



Evaluation of Critical Success Factors Affecting Hydropower Project Performance

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Abstract: Hydropower projects play a significant role in sustainable energy generation and infrastructure development. However, the successful execution of such projects is often challenged by technical, managerial, financial, environmental, and organizational factors. Understanding these factors is essential for improving project performance and minimizing the risk of project failure. The present study aims to identify, evaluate, and rank the critical success and failure factors affecting hydropower projects. A comprehensive review of literature was conducted to identify major factors influencing project outcomes. Data were collected through a structured questionnaire survey administered to professionals associated with hydropower projects, including project managers, construction managers, engineers, consultants, and contractors. The collected responses were analyzed using the Relative Importance Index (RII) method to determine the significance of individual factors. The analysis revealed that project manager's experience, contractor's experience, leadership capability, effective site management,

design team expertise, availability of construction materials, and site conditions are among the most influential factors contributing to project success. Conversely, inadequate planning, poor coordination among stakeholders, financial constraints, resource shortages, and environmental uncertainties were identified as major causes of project failure. The findings of this study provide valuable insights for project owners, consultants, contractors, and policymakers in developing effective strategies for enhancing the performance and sustainability of hydropower projects. The study also establishes a framework for future research on project success assessment and risk management in the hydropower sector.

Keywords: Hydropower Projects, Critical Success Factors, Project Failure Factors, Relative Importance Index (RII), Project Performance, Construction Management, Risk Assessment.



1. Introduction

Construction projects are dynamic in nature due to uncertainties in budgets, technology and development processes. Major goals in construction industry are budget, schedule and quality.

Failure or success of the achievement of these objectives depends upon variety of factors. The concept of project success is a means to improve the effectiveness of the project. There is ambiguity about the concept of project success in the minds of construction professionals. Project success can be defined as meeting the required expectation of stakeholders and achieving its purpose. A successful project is one that is delivered on the time and managed with budget, time, cost and quality. Those measures which results in the organization success are called critical success factors. Therefore the main purpose of this research paper is to recognize the factors which are responsible for the success of the hydropower projects.

1.1 Need of Study

Hydropower projects frequently encounter challenges such as resource shortages, poor coordination, inadequate planning, financial constraints, and environmental uncertainties. These challenges adversely affect project performance and increase the likelihood of delays and cost overruns. Although several studies have examined project success factors in general construction projects, limited research has specifically focused on hydropower projects. Therefore, a systematic evaluation of critical success factors is necessary to support effective project management and improve project outcomes.

1.2 Objective

The main objectives of this project are:-

- ❖ To identify the factors affecting the success and failure of hydropower projects.
- ❖ To evaluate the significance of identified factors using Relative Importance Index (RII).
- ❖ To rank the critical success factors affecting project performance.
- ❖ To provide recommendations for improving hydropower project management.

2. Literature Review

Several researchers have investigated the factors affecting project success in construction and infrastructure projects. Kartam and Levitt (1990) highlighted the importance of planning and decision-making through artificial intelligence-based construction management systems. Their study demonstrated that effective planning significantly improves project execution and performance.

Sanvido et al. (1992) identified critical success factors for construction projects and concluded that experienced project teams, effective contract management, proper planning, and stakeholder coordination are essential for project success. Their work established the foundation for subsequent studies on critical success factors.

Belassi and Tukel (1996) proposed a comprehensive framework for categorizing project success factors into project-related, manager-related, organizational, and external environmental factors. Their study emphasized the interaction among different factors and their collective influence on project outcomes.

Chua, Kog, and Loh (1999) applied the Analytical Hierarchy Process (AHP) to evaluate critical success factors in construction projects. Their findings indicated that adequate project planning, constructability,



funding availability, and economic stability are among the most significant factors affecting project performance.

Chan et al. (2004) developed a conceptual framework that grouped critical success factors into five categories: human-related factors, project-related factors, project procedures, management actions, and external environmental factors. Their research demonstrated that project success is influenced by both technical and managerial aspects.

Iyer and Jha (2006) investigated factors affecting schedule performance in Indian construction projects and identified project participant commitment, owner competency, coordination among stakeholders, and project manager capability as significant determinants of project success.

Tabish and Jha (2012) introduced the concept of success traits and concluded that human factors and management actions play a decisive role in determining project outcomes. Their study highlighted the importance of leadership, communication, coordination, and managerial competence.

Several other researchers have also emphasized the significance of contractor experience, project manager competency, financial management, material availability, resource allocation, environmental conditions, and stakeholder participation in achieving project objectives. These studies collectively suggest that project success is influenced by a combination of technical, organizational, financial, managerial, and environmental factors.

3. Research Methodology

The study adopted a questionnaire survey approach to collect data from professionals associated with hydropower projects. Twenty respondents representing engineers, project managers, construction managers, consultants, and contractors participated in the survey.

The research methodology consisted of:

1. Literature Review
2. Identification of Success Factors
3. Questionnaire Design
4. Data Collection
5. RII Analysis
6. Ranking of Factors
7. Interpretation of Results

The Relative Importance Index (RII) was used to determine the significance of each factor.

$$RII = \frac{\sum W}{A \times N}$$



Where:

W = Weight assigned by respondents

A = Highest weight (5)

N = Total number of respondents

4. Result and Discussion

The responses obtained from the questionnaire survey were analyzed using the Relative Importance Index (RII) method to determine the significance of various factors affecting hydropower project performance. A total of thirteen categories comprising project-related, management-related, client-related, contractor-related, design-related, technical, financial, environmental, and human resource factors were evaluated. The calculated RII values were used to rank the factors according to their relative importance.

The analysis revealed considerable variation among the identified factors, indicating that certain factors have a significantly greater influence on project performance than others. The results demonstrate that management competency, technical expertise, contractor capability, resource availability, and effective project coordination play a crucial role in determining the success of hydropower projects.

4.1 Project Manager Related Factors

Among all the factors analyzed, Project Manager's Experience (RII = 0.91) achieved the highest ranking. This finding indicates that experienced project managers possess better decision-making abilities, technical knowledge, leadership skills, and problem-solving capabilities required for managing complex hydropower projects. Their experience helps in anticipating project challenges, coordinating project activities, and ensuring effective utilization of resources.

Similarly, Leadership Skills of the Project Manager (RII = 0.89) emerged as one of the most influential factors. Effective leadership improves communication among stakeholders, motivates project teams, resolves conflicts, and enhances overall project performance. These findings are consistent with previous studies that emphasize the importance of managerial competence in achieving project success.

4.2 Contractor Related Factors

The analysis indicates that Contractor Experience (RII = 0.90) is the second most critical success factor. Experienced contractors are generally better equipped to manage construction activities, allocate resources efficiently, maintain quality standards, and handle project uncertainties. Their expertise significantly contributes to timely project completion.

Site Management (RII = 0.87) and Supervision (RII = 0.87) were also ranked among the top factors. Effective site management ensures smooth execution of construction activities, proper coordination among workers, adherence to safety standards, and efficient utilization of equipment and materials. Strong supervision helps minimize errors, improve productivity, and maintain construction quality.



4.3 Design Team Related Factors

The study found that Design Team Experience (RII = 0.86) significantly influences project performance. Hydropower projects involve complex engineering designs requiring specialized technical knowledge and experience. An experienced design team can reduce design errors, improve constructability, and facilitate better coordination during project implementation.

Additionally, project design complexity and quality of coordination among design team members were found to have a considerable impact on project success. Proper design management reduces the likelihood of design revisions, construction delays, and additional project costs.

4.4 Resource and Material Related Factors

The factor Shortage of Materials (RII = 0.86) emerged as one of the most critical issues affecting hydropower projects. Material shortages can interrupt construction activities, increase project costs, and cause schedule delays. Therefore, effective procurement planning and inventory management are essential for ensuring continuous project progress.

Similarly, Equipment Availability and Performance (RII = 0.84) was identified as a highly significant factor. Hydropower projects require heavy construction equipment and specialized machinery for excavation, tunneling, concrete placement, and transportation activities. Equipment failures or inadequate availability can adversely affect project productivity and performance.

4.5 Technology and Innovation Factors

The study revealed that Technology Availability (RII = 0.83) is an important contributor to project success. Advanced construction technologies, modern project management tools, digital monitoring systems, and information-sharing platforms improve project efficiency, communication, and decision-making. Organizations that adopt modern technologies are better positioned to manage project complexities and achieve desired outcomes.

4.6 Project Related Factors

Among project-related factors, Type of Project (RII = 0.82) received the highest ranking. Different hydropower projects possess varying degrees of complexity, resource requirements, technical challenges, and environmental constraints. Therefore, project characteristics significantly influence project performance.

Other project-related factors such as project value, urgency, and project lifecycle also demonstrated moderate to high significance, indicating their influence on planning, execution, and resource allocation decisions.

4.7 Management and Organizational Factors

The analysis indicates that Communication Systems (RII = 0.81) and Planning Efforts (RII = 0.81) are among the most important management-related factors. Effective communication ensures timely information exchange among project stakeholders and facilitates better coordination. Likewise, proper planning enables efficient scheduling, budgeting, risk management, and resource allocation.

Factors such as organizational structure, quality assurance programs, safety management systems, and control mechanisms also contribute significantly to project performance. Organizations with well-defined management procedures are generally more successful in achieving project objectives.



4.8 Work Environment and External Factors

External factors such as political environment, economic conditions, social environment, and technology advancement were found to influence project outcomes. Although these factors received comparatively lower rankings, they remain important because they can affect project approvals, funding availability, stakeholder acceptance, and resource accessibility.

Adequacy of funding and commitment of project participants were also identified as critical contributors to successful project execution. Financial stability enables uninterrupted project progress, while stakeholder commitment enhances collaboration and project efficiency.

Conclusion

The questionnaire survey was carried out to know the influence of various success or failure factors. The top ten factors rated by the various respondents are responsible for the success of hydropower projects. Rating given by the different respondents is not same as the respondents from different organizations have different point of view on the factors causing the success or failure of hydropower projects. The results of questionnaire survey were obtained on the basis of responses from questionnaire survey. The top ten factors which significantly affect the success or failure of hydropower projects are listed as: (1) project manager's experience, (2) contractor experience, (3) leadership skills of project manager, (4) supervision, (5) site management (6) design team experience,(7) shortage in material,(8) site location,(9) equipment availability & failure,(10) technology availability. The other factors will also affect the success or failure of projects but the probability of top ten factors are more.

6.2 Future scope

More investigation is required to identify factors attributes to the success or failure of the project. Further the analysis of success factors can be done by various other methods such as SAPP software, SEM software and other quantitative analysis approach.



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