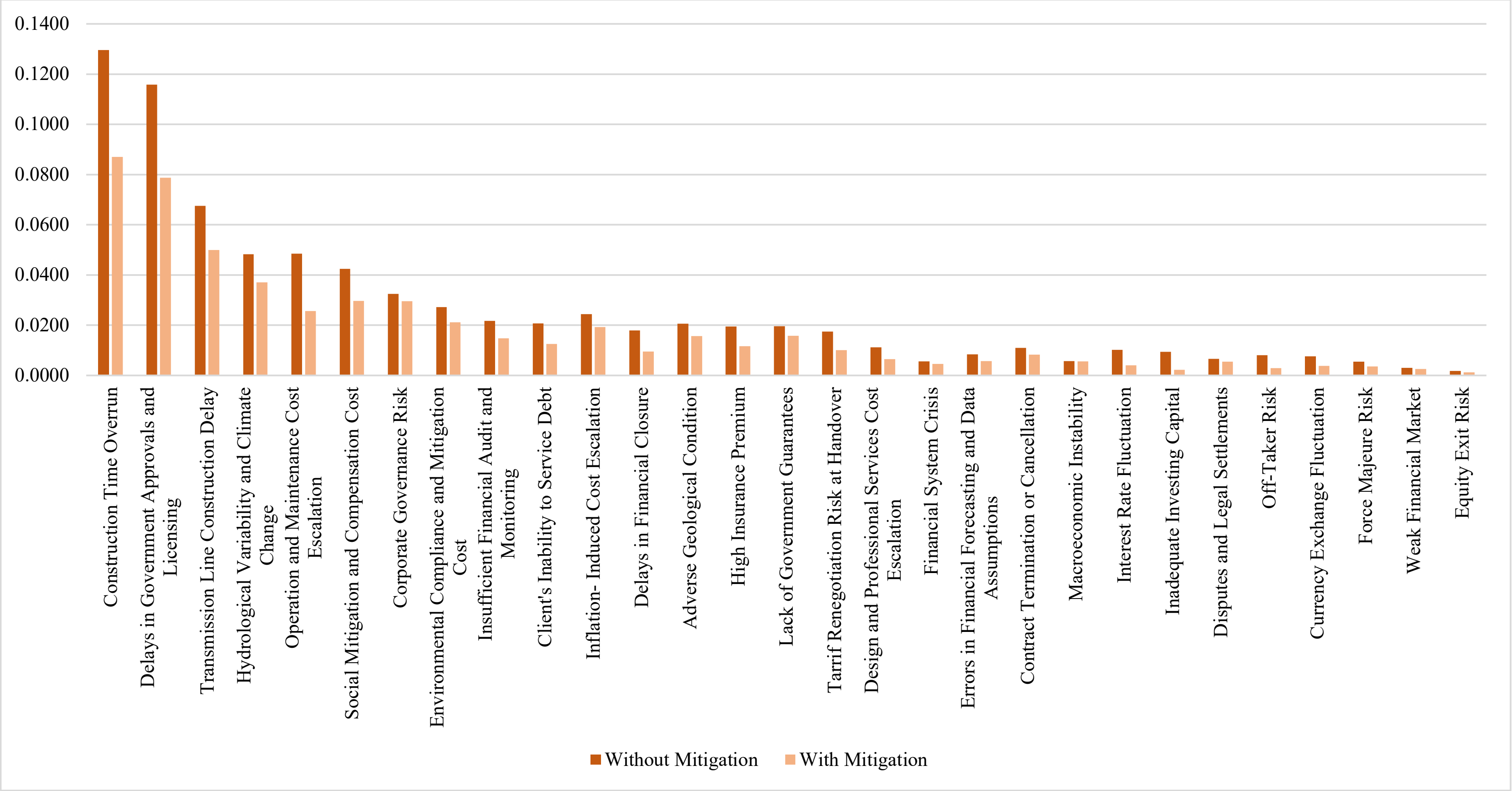


Figure 4.4 FRI Contribution of Risk Factors (Without Mitigation vs. With Mitigation)

Figure 4.4 presents a grouped bar chart comparing, for each of the 29 risk factors in global AHP priority order, the unmitigated FRI contribution (darker bars) and the residual FRI contribution after mitigation (lighter bars). The visual contrast between the two bar series for each factor directly communicates both the absolute level of risk and the degree of mitigation effectiveness for that factor: a larger gap between bars indicates more effective mitigation, while bars of nearly equal height indicate risk factors where existing instruments provide little protection.

The chart reveals several important visual patterns. First, the two leftmost factors, namely Construction Time Overrun and Delays in Government Approvals and Licensing, have the tallest bars in both series, confirming their dominant role in both the unmitigated and residual financial risk profiles. The gap between the two bars for these factors, representing 32.8% and 32.0% mitigation respectively, is visible but relatively modest compared to several other factors. This visual representation reinforces the finding that despite being the most financially consequential risks in the sector, they remain among the least well-mitigated in proportional terms. Second, factors in the middle section of the chart, particularly Operation and Maintenance Cost Escalation (47.0% mitigation, visible gap) and Delays in Financial Closure (46.7%, visible gap), show more pronounced differences between the two bar series, indicating comparatively more effective mitigation relative to their unmitigated FRI contribution. Third, factors toward the right of the chart, where bars are shorter due to lower AHP weights, showing both smaller absolute bar heights and highly variable gaps between the two series. Inadequate Investing Capital and Off-Taker Risk, despite their lower AHP weights, show the proportionally largest bar gaps (76% and 64% reduction respectively), reflecting the effectiveness of Nepal's NEPSE equity mobilization model and the PPA/PDA framework in addressing these specific risk dimensions.

After mitigation, Construction Time Overrun retains the largest residual FRI contribution (0.0870), followed closely by Delays in Government Approvals and Licensing (0.0787), Transmission Line Construction Delay (0.0500), and Hydrological Variability and Climate Change (0.0370). These four factors collectively account for 0.2447 of the Residual FRI of 0.5239 (representing 46.7% of total post-mitigation risk) demonstrating that even after all available mitigation instruments are applied, the sector's residual financial risk remains highly concentrated in the same operational and institutional factors that dominate the unmitigated risk profile. This persistence of risk concentration in the post-mitigation landscape carries a critical implication: the existing mitigation architecture is not only insufficient in aggregate effectiveness but also fails to rebalance the relative contribution of high-priority risks, leaving the top-ranked factors as disproportionate residual risk drivers even after mitigation.

A notable finding from Figure 4.4 concerns Corporate Governance Risk, whose two bars are nearly equal in height: the unmitigated FRI contribution is 0.0325 versus a residual contribution of 0.0295, representing only a 9.3% reduction. The visual near-equivalence of these bars highlights that Corporate Governance Risk is effectively unmitigated in practice, despite being the 7th highest-weight factor in the global AHP ranking. This graphical representation reinforces the analytical conclusion that governance quality reform, through mandatory independent director requirements, enhanced financial reporting standards, and lender-embedded governance covenants, represents one of the most actionable and currently neglected intervention priorities in Nepal's IPP hydropower financial risk management landscape. The case of Macroeconomic Instability is similarly stark: both bars for this factor are nearly identical, with the mitigation bar barely distinguishable, confirming the 4.0% effectiveness score and the structural limitation that project-level instruments cannot substitute for Nepal's broader macroeconomic management capacity (North, 1990; World Bank, 2020).

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions drawn from the study and the recommendations arising from the findings. The study was conducted with three main objectives: to prioritize the financial risk factors affecting IPP-developed hydropower projects in Nepal, to develop a composite Financial Risk Index (FRI) that measures the overall financial risk level, and to evaluate how effective the existing risk mitigation instruments are in reducing that risk. The conclusions are organized according to these three objectives, followed by practical recommendations for stakeholders and suggestions for future research.

5.1 Conclusions

1. **Financial Risk in Nepal's IPP Hydropower Sector is Dominated by a Few Critical Factors**

   The results show clearly that not all financial risks are equally important. Two categories stand out as the most critical: Cost-Related Risks and Regulatory and Institutional Risks, which together account for more than 60% of the total financial risk weight. Among individual risk factors, Construction Time Overrun ranked highest, followed by Delays in Government Approvals and Licensing, Transmission Line Construction Delay, Hydrological Variability and Climate Change, and Operation and Maintenance Cost Escalation. These five factors alone account for nearly half of the total risk priority across all 29 factors. Chi-square testing confirmed that all six AHP weight distributions are statistically non-uniform and significant, validating that the prioritization reflects genuine expert discrimination rather than random or indifferent assignment of importance.

2. **Nepal's IPP Hydropower Sector Faces a High Level of Aggregate Financial Risk**

   Integrating AHP-derived weights with likelihood scores from five key informants produced a composite Financial Risk Index classified in the High Risk band, approaching the Very High Risk threshold. Construction Time Overrun and Delays in Government Approvals and Licensing are assessed by key informants as near-certain to occur in any IPP project in Nepal and together constitute the largest single contribution to the composite index. This FRI constitutes the first empirically derived quantitative financial risk benchmark for Nepal's IPP hydropower sector, providing a standardized and communicable measure for use by investors, lenders, and policymakers in risk assessment and decision-making.

3. **Existing Risk Mitigation Instruments Provide Only Limited Protection**

   Mitigation effectiveness ratings from five key informants produced a composite Mitigation Score classified as Slightly Effective, representing a modest overall reduction in financial risk and yielding a Residual FRI that remains in the Moderate Risk band. While certain financing risks, particularly those addressed through Nepal's equity market model and PPA framework are reasonably well mitigated, the two highest-priority factors, Construction Time Overrun and Delays in Government Approvals and Licensing, remain substantially unprotected. Corporate Governance Risk and Macroeconomic Instability are effectively unmitigated by any available instrument. These findings reveal a structural mismatch between where mitigation instruments are effective and where financial risk is most concentrated, confirming that the current instrument package is insufficient to bring the sector to an acceptable residual risk level.

5.2 Recommendations from Study

Based on the findings, the following recommendations are directed at policymakers, regulators, developers, and lenders working in Nepal's IPP hydropower sector.

1. Establish a single-window regulatory clearance mechanism with legally binding timelines for hydropower licensing to reduce pre-construction delays and financing costs.
2. NEA must match transmission line construction schedules to IPP commissioning dates, with binding connection commitments and compensation provisions for delay.
3. Developers and lenders should enforce stricter EPC performance bonds, independent technical supervision, and reference-class-based schedule planning to reduce construction overrun risk.
4. NERC should mandate independent board membership, audited financial reporting, and related-party transaction disclosure for all IPP project companies.

5. The Financial Risk Index should be updated annually as a sector-level monitoring and communication tool to track the impact of reforms and signal improving conditions to investors.

5.2.1 Recommendations for Further Research

Some of the recommendations for further research are as follows.

1. Conduct annual KII-based FRI updates to track whether financial risk conditions in Nepal's IPP sector improve as policy reforms are implemented over time.
2. Apply the AHP-KII framework at the individual project level to enable comparative financial risk benchmarking across Nepal's IPP portfolio.
3. Extend the framework to regional peer markets– Bhutan, India's Himalayan regions, and Pakistan to compare financial risk levels and identify effective policy interventions.
4. Validate the AHP priority weights against actual project performance data, including DSCR realizations, cost overruns, and construction schedule delays.
5. Empirically assess the effectiveness of new mitigation instruments as they are introduced in Nepal's market, including hydrological insurance and government guarantee facilities.

REFERENCES

Ansar, A., Flyvbjerg, B., Budzier, A. & Lunn, D., 2014. Should we build more large dams? The actual costs of hydropower megaproject development. *Energy Policy,* Volume 69, pp. 43-56.

Asian Development Bank [ADB], 2015. *Hydropower development in Nepal: Environment and social safeguard policy review,* s.l.: s.n.

Awojobi, O. & Jenkins, G. P., 2016. Managing the cost overrun risks of hydropower projects: The tail of the distribution. *Journal of Risk,* 18(5), pp. 31-59.

Bhattarai, S. K. et al., 2024. Enhancing success in small hydropower projects: Analysis of key performance indicators and strategies for improvement in Nepal.. *Journal of Advanced Research in Civil and Environmental Engineering,* 11(1), pp. 21-37.

Calderón, C. & Servén, L., 2008. *Infrastructure and economic development in Sub-Saharan Africa,* s.l.: World Bank.

Cochran, W. G., 1952. The chi-square test of goodness of fit. *The Annals of Mathematical Statistics,* 23(3), pp. 315--345.

Creswell, J. W. & Creswell, J. D., 2018. *Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.).* s.l.:s.n.

Delmon, J., 2017. *Public-private partnership projects in infrastructure: An essential guide for policy makers.* s.l.:s.n.

Department of Electricity Development [DOED], 2022. *Annual progress report,* s.l.: s.n.

Esty, B. C., 2003. *The economic motivations for using project finance.* s.l.:Harvard Business School.

Finnerty, J. D., 1996. *Project financing: Asset-based financial engineering.* s.l.:s.n.

Flyvbjerg, B., 2009. Survival of the unfittest: Why the worst infrastructure gets built and what we can do about it. *Oxford Review of Economic Policy,* Volume 25, p. 344–367.

Flyvbjerg, B., Bruzelius, N. & Rothengatter, W., 2003. *Megaprojects and risk: An anatomy of ambition.* s.l.:s.n.

Forman, E. H. & Peniwati, K., 1998. Aggregating individual judgments and priorities with the analytic hierarchy process. *European Journal of Operational Research,* 108(1), p. 165–169.

Government of Nepal [GoN], 2018. *Electricity Act 2018,* s.l.: s.n.

Grimsey, D. & Lewis, M. K., 2002. Evaluating the risks of public private partnerships for infrastructure projects. *International Journal of Project Management,* 20(2), p. 107–118.

Guasch, J. L., Laffont, J.-J. & Straub, S., 2006. Renegotiation of concession contracts: A theoretical approach. *Review of Industrial Organization,* 29(1–2), p. 55–73.

Ho, W., 2008. Integrated analytic hierarchy process and its applications: A literature review. *European Journal of Operational Research,* 186(1), p. 211–228.

Hwang, B.-G., Zhao, X. & Gay, M. J. S., 2013. Public private partnership projects in Singapore: Factors, critical risks and preferred risk allocation from the perspective of contractors. *International Journal of Project Management,* 31(3), p. 424–433.

Ika, L. A., Diallo, A. & Thuillier, D., 2012. Critical success factors for World Bank projects: An empirical investigation. *International Journal of Project Management,* 30(1), p. 105–116.

International Finance Corporation, 2015. *IFC performance standards on environmental and social sustainability,* s.l.: s.n.

International Hydropower Association [IHA], 2021. *2021 hydropower status report: Sector trends and insights,* s.l.: s.n.

Kumar, D. & Katoch, S. S., 2016. Sustainability assessment and ranking of run of the river (RoR) hydropower projects using analytical hierarchy process (AHP): A study from western Himalayan region of India. *Journal of Mountain Science,* 13(2), p. 234–251.

Kumar, N., 2007. *Research methodology (2nd ed.).* s.l.:s.n.

Multilateral Investment Guarantee Agency [MIGA], 2013. *MIGA annual report: Investment guarantee products and Nepal risk coverage,* s.l.: s.n.

Nepal Electricity Authority [NEA], 2025. *NEA annual report 2024/25,* s.l.: s.n.

Nepal Electricity Authority [NEA], 2082 B.S. (2025–26 A.D.). *NEA quarterly report Kartik–Poush 2082,* s.l.: s.n.

Nepal Electricity Regulatory Commission [NERC], 2021. *Annual report 2020/21,* s.l.: s.n.

Nepal Rastra Bank [NRB], 2025. *Current macroeconomic and financial situation, mid-February 2024/25,* s.l.: s.n.

Neupane, A., 2014. The necessity of and challenges to international project financing of hydropower projects in Nepal. *Hydro Nepal: Journal of Water, Energy and Environment,* Volume 13, p. 16–19.

North, D. C., 1990. *Institutions, institutional change and economic performance.* s.l.:s.n.

Organisation for Economic Co-operation and Development [OECD], 2008. *Handbook on constructing composite indicators: Methodology and user guide.* s.l.:s.n.

Pandey, R., Shrestha, R., Bhattarai, N. & Dhakal, R., 2023. Problems identification and performance analysis in small hydropower plants in Nepal. *International Journal of Low-Carbon Technologies,* Volume 18, p. 561–569.

Patel, G., Shrimali, N. V. & Modi, B., 2021. Risk management of hydropower projects for sustainable development: A review. *Environment, Development and Sustainability,* Volume 23, pp. 45-76.

Pearson, K., 1900. On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *Philosophical Magazine,* 50(302), p. 157–175.

Saaty, T. L., 1980. *The analytic hierarchy process: Planning, priority setting, resource allocation.* s.l.:s.n.

Saaty, T. L., 2008. Decision making with the analytic hierarchy process. *International Journal of Services Sciences,* 1(1), p. 83–98.

Saaty, T. L. & Peniwati, K., 2013. *Group decision making: Drawing out and reconciling differences.* s.l.:s.n.

Saaty, T. L. & Vargas, L. G., 1984. Comparison of eigenvalue, logarithmic least squares and least squares methods in estimating ratios. *Mathematical Modelling,* 5(5), p. 309–324.

Shrestha, S., Anal, A. K., Salam, P. A. & van der Valk, M., 2015. *Managing water resources under climate uncertainty: Examples from Asia, Europe, Latin America and Australia.* s.l.:s.n.

Sridharan, V. et al., 2021. The role of hydropower in South Asia's energy future. *International Journal of Water Resources Development,* 37(3), p. 367–391.

Vaidya, O. S. & Kumar, S., 2006. Analytic hierarchy process: An overview of applications. *European Journal of Operational Research,* 169(1), p. 1–29.

Wang, Q., Liu, J. & Zhang, R., 2018. Risk prioritization for large hydropower projects in China using AHP and fuzzy theory. *Water,* 10(11), p. 1558.

Water and Energy Commission Secretariat, 2019. *National water resources assessment,* s.l.: s.n.

World Bank, 2020. *World Bank hydropower development report,* s.l.: s.n.

Yescombe, E. R., 2013. *Principles of project finance (2nd ed.).* s.l.:s.n.

APPENDIX 1: DEMOGRAPHIC INFORMATION OF EXPERTS FOR RISK VALIDATION

ID	**Sector**	**Position**	**Experience**
Exp- 1	Private (Independent Power Producer)	Project Manager	10 years
Exp- 2	Private (Independent Power Producer)	Managing Director	15 years
Exp- 3	Private (Independent Power Producer)	Managing Director	10 years
Exp- 4	Public (Nepal Electricity Authority)	Deputy Manager	25 years
Exp- 5	Public (Nepal Electricity Authority)	Assistant Manager	10 years

APPENDIX 2: EXPERT VALIDATION REPORT

Validation of Identified Risk Factors by Five Experts

Risk Category	**Financial Risk Factors**	**1 = relevant, 0 = not relevant**					**Total**	**Decision**
		Exp-1	**Exp-2**	**Exp-3**	**Exp-4**	**Exp-5**		
Cost-Related Risks	Design and professional services cost escalation	0	1	1	0	1	3	SELECTED
	Construction time overrun	1	1	1	1	1	5	SELECTED
	Operation and maintenance cost escalation	1	1	1	1	1	5	SELECTED
	Inflation-induced cost escalation	1	1	1	1	1	5	SELECTED
	Environmental compliance and mitigation cost	1	0	1	1	1	4	SELECTED
	Social mitigation and compensation cost	1	0	1	1	1	4	SELECTED
	High occupational safety and health expenses	0	0	1	0	1	2	DISCARDED
	High insurance premium	1	1	1	1	1	5	SELECTED

Revenue and Market Risks	Market demand changes	1	0	0	1	0	2	DISCARDED
	Tariff renegotiation risk at handover	0	1	0	1	1	3	SELECTED
	Off-taker risk (PPA and payment risk)	1	1	0	1	0	3	SELECTED
	Hydrological variability and climate change	1	1	1	1	1	5	SELECTED
	High taxation risk	1	0	0	1	0	2	DISCARDED
	Transmission line construction delay	1	1	1	1	1	5	SELECTED
Financing Risks	Interest rate fluctuation	1	1	1	1	1	5	SELECTED
	Currency exchange fluctuation	1	1	1	1	1	5	SELECTED
	Weak financial market	1	0	0	1	1	3	SELECTED
	Financial system crisis	1	1	1	1	1	5	SELECTED
	Macroeconomic instability	1	1	1	1	1	5	SELECTED
	Inadequate investing capital	1	1	1	1	1	5	SELECTED
	Equity exit risk	0	1	1	1	1	4	SELECTED

	Client inability to service debt	1	1	1	1	1	5	SELECTED
	Delays in financial closure	1	1	1	1	1	5	SELECTED
Regulatory and Institutional Risks	Lack of government guarantees	1	1	1	1	0	4	SELECTED
	Delays in government approvals and licensing	1	1	1	1	1	5	SELECTED
	Insufficient financial audit and monitoring	1	1	1	1	1	5	SELECTED
	Corporate governance risk	0	1	1	0	1	3	SELECTED
	Errors in financial forecasting and data assumptions	0	1	0	1	1	3	SELECTED
External Risks	Permit and license expenditure	0	0	1	0	1	2	DISCARDED
	Adverse geological condition	1	1	1	1	1	5	SELECTED
	Disputes and legal settlements	1	0	1	1	1	4	SELECTED
	Contract termination or cancellation	1	1	0	0	1	3	SELECTED
	Force majeure risk	1	1	1	1	1	5	SELECTED

APPENDIX 3: DEMOGRAPHIC INFORMATION OF AHP EXPERT PANEL

ID	**Sector**	**Position**	**Experience**
Exp- 1	Private (Independent Power Producer)	Project Manager	12 years
Exp- 2	Private (Independent Power Producer)	Managing Director	16 years
Exp- 3	Private (Independent Power Producer)	Project Manager	10 years
Exp- 4	Private (Independent Power Producer)	Vice President- Finance	15 years
Exp- 5	Private (Independent Power Producer)	Chief Executive Officer	25 years

APPENDIX 4: AHP QUESTIONNAIRE FORM

Pairwise Comparison Matrix for Financial Risk Categories

	Cost- Related Risks	Revenue and Market Risks	Financing Risks	Regulatory and Institutional Risks	External Risks
Cost- Related Risks	1				
Revenue and Market Risks		1			
Financing Risks			1		
Regulatory and Institutional Risks				1	
External Risks					1

Pairwise Comparison Matrix for Cost-Related Risk Factors

	Design and Professional Services Cost Escalation	Construction Time Overrun	Operation and Maintenance Cost Escalation	Inflation-Induced Cost Escalation	Environmental Compliance and Mitigation Cost	Social Mitigation and Compensation Cost	High Insurance Premium

Design and Professional Services Cost Escalation	1						
Construction Time Overrun		1					
Operation and Maintenance Cost Escalation			1				
Inflation- Induced Cost Escalation				1			
Environmental Compliance and Mitigation Cost					1		
Social Mitigation and Compensation Cost						1	
High Insurance Premium							1

Pairwise Comparison Matrix for Revenue and Market Risk Factors

	Tarrif Renegotiation Risk at Handover	Off-Taker Risk	Hydrological Variability and Climate Change	Transmission Line Construction Delay
Tarrif Renegotiation Risk at Handover	1			
Off-Taker Risk		1		
Hydrological Variability and Climate Change			1	
Transmission Line Construction Delay				1

Pairwise Comparison Matrix for Financing Risk Factors

	Interest Rate Fluctuation	Currency Exchange Fluctuation	Weak Financial Market	Financial System Crisis	Macroeconomic Instability	Inadequate Investing Capital	Equity Exit Risk	Client's Inability to Service Debt	Delays in Financial Closure
Interest Rate Fluctuation	1								

Currency Exchange Fluctuation		1							
Weak Financial Market			1						
Financial System Crisis				1					
Macroeconomic Instability					1				
Inadequate Investing Capital						1			
Equity Exit Risk							1		
Client's Inability to Service Debt								1	
Delays in Financial Closure									1

Pairwise Comparison Matrix for Regulatory and Institutional Risk Factors

	Lack of Government Guarantees	Delays in Government Approvals and Licensing	Insufficient Financial Audit and Monitoring	Corporate Governance Risk	Errors in Financial Forecasting and Data Assumptions
Lack of Government Guarantees	1				
Delays in Government Approvals and Licensing		1			
Insufficient Financial Audit and Monitoring			1		
Corporate Governance Risk				1	
Errors in Financial Forecasting and Data Assumptions					1

Pairwise Comparison Matrix for External Risk Factors

	Adverse Geological Condition	Disputes and Legal Settlements	Contract Termination or Cancellation	Force Majeure Risk

Adverse Geological Condition	1			
Disputes and Legal Settlements		1		
Contract Termination or Cancellation			1	
Force Majeure Risk				1

APPENDIX 5 : AHP CALCULATION SHEET

Financial Risk Categories

SN		**Cost-Related Risks**	**Revenue and Market Risks**	**Financing Risks**	**Regulatory and Institutional Risks**	**External Risks**	**Average**	**Lambda (λ)**	**λ_{max}**	**C.I.**	**R.C.I.**	**C.R.**
1	**Cost-Related Risks**	0.370	0.338	0.381	0.409	0.305	0.361	5.047624553	5.047624553	0.011906138	1.12	**0.010630481**
2	**Revenue and Market Risks**	0.201	0.184	0.176	0.161	0.200	0.184	5.025411197				
3	**Financing Risks**	0.131	0.141	0.135	0.126	0.178	0.142	5.025688226				
4	**Regulatory and Institutional Risks**	0.221	0.279	0.261	0.244	0.255	0.252	5.040973994				
5	**External Risks**	0.077	0.058	0.048	–	0.063	0.061	5.000467519				
Sum		1.000	1.000	1.000	0.940	1.000	1.000					

Cost- Related Risk Factors

SN		Design and Professional Services Cost Escalation	Construction Time Overrun	Operation and Maintenance Cost Escalation	Inflation-Induced Cost Escalation	Environmental Compliance and Mitigation Cost	Social Mitigation and Compensation Cost	High Insurance Premium	Average	Lambda (λ)	λ_{max}	C.I.	R.C.I.	C.R.
1	**Design and Professional Services Cost Escalation**	0.054	0.061	0.049	0.050	0.048	0.048	0.051	0.052	7.039205032	7.082023545	0.013670591	1.32	**0.010356508**
2	**Construction Time Overrun**	0.337	0.382	0.462	0.370	0.378	0.357	0.332	0.374	7.082023545				
3	**Operation and Maintenance Cost Escalation**	0.158	0.120	0.145	0.183	0.177	0.181	0.155	0.160	7.053362798				
4	**Inflation-Induced Cost**	0.094	0.090	0.070	0.088	0.088	0.090	0.101	0.089	7.02120361				

	Escalation													
5	**Environmental Compliance and Mitigation Cost**	0.119	0.108	0.088	0.107	0.107	0.106	0.141	0.111	7.016998749				
6	**Social Mitigation and Compensation Cost**	0.157	0.150	0.113	0.136	0.142	0.140	0.141	0.140	7.024962594				
7	**High Insurance Premium**	0.081	0.089	0.073	0.067	0.059	0.077	0.078	0.075	7.031367682				
Sum		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000					

Revenue and Market Risk Factors

SN		**Tarrif Renegotiation Risk at Handover**	**Off-Taker Risk**	**Hydrological Variability and Climate Change**	**Transmission Line Construction Delay**	**Average**	**Lambda (λ)**	**λ_{max}**	**C.I.**	**R.C.I.**	**C.R.**

1	**Tarrif Renegotiation Risk at Handover**	0.112	0.164	0.111	0.109	0.124	4.018397931	4.053033456	0.017677819	0.9	**0.019642021**
2	**Off-Taker Risk**	0.039	0.057	0.055	0.066	0.055	4.005680791				
3	**Hydrological Variability and Climate Change**	0.365	0.374	0.360	0.355	0.363	4.041356916				
4	**Transmission Line Construction Delay**	0.483	0.405	0.474	0.469	0.458	4.053033456				
Sum		1.000	1.000	1.000	1.000	1.000					

Financing Risk Factors

SN		**Interest Rate Fluctuation**	**Currency Exchange Fluctuation**	**Weak Financial Market**	**Financial System Crisis**	**Macroeconomic Instability**	**Inadequate Investing Capital**	**Equity Exit Risk**	**Client's Inability to Service Debt**	**Delays in Financial Closure**	**Average**	**Lambda (λ)**	**λ_{max}**	**C.I.**	**R. C.I.**	**C.R.**

1	**Interest Rate Fluctuation**	0.084	0.081	0.111	0.077	0.075	0.098	0.114	0.085	0.075	0.089	9.174467619	9.290351917	0.03629399	1.45	**0.025030338**
2	**Currency Exchange Fluctuation**	0.062	0.060	0.067	0.039	0.044	0.064	0.074	0.067	0.068	0.061	9.129007294				
3	**Weak Financial Market**	0.035	0.042	0.047	0.038	0.037	0.040	0.038	0.063	0.051	0.043	9.143999279				
4	**Financial System Crisis**	0.115	0.162	0.130	0.106	0.145	0.077	0.156	0.094	0.097	0.120	9.200524321				
5	**Macroeconomic Instability**	0.093	0.113	0.106	0.061	0.083	0.076	0.130	0.076	0.090	0.092	9.139877618				
6	**Inadequate Investing Capital**	0.065	0.071	0.090	0.105	0.083	0.076	0.114	0.072	0.068	0.083	9.233946235				
7	**Equity Exit Risk**	0.021	0.023	0.035	0.019	0.018	0.019	0.028	0.037	0.047	0.028	9.038974522				
8	**Client's Inability to Service Debt**	0.265	0.242	0.201	0.302	0.297	0.288	0.205	0.270	0.269	0.260	9.290351917				

9	**Delays in Financial Closure**	0.261	0.206	0.213	0.254	0.217	0.262	0.140	0.235	0.234	0.225	9.273243057				
Sum		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000					

Regulatory and Institutional Risk factors

SN		**Lack of Government Guarantees**	**Delays in Government Approvals and Licensing**	**Insufficient Financial Audit and Monitoring**	**Corporate Governance Risk**	**Errors in Financial Forecasting and Data Assumptions**	**Average**	**Lambda (λ)**	**λ_{max}**	**C.I.**	**R.C.I.**	**C.R.**
1	**Lack of Government Guarantees**	0.100	0.101	0.106	0.085	0.120	0.103	5.056512366	5.119110932	0.029777733	1.12	**0.026587262**
2	**Delays in Government Approvals and Licensing**	0.514	0.515	0.548	0.545	0.377	0.500	5.119110932				

3	**Insufficient Financial Audit and Monitoring**	0.138	0.138	0.147	0.165	0.182	0.154	5.081020071				
4	**Corporate Governance Risk**	0.190	0.152	0.143	0.161	0.252	0.179	5.042019105				
5	**Errors in Financial Forecasting and Data Assumptions**	0.058	0.094	0.056	0.044	0.069	0.064	5.022289796				
Sum		1.000	1.000	1.000	1.000	1.000	1.000					

External Risk Factors

SN		**Adverse Geological Condition**	**Disputes and Legal Settlements**	**Contract Termination or Cancellation**	**Force Majeure Risk**	**Average**	**Lambda (λ)**	**λ_{max}**	**C.I.**	**R.C.I.**	**C.R.**
1	**Adverse Geological Condition**	0.467	0.498	0.455	0.451	0.468	4.007813639	4.007813639	0.002604546	0.9	**0.00289394**

2	**Disputes and Legal Settlements**	0.152	0.162	0.177	0.177	0.167	4.002737442				
3	**Contract Termination or Cancellation**	0.245	0.219	0.239	0.241	0.236	4.002756518				
4	**Force Majeure Risk**	0.136	0.120	0.130	0.131	0.129	4.002962168				
Sum		1.000	1.000	1.000	1.000	1.000					

APPENDIX 6: DEMOGRAPHIC INFORMATION OF KEY INFORMANTS

ID	**Sector**	**Position**	**Experience**
KI-1	Private (Independent Power Producer)	General Manager	16 years
KI-2	Private (Independent Power Producer)	Managing Director	35 years
KI-3	Private (Independent Power Producer)	Project Manager	12 years
KI-4	Private (Independent Power Producer)	Project Manager	10 years
KI-5	Private (Independent Power Producer)	Managing Director	10 years

APPENDIX 7: KII QUESTIONNAIRE FORM (MODULE 1)

Likelihood Assessment of Financial Risk Factors (Likert-Scale)

Rank	**Financial Risk Factors**	**Likelihood of occurrence (1-5 scale)**
1	Construction Time Overrun	
2	Delays in Government Approvals and Licensing	
3	Transmission Line Construction Delay	
4	Hydrological Variability and Climate Change	
5	Operation and Maintenance Cost Escalation	
6	Social Mitigation and Compensation Cost	
7	Corporate Governance Risk	
8	Environmental Compliance and Mitigation Cost	
9	Insufficient Financial Audit and Monitoring	
10	Client's Inability to Service Debt	
11	Inflation- Induced Cost Escalation	

12	Delays in Financial Closure	
13	Adverse Geological Condition	
14	High Insurance Premium	
15	Lack of Government Guarantees	
16	Tarrif Renegotiation Risk at Handover	
17	Design and Professional Services Cost Escalation	
18	Financial System Crisis	
19	Errors in Financial Forecasting and Data Assumptions	
20	Contract Termination or Cancellation	
21	Macroeconomic Instability	
22	Interest Rate Fluctuation	
23	Inadequate Investing Capital	
24	Disputes and Legal Settlements	
25	Off-Taker Risk	

26	Currency Exchange Fluctuation	
27	Force Majeure Risk	
28	Weak Financial Market	
29	Equity Exit Risk	

APPENDIX 8: KII QUESTIONNAIRE FORM (MODULE 2)

Effectiveness Assessment of Mitigation Instruments for Financial Risk Factors (Likert-Scale)

Rank	**Financial Risk Factors**	**Effectiveness of Mitigation Instruments (1-5 scale) if applicable**						
		Power Purchase Agreement	**Power Development Agreement**	**Syndicated Credit Facilities Agreement**	**Engineering Procurement and Construction Contract**	**Operation and Maintenance Contract**	**Insurance Mechanisms**	**Financial Hedging**
1	Construction Time Overrun							
2	Delays in Government Approvals and Licensing							
3	Transmission Line Construction Delay							

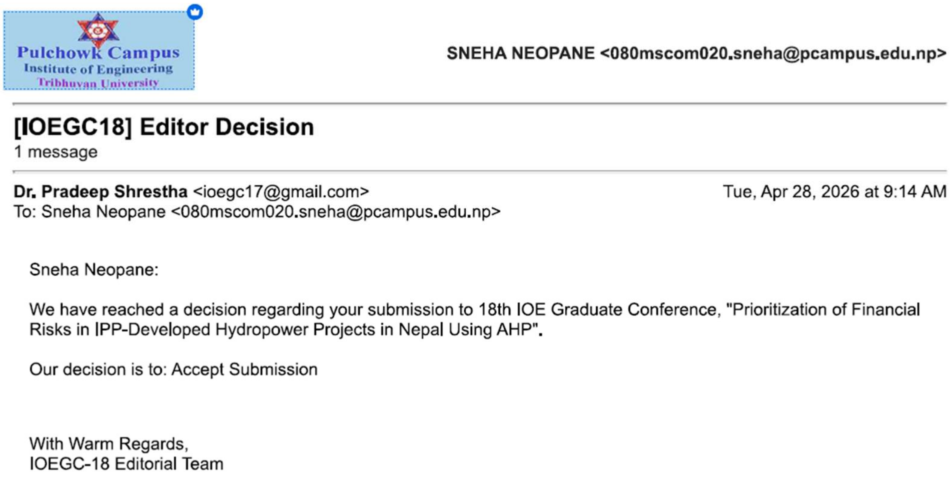
4	Hydrological Variability and Climate Change							
5	Operation and Maintenance Cost Escalation							
6	Social Mitigation and Compensation Cost							
7	Corporate Governance Risk							
8	Environmental Compliance and Mitigation Cost							
9	Insufficient Financial Audit and Monitoring							
10	Client's Inability to Service Debt							
11	Inflation- Induced Cost Escalation							

12	Delays in Financial Closure							
13	Adverse Geological Condition							
14	High Insurance Premium							
15	Lack of Government Guarantees							
16	Tarrif Renegotiation Risk at Handover							
17	Design and Professional Services Cost Escalation							
18	Financial System Crisis							

19	Errors in Financial Forecasting and Data Assumptions							
20	Contract Termination or Cancellation							
21	Macroeconomic Instability							
22	Interest Rate Fluctuation							
23	Inadequate Investing Capital							
24	Disputes and Legal Settlements							
25	Off-Taker Risk							
26	Currency Exchange Fluctuation							
27	Force Majeure Risk							

28	Weak Financial Market							
29	Equity Exit Risk							

ANNEX I: ACCEPTANCE LETTER FOR 18TH IOE GRADUATE CONFERENCE



Pulchowk Campus
Institute of Engineering
Tribhuvan University

SNEHA NEOPANE <080mscom020.sneha@pcampus.edu.np>

[IOEGC18] Editor Decision
1 message

Dr. Pradeep Shrestha <ioegc17@gmail.com> Tue, Apr 28, 2026 at 9:14 AM
To: Sneha Neopane <080mscom020.sneha@pcampus.edu.np>

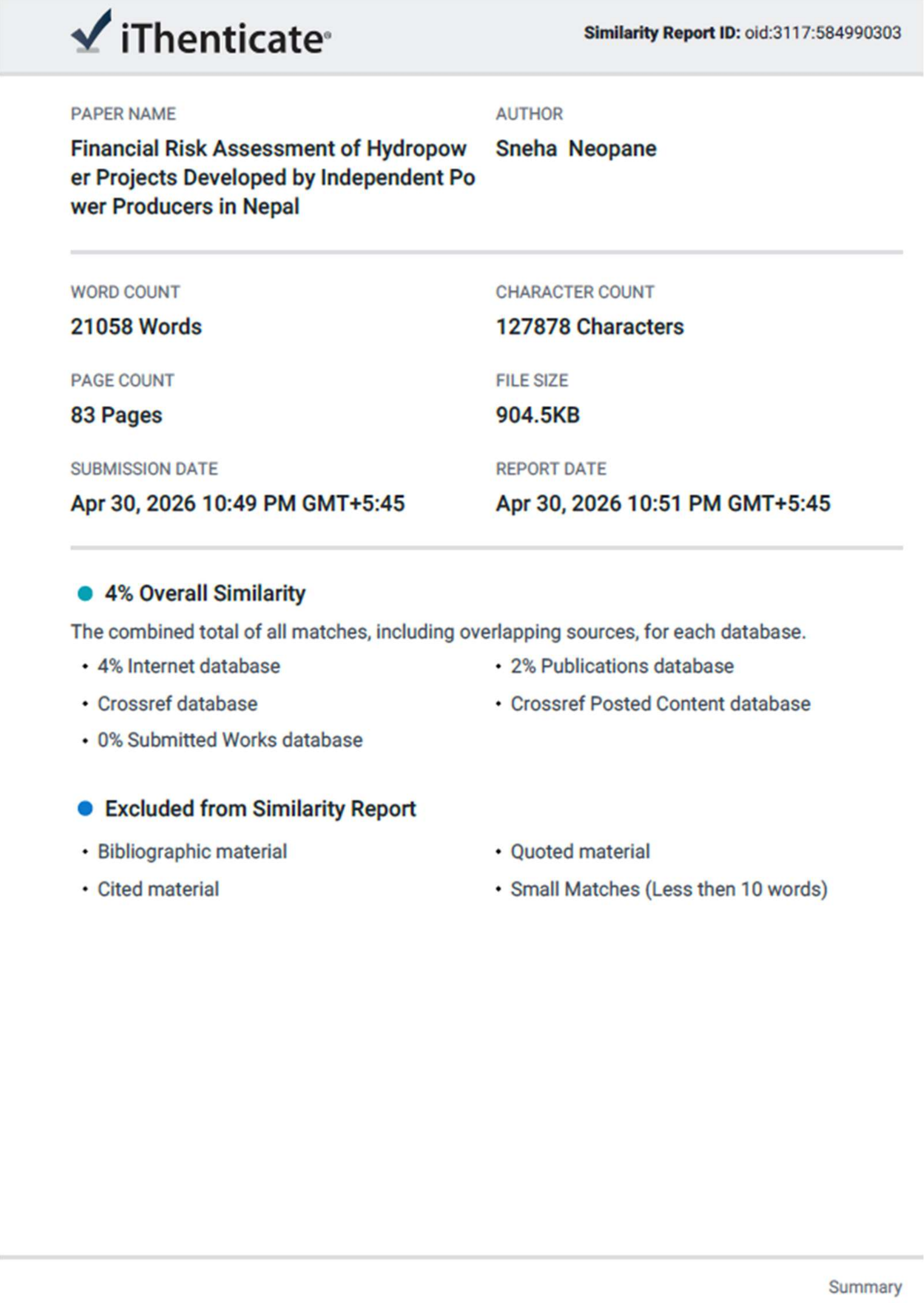
Sneha Neopane:

We have reached a decision regarding your submission to 18th IOE Graduate Conference, "Prioritization of Financial Risks in IPP-Developed Hydropower Projects in Nepal Using AHP".

Our decision is to: Accept Submission

With Warm Regards,
IOEGC-18 Editorial Team

ANNEX II: ORIGINALITY REPORT



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PAPER NAME

Financial Risk Assessment of Hydropower Projects Developed by Independent Power Producers in Nepal

AUTHOR

Sneha Neopane

WORD COUNT

21058 Words

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127878 Characters

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83 Pages

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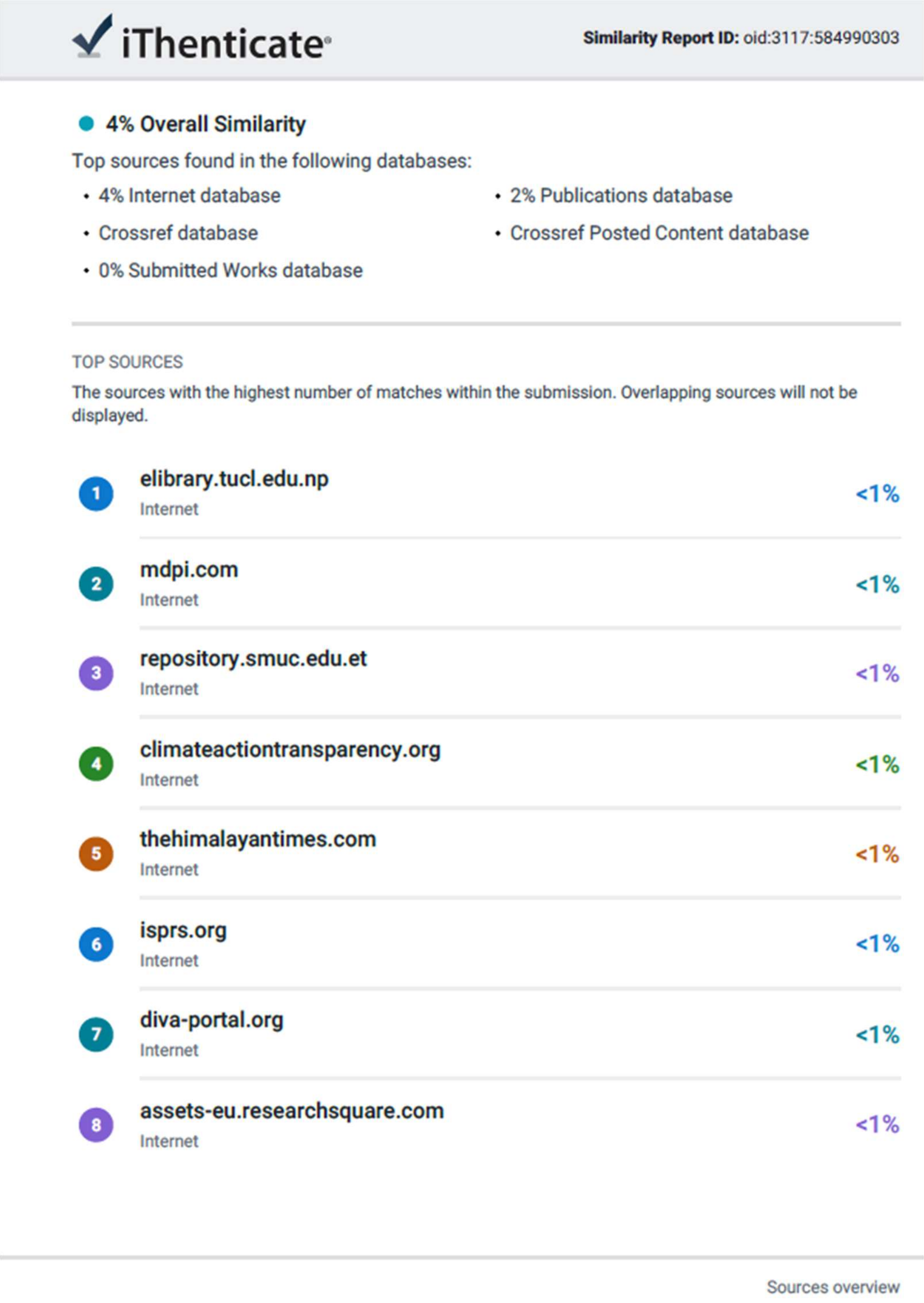

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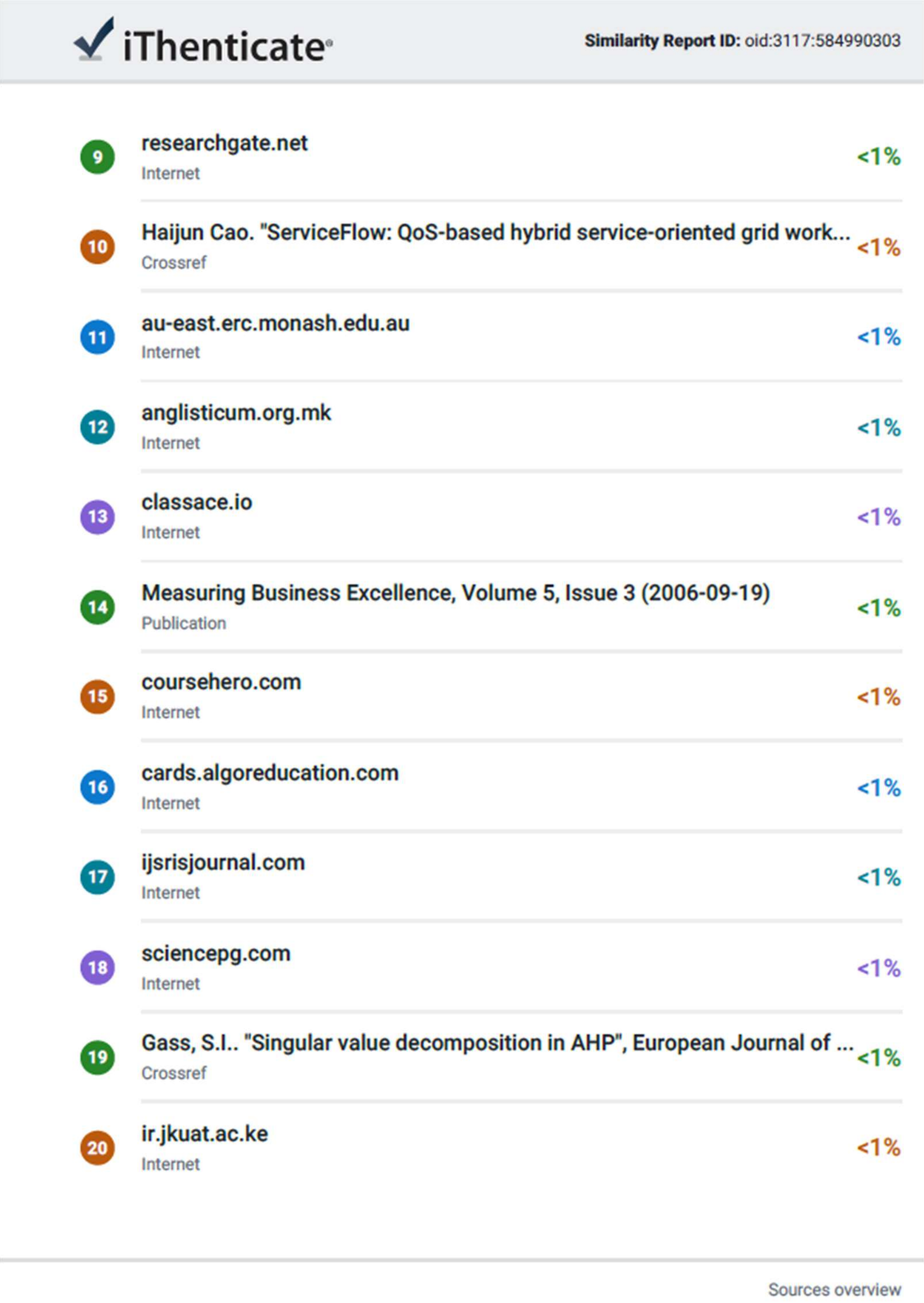

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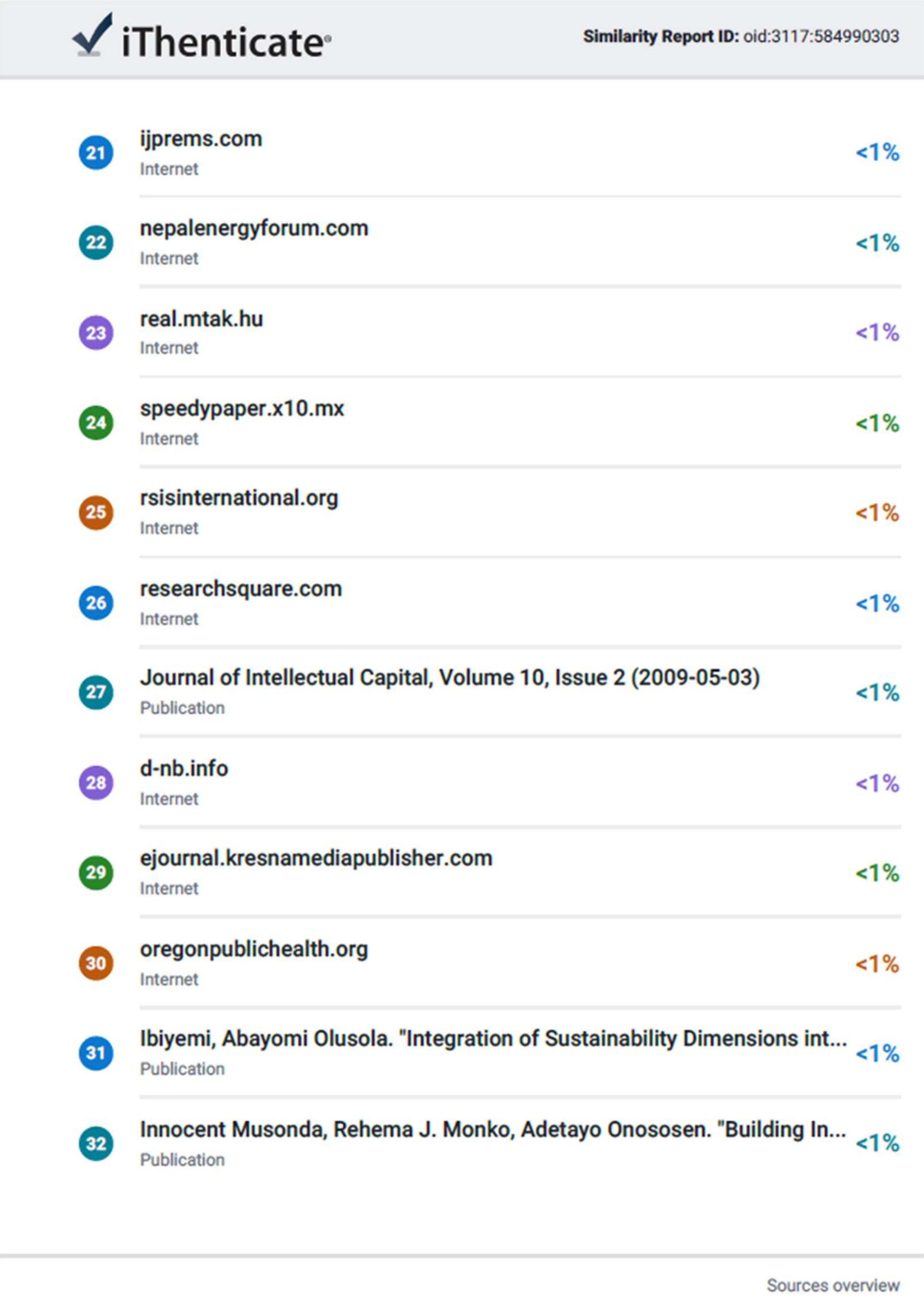

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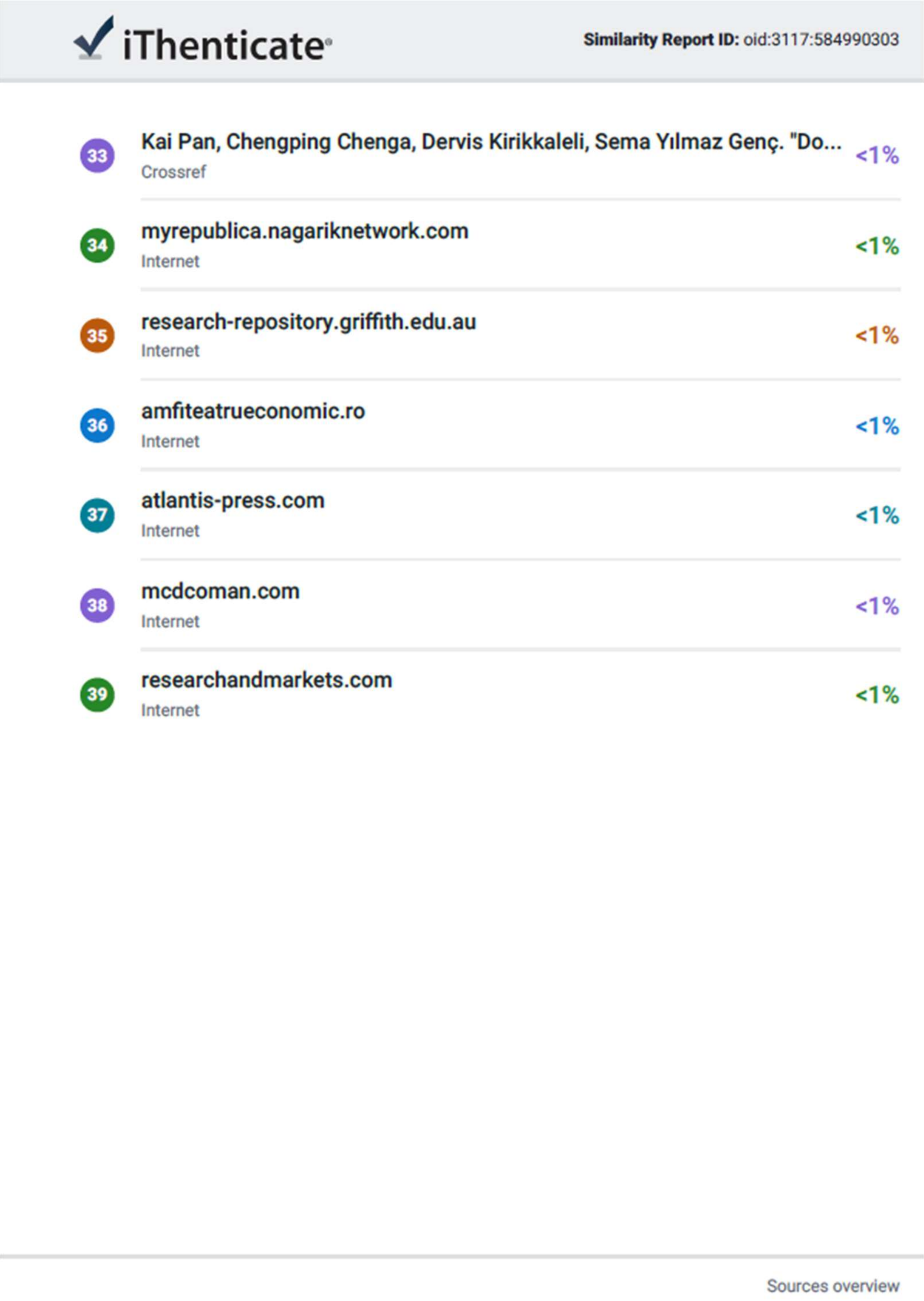

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