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Identifying And Ranking The Significant Causes Of Construction Delay In Private Hydropower Projects In Nepal

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Abstract

Construction delays in hydropower projects causes a significant challenge to project completion and operations, particularly in Nepal's private sector. This research aims to identify and rank the primary causes of delays using empirical data collected from stakeholders such as project engineers, managers, and developers. A qualitative research approach, including structured surveys, was employed to gather data from 34 private hydropower projects. Statistical analysis, including ranking techniques, was applied to identify the delay factors such as financial constraints, environmental issues, regulatory hurdles, and labor/material shortages. The findings also highlight that inefficiencies in project funding shortages, approval processes, and adverse weather conditions significantly impact project timelines. This study provides perilous perceptions for officials, investors, engineers and managers, suggesting efficient regulatory framework, boosted financial structuring, and improved stakeholder collaboration to mitigate delays. The recommendations aim to enhance project efficiency and contribute to the sustainable growth of Nepal's hydropower industry.

Keywords: Construction Delays, Nepal, Hydropower, Development, Risk and Causes, Project Management.

1. Introduction

Nepal's hydropower sector plays a vital role in the country's energy generation. However, construction project delays in private hydropower developments have been identified, leading to increased costs and postponements in RCOD and electricity supply benefits. Despite Nepal's massive hydropower potential, only a fraction of it has been connected to national grid due to various challenges, including time and cost overruns in project construction. This study examines and ranks the most significant causes of delays.

Understanding the key factors leading to these delays is important for effective project management and policy design. Hydropower projects often face issues such as regulatory hurdles, technical inefficiencies, financial constraints, and social or environmental concerns. The impact of these delays affects the overall energy production of Nepal, increase costs for projects, and hindering the expansion of upcoming projects. The general objective of the study is to identify and rank the root causes of construction delays in private hydropower projects within Nepal. The specific objectives are:

- To identify the current status and challenges of under-construction private hydropower projects,
- To identify the causes of delays in operational and under construction Projects, and
- To rank the identified significant causes of delays.

2. Hydropower Development In Nepal

Nepal has huge hydropower energy production probable, but only a fraction has been connected to the national grid. Even though the construction/development of hydropower in Nepal was started at an early stage, the slow growth of hydropower projects construction has been attributed to financial limitations, regulatory bottlenecks, and technical inefficiencies. Hydropower projects require multiple approvals from regulatory bodies, making the licensing and approval process cumbersome. Past studies highlight common delay factors such as environmental regulations, financing issues, and technical inefficiencies. Also, similar studies from Pakistan, India, and other developing nations show comparable challenges, indicating the need for localized solutions in Nepal. Existing literature too underlines that delays in infrastructure projects are mainly due to poor planning, insufficient risk assessment, and lack of coordination among stakeholders.

3. Research Methodology

A qualitative research approach was adopted during this study. Data was collected by using questionnaires from 34 private hydropower projects. The selection of 34 projects as sample size were done from random sampling by using Slovin's formula.

$$n = \frac{N}{1+Ne^2} \quad \text{……..…... I}$$

Where, n = Sample Size and N = Population Size = 144, referring to the total number of hydropower projects under construction at the time of this research.

e = Margin of error, for this, A 85% confidence level implies the accepting a greater risk that sample may reflect the population. i.e., e = 100%- 85% = 15%

So, on using Equation I, sample size (SS) is 33.96 which is nearly equals to 34 i.e. which is the numbers of projects for the study. Out of the 34 projects the capacity wise studied projects are

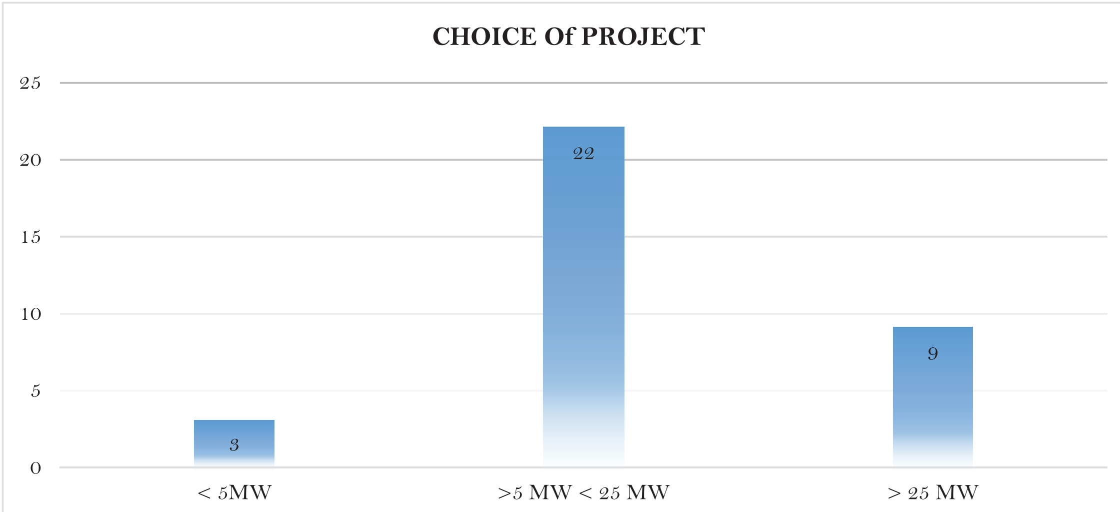

Figure 1: Capacity wise studied projects

All thirty-four projects have a similar practice of construction in terms of planning, construction, documentation, financial management, PPA with NEA, consultants and contractors. The survey targeted key stakeholders, including project managers, engineers from employers, consultants and contractors. The analysis used to find out the results is based on Slovin's formula for sample size, Cronbach's alpha for reliability testing and Relative Importance Index (RII) for ranking techniques to determine the delay factors. The number of survey participants was determined using statistical techniques for estimating sample size based on population proportions.

Population Sample Size (n) = $\frac{Z^2 * P\ (1-P)}{C^2}$

- Where Z is confidence Level value for 95% = 1.96
- P is Percentage Picking a choice expressed in decimal, = 0.5
- and C is Confidence interval expressed in decimal, also known as margin of error. C= 0.1, taking 10% margin of error.

As our population size (N) is relatively so we use, Finite population sample size

(SS) = $\frac{n}{1+\frac{n-1}{Pop.}}$ ……..…... II

- Where Pop. is the population from where the sample size is determined.
- Pop = 155 Nos
- By applying Equations I and II, the calculated sample size (SS) is 59.53, which is approximately 60, the number of individuals who participated in the study.

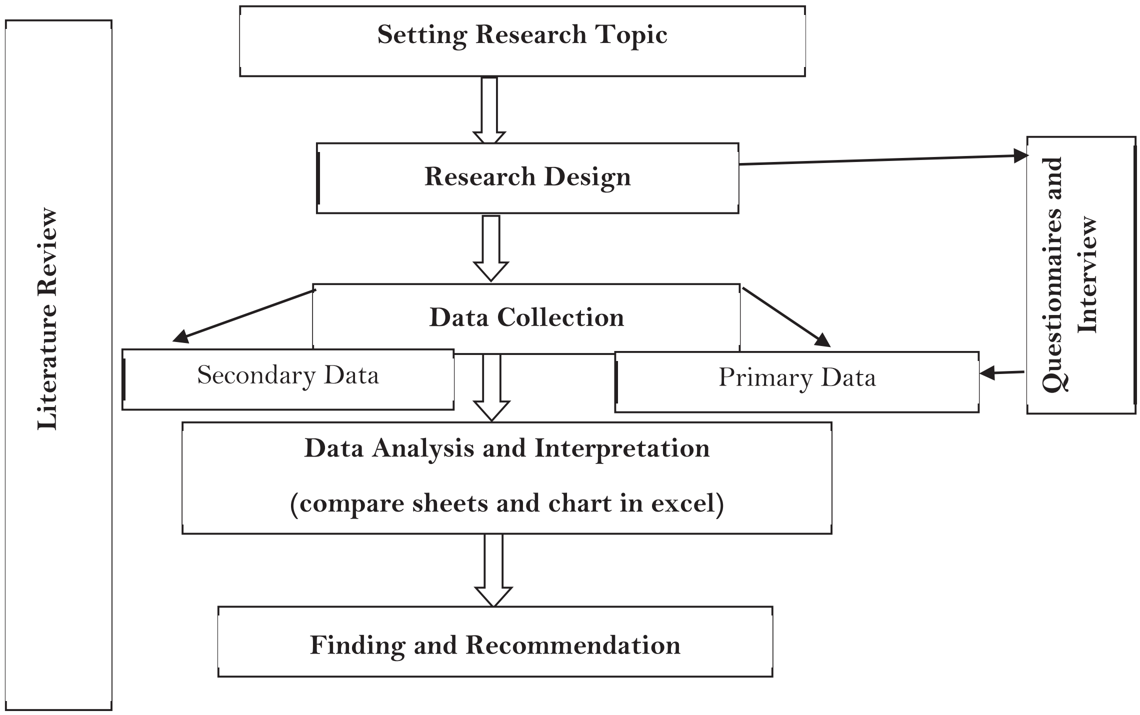

Figure 2: Flow chart of Research Methodology

The research is aimed to gather data about the current scenario of hydropower projects in Nepal. Data collection for this study was done in two stages. In the first stage, all related causes of construction delays were collected as primary data through site observations and questionnaires. Specific questionnaires were prepared, which are very common in many construction projects. In the second stage secondary data collection was undertaken with a focus on the study's objectives. Primary data sources included individual personnel form hydropower projects whereas the secondary data include the report of individual projects, IPPAN Annual Report, Environmental Monitoring Reports, Power Purchase Agreement, EIA reports, and various documents from websites including research books, and journal articles. During the site visit group conversations were conducted with managers and engineers to find their perceptions towards the project and their issues. The methodology adopted for doing this research from questionnaire to result finding is as:

1 The questionnaire is systematically structured into three key sections to comprehensively examine the interrelated factors contributing to delays in hydropower project construction:

- **Section A: Respondent General Information**

  This section captures the demographic and professional profiles of participants, including their stakeholder role (Client, Contractor, Consultant, or Third Party), years of experience, functional area (technical, managerial, stakeholder), as well as the type and capacity of the hydropower project they are involved in.
- **Section B: Project Details and Impact of Delays**

  This part gathers insights into the status of the respondent's project, observed or anticipated effects of delays (e.g., cost overruns, stakeholder disputes, social consequences), and the frequency of construction schedule revisions, providing a measure of project volatility.
- **Section C: Delay Causes Factors Assessment**

Utilizing a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree), this section enables respondents to rate the significance of various delay-causing factors, allowing for quantifiable analysis of perceived risks and their severity.

2 All project parties' (Client, Consultant and Contractor) engineers, managers were questionnaire on the subject. The questionnaire set was followed by a formal interview/ questionnaire and particular parties related discussion.

3 The delay factors were divided into 4 groups. They were client-related, consultant-related, contractor-related, other factors. The other factors include the (Government institutions, Financial Intuitions, Social Community, NEA, IPPAN, DOED etc.)

4 The responses obtained from the questionnaires were systematically entered into a Microsoft Excel for digital organization, preliminary cleaning, and subsequent analysis.

5 To find factors of delay Likert scale is used to get the result of this part

Table 1: Likert Scale

Table: Likert Scale

Items	*Highly Disagree*	*Disagree*	*Neither Agree Not Disagree*	*Agree*	*Highly Agree*
Scaler	5	4	3	2	1

6 The qualitative data of questionnaires had been converted to quantitative data with five ranking Likert scale to calculate Cronbach's Alpha Reliability Test for the reliability of the data as,

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K}\sigma_i^2}{\sigma_X^2}\right)$$

- Were, K= number of items in a scale
- σ_i^2= refer to the variance associated with item i
- σ_X^2= refers to the variance associated with the observed total scores,

which is expressed as a number between 0 to 1 and higher the value more consistent and reliable. In our case the result achieved from the data is 0.93, which is excellent.

7 And the data obtained from the Likert scale are ranked by Relative Importance Index (RII), one of the most widely used methods in construction management research later the result are converted to percentage.

$$\text{RII} = \frac{\sum W}{A \; x \; N}$$

Where:

- $\sum$w = Sum of the weights given to each factor by the respondents (i.e., $w_1+w_2+\ldots+w_n$)
- A= Highest possible weight (e.g., 5 in a 1–5 Likert scale)
- NN = Total number of respondents,
- RII values range from 0 to 1. Higher values indicate more significant causes and rank as the first priority.

4. Results And Discussion

This study employs a mixed-method research approach, combining qualitative and quantitative research approach, i.e. including questionnaire surveys and structured interviews with professionals involved in private hydropower projects. A sample of 34 private hydropower projects was selected using Slovin's formula to ensure a statistically significant representation. Most of the projects have failed to meet their project schedule to generate electricity in RCOD. They have experienced time overruns ranging from 15 months to 36 months beyond the original schedule and cost overrun ranging from 5 to 10 % above from the original budget.

The results of this study provide an inclusive understanding of the key factors contributing to delays in private hydropower projects in Nepal. Based on data collected from surveys and interviews, the findings highlight the most significant issues that impact project completion.

4.1 Approval and Regulatory Delays

- Lengthy licensing procedures requiring approval from number of institutions.
- land acquisition and environmental policies causing lengthy waiting periods.

4.2 Financial and Economic Constraints

- Delays in investment approvals and project financing and slow in loan and grants disbursement from financial institutions
- Budget overruns due to inflation and unexpected cost escalations.

4.3 Employer, Contractor and Consultant Issues

- Poor project planning and lack of skilled workforce including the Inefficient contract management and delays in procurement of materials.
- Frequent design changes and disputes between contractors and consultants.

4.4 External and Environmental Factors

- Adverse weather, geological conditions affecting construction timelines and leading to technical challenges.
- Social and political disruptions, including local protests and strikes.

5 Findings And Ranking

The study analyzed delays by interviewing and questioning key stakeholders from projects. The findings exposed varied views from employers, contractors, and consultants. The delays were ranked based on scores provided by respondents, highlighting the top reasons for the setbacks. This analysis offers a comprehensive view of the challenges and diverse opinions on the causes of delays in these projects on behalf of Client, Consultants, Contractors and other parties.

Client/ Employer/Owner Related Causes

In privately owned ongoing construction hydropower projects in Nepal, several factors contribute to delays. One significant issue is the unseen interference of the owner. The list of delays caused due to client related is shown in the chart and their ranking is tabulated below:

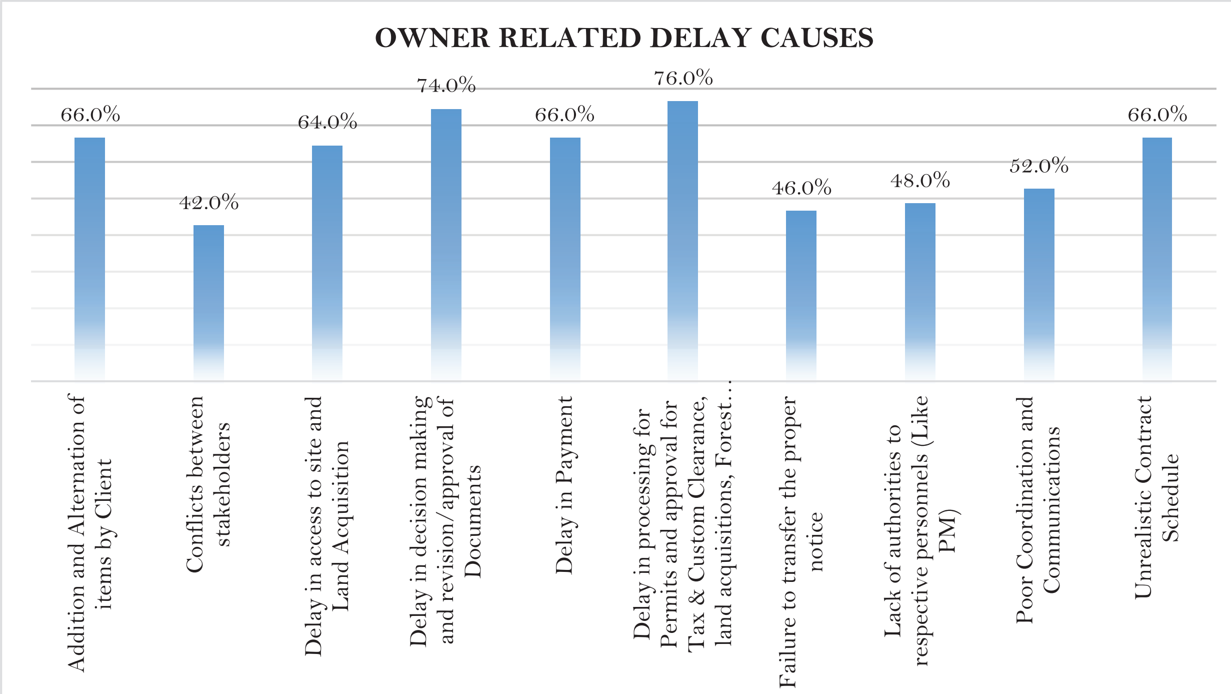

Figure 3: Delay Causes due to Client/ Employer/Owner

Table 2: Owner related five major ranked Delay Causes

Major Causes of Delays	Topmost ranking from the respondents View
Delay in processing for permits and approval for Tax & custom clearance, land acquisitions, forest clearance and Visa etc..	1
Delay in decision making and revision/approval of documents	2
Delay in payment, lack of finance to complete the works	3
Unrealistic Contract Schedule	4
Addition / alternation of items and variation in scope of works	5

Consultant Related Causes

Similarly, in privately owned hydropower projects in Nepal, consultant-related delays are caused by several factors are shown in chart and their ranking is tabulated below:

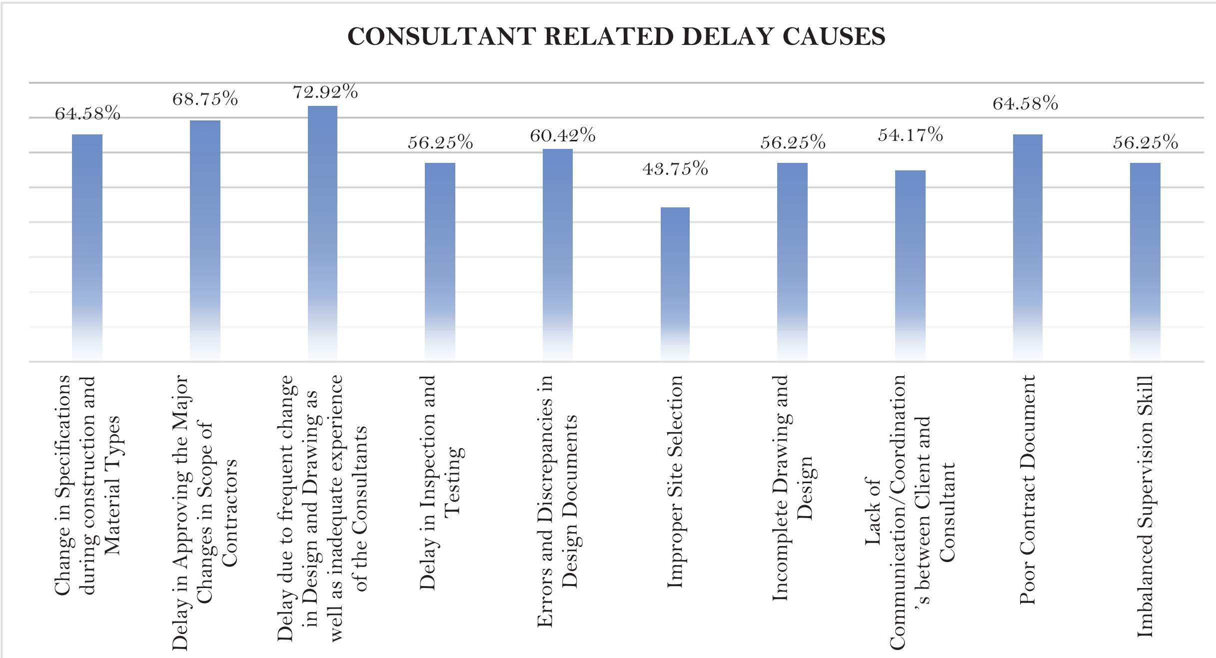

Figure 4: Delay Causes due to consultant

Table 3: Consultant related five major Delay Causes

Major Causes of Delays	Topmost ranking from the respondents View
Delay due to frequent change in design and drawing as well as inadequate experience of the consultants	1
Delay in approving the major changes in scope of contractors	2
Poor contract document	3
Change in specifications during construction and material types	4
Errors and discrepancies in design documents	5

Contractor Related Causes

Likewise, the cause of delay in construction in privately owned hydropower projects in Nepal, on behalf of contractor are shown in chart and their ranking is tabulated below:

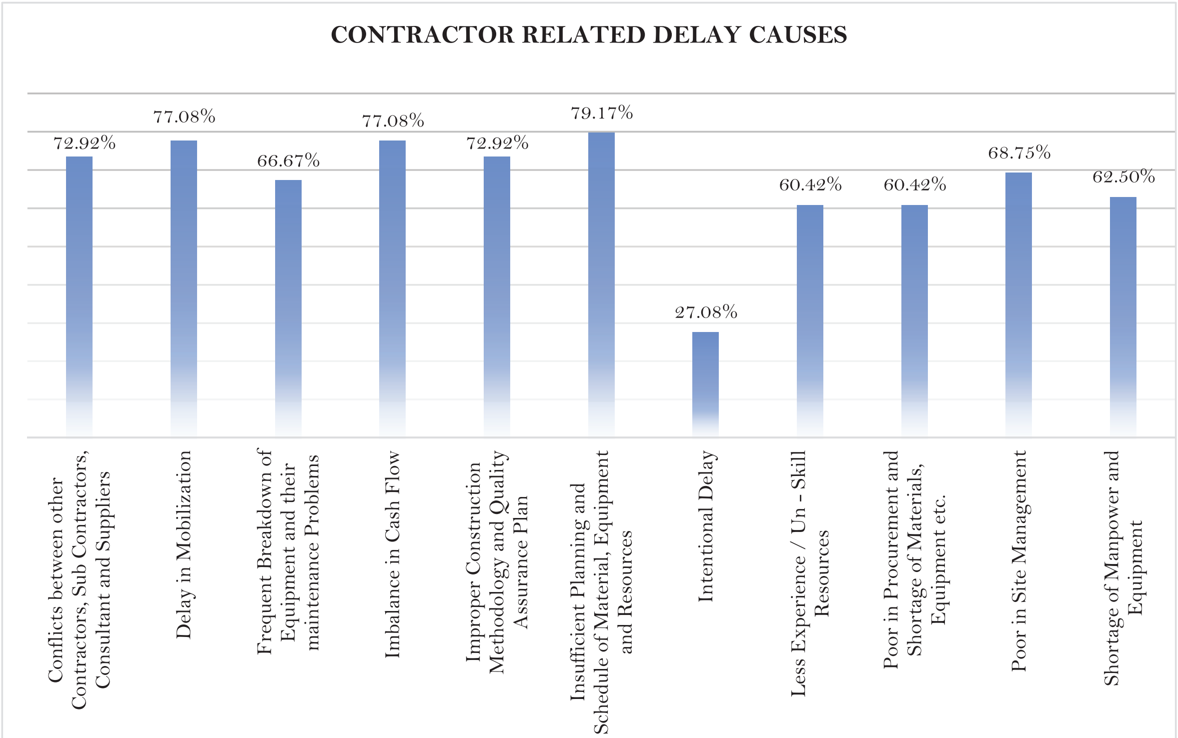

Figure 5: Delay Causes due to consultant

Table 4: Contractor related five major Delay Causes

Major Causes of Delays	Topmost ranking from the respondents View
Insufficient planning and schedule of material, equipment and resources	1
Delay in mobilization	2
Imbalance in cash flow	3
Conflicts between other contractors, subcontractors, consultants and suppliers	4
Improper construction methodology and quality assurance plan	5

Other related Causes

Several significant factors like natural calamities (earthquakes, pandemics, floods, landslides, hurricanes, and wind) are also primary causes that create delay. As well as constructing grid connections and transmission lines by the Nepal Electricity Authority (NEA), delay in approval from DOED, ministry and their supplementary body, financial institutions, Social and local bodies, government policies, whether effects, price hike, strikes, blockades also contribute significantly to delay from other.

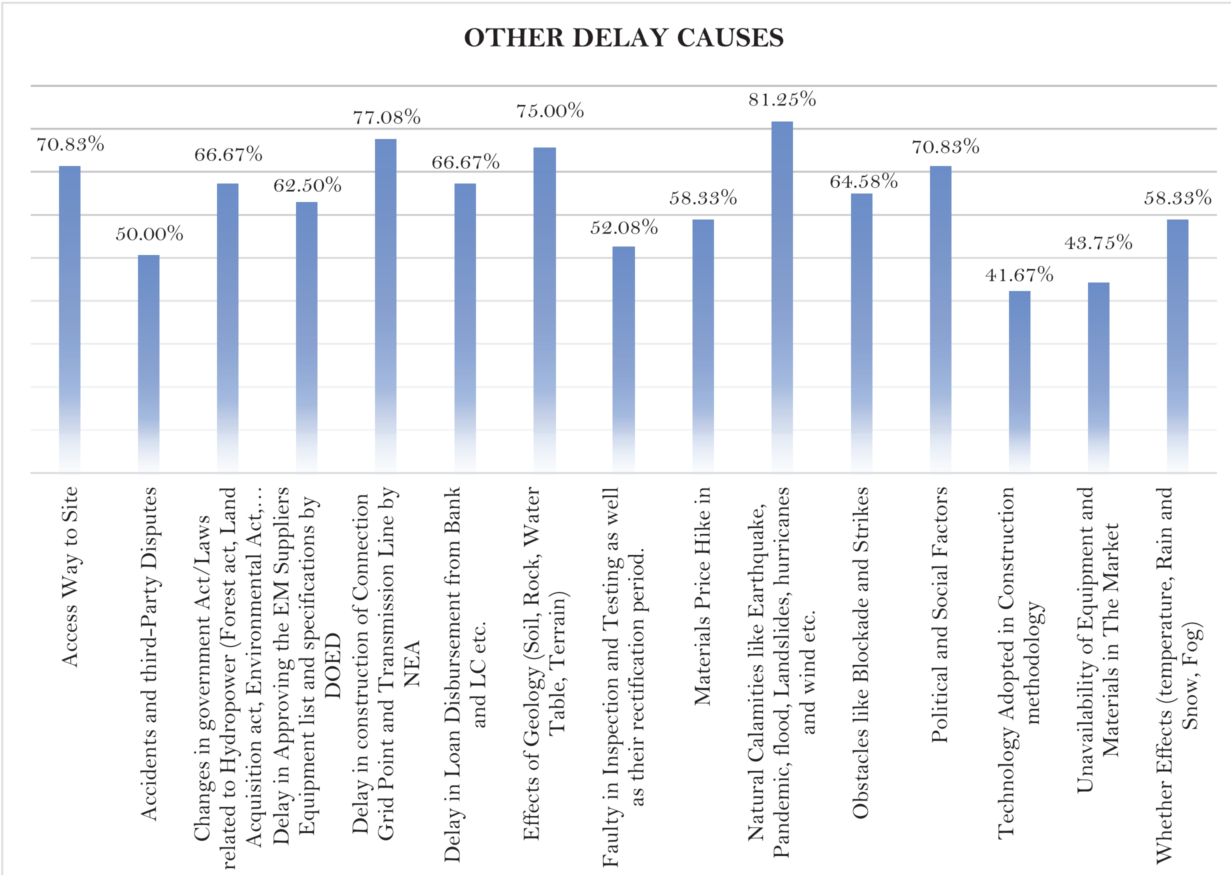

Figure 6: Delay Causes due to Other institutions

Table 5: Other related five major Delay Causes

Major Causes of Delays	Topmost ranking from the respondents View
Natural calamities like earthquake, pandemic, flood, landslides, hurricanes and wind etc.	1
Delay in construction of connection grid point and transmission line by NEA	2
Effects of geology (soil, rock, water table, terrain)	3
Access Way to Site	4
Political and social factors	5

6 Impacts of Delays on Project Costs

Delays in hydropower projects in Nepal have significant impacts on various aspects of project execution, time, costs, and outcomes.

Increase in Project Time Schedule

Extended project schedules lead to financial stress due to cost overruns from continued equipment, labor, and material expenses, along with additional interest payments from extra funding needs and previous disbursements. Resource management becomes composite as labor and equipment remain tied up, and machinery requires more maintenance. Contractual and legal issues may arise from breaches of contract and penalty clauses, leading to arguments with contractors, financial institutions and financial penalties. Commercial operational delays in revenue generation and disrupt coordination with other organizations. Stakeholder confidence corrodes, affecting investors and public trust. Extended construction periods also cause increased environmental disturbance and social pressures including questioned regarding project feasibility, requiring feasibility reviews.

Increase in Project Costs

Delays often lead to increased direct costs, such as labor, equipment, and material expenses but also prolonged project timelines: mean longer use of resources, which significantly expands the budget. Indirect costs related to overheads, management, and administrative expenses also increase with project delays, further straining the project's financial health.

Increase in Operational Delays

Due to delays in construction, the operational delays result in postponed revenue generation, impacting financial projections and investor returns. Projects dependent on completion dates for revenue generation, early completion will be beneficial to investors in terms of revenue whereas a delay in completion will result in a loss of revenue generation.

7 Comparison if Delay Causes Across Different Infrastructure Projects at Different Locations

A relative examination of key delay factors across multiple infrastructure projects in Nepal and outside Nepal is presented in the chart below:

Table 6: Comparison between the cause of delay identified in other countries and in this research

Causes Identified	Batool, A. Pakistan	Thapa, S. Nepal	This Research (Nepal)
Stakeholder Issues	Lack of coordination among different stakeholders i.e. clients, consultants, contractors, and project teams	Poor communication and coordination with other contractors and parties by contractors	Delay in processing permits and approval for tax & custom clearance, land acquisitions, forest clearance and visa etc.
Contractor-related Delays	Delay of work by local contractors	Delay due to demand and strikes of locals	Delay in decision making and revision/approval of documents
	Personal motives of contractors (intentional delays etc.)	Poor planning and management by the client.	Delay in payment, lack of finance to complete the works

Causes Identified	Batool, A. Pakistan	Thapa, S. Nepal	This Research (Nepal)
Land & Site Access	Delays in land acquisition by land department	Quantity overrun of the project	Delay in access to site and land acquisition
Contractual Issues	Non-compliance by contractor with contractual provisions	Topography of the project	Addition / alternation of items and variation in scope of works
Force Majeure / Environment	Force majeure – war, strikes, bad weather, flood, earthquake, land sliding etc.	Delays in land acquisition and resettlement processes	Delay due to frequent change in design and drawing as well as inadequate experience of the consultants
Design & Documentation	Lack of quality management framework	Slow mobilization of the contractor	Delay in approving the major changes in scope of contractors
	Lack of skilled & professional manpower at executing agency	Poor and inappropriate design and drawing	Change in specifications during construction and material types
	Poor project time management	Natural disaster.	Poor contract document
Procurement & Logistics	Delay in procurement and transportation of equipment and supplies	—	Conflicts between other contractors, sub-contractors, consultants and supplier
	Unavoidable changes during execution due to unforeseen geological conditions	—	Insufficient planning and schedule of material, equipment and resources
Financial Constraints	Poor financial planning	—	Delay in mobilization
	Higher inflationary trends (material cost, labor, equipment etc.)	—	Natural calamities like earthquake, pandemic, flood, landslides, hurricanes and wind etc.
Governance & Regulation	Bad law and order situation	—	Delay in construction of connection grid point and transmission line by NEA
	Delays in tendering process	—	Effects of geology (soil, rock, water table, terrain)
Planning & Administration	Poor project planning	—	Access way to sit

Causes Identified	Batool, A. Pakistan	Thapa, S. Nepal	This Research (Nepal)
Political & Social Factors	Delay in issuance of NOC-permits from other departments	—	Errors and discrepancies in design documents
	Lack of political will	—	Improper construction methodology and quality assurance plan
	Delay in civil work	—	Imbalance in cash flow
	Incompetent contractors	—	Political and social factors

8 Conclusion and Recommendations

This study sightseen the causes of completing hydropower projects on specified schedule and budget in Nepal, with a focus on the primary causes of delays. Key factors contributing to these issues were recognized, poor project management and insufficient planning, regulatory hurdles, labor, material and equipment deficiencies, and unforeseen geological and whather conditions. These challenges not only lead to delays and cost overruns but also hinder the long-term sustainability of hydropower projects and the country, impacting the revenue generation, energy supply, job creation and environmental outcomes.

In summary, delays in hydropower projects lead to financial stress, resource management, contractual disputes, operational setbacks, stakeholder distrust, technological obsolescence, quality and safety concerns, environmental and social impacts, and overall viability of projects. Based on the findings of this study, the following recommendations are proposed to mitigate the delays faced in hydropower projects:

1. Confirming that projects are systematically planned from the start, with detailed risk calculations and realistic schedules, can help reduce delays and cost overruns. More accurate forecasting of time and budget will be vital for securing funding.
2. Advanced project management tools and methodologies, such as the Critical Path Method (CPM) and Earned Value Management (EVM), to monitor progress and anticipate issues before they arise shall be adopted.
3. To manage the technical challenges and improve overall project performance, training should be provided for project personnel, including engineers, project managers, and workers.
4. The Public-Private Partnerships (PPP) model shall be more invigorated, encouraging collaboration between the public and private sectors can help alleviate financial and operational pressures, ensuring projects are adequately funded and managed with a focus on long-term success.
5. Starting a clear communication framework and regular progress meetings and coordination between all stakeholders, including government agencies, consultants, contractors, local communities, and environmental organizations, for better output.
6. Effective risk management strategies shall be implemented including comprehensive risk identification, assessment, and mitigation plans, so that better preparation in handling unpredictable events, such as natural disasters, political instability, market fluctuations, cultural and social hinderance can be done.

By addressing these challenges and adopting the proposed recommendations, the hydropower sector in Nepal can be improved in its capability to complete projects on time and within budget, thus contributive to the country's energy generation, revenue generation and sustainable development.

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