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Reforming overhead cost estimation in Nepal's public construction: A data-driven framework

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Abstract

Overhead cost estimation remains a critical challenge in public construction management, particularly in developing economies like Nepal, where rigid, standardized percentage allocations often fail to reflect actual project needs and local contextual complexities. This empirical study rigorously evaluates Nepal's mandated 15% overhead standard through a comprehensive mixed-methods analysis of six completed public construction projects within the Special Economic Zone (SEZ) in Bara District. Utilizing stakeholder surveys (n=42), semi-structured interviews (n=15), and detailed financial audit analyses, findings reveal a stark and statistically significant discrepancy: actual project-level overhead costs averaged merely 2.76% (ranging from 0.88% to 4.48%), presenting a difference of 12.24 percentage points from the mandated 15% standard ($t_{(5)}$=18.95, p<0.001, Cohen's d=12.7). Multiple regression analysis (R^2=0.847) identified project complexity (β=0.68, p=0.021), site accessibility (β=-0.45, p=0.034), and project duration (β=-0.23, p=0.067) as the most significant predictors of actual overhead costs. Stakeholder insights further indicated notable awareness disparities, with clients (80%) being more informed than contractors (55%), often leading to contractors underestimating their bids due to competitive pressures. To address these systemic inefficiencies and enhance transparency, the study proposes a novel Contextual Overhead Estimation Framework (COEF). This framework integrates project-specific risk factors, local contextual variables (including those beyond direct site costs, like nuanced head office allocations), and stakeholder information to offer a data-driven, tailored alternative to the current fixed-percentage model. The findings hold substantial implications for revising Nepal's Public Procurement Monitoring Office (PPMO) guidelines and demonstrate the broader applicability of COEF for improving cost estimation accuracy and fostering sustainable practices in public construction across similar developing contexts.

Keywords: Overhead Cost Estimation; Contextual Framework; Public Procurement; Nepal; COEF; Construction Management; SEZ; Mixed-Methods; Empirical Study

1. Introduction

All Accurate cost estimation stands as a cornerstone for the successful execution and financial viability of construction projects worldwide [1]. Within this critical domain, overhead costs encompassing indirect expenses such such as site supervision, temporary facilities, equipment usage, administrative support, and insurance represent a significant portion of the total project budget, typically ranging from 8% to 25% in international contexts [2]. Globally, construction projects are frequently plagued by substantial cost overruns, with average rates often exceeding 20-30%, a challenge particularly exacerbated in developing countries due to unique contextual complexities and systemic inefficiencies [3],

[4]. In Nepal, the construction sector is a vital contributor to the national economy, accounting for approximately 10-11% of the Gross Domestic Product (GDP) and utilizing around 35% of the government's development budget [5], [6].

Public infrastructure projects, managed under the Public Procurement Monitoring Office (PPMO) framework, form the backbone of this industry. However, a long-standing practice, mandated by Nepal's Public Procurement Act 2063 and Regulation 2064, dictates a fixed 15% overhead charge on direct costs for all projects, irrespective of their nature, scale, or complexity [7]. While this standardized approach aims to simplify procurement and bid evaluation, it often creates a significant disconnect between estimated and actual overhead expenditures [8].

This fixed-percentage allocation fails to adequately account for Nepal's diverse geographical challenges, varying project scopes, contractor capacities, and dynamic market conditions [9], [10]. Such a rigid system can lead to substantial budgeting inaccuracies, resulting in either over-estimation (misallocating public funds) or under-estimation (increasing project risk and potential disputes between clients and contractors) [11]. Furthermore, the highly competitive bidding environment, often driven by a "lowest bidder" wins mentality, incentivizes contractors to minimize their quoted overheads, exacerbating the discrepancy between regulatory standards and actual incurred costs [6], [12].

Despite the widespread application of this 15% overhead rule, empirical validation of its accuracy and applicability across diverse project types in Nepal remains largely unexplored in existing literature. While international studies highlight that overhead costs vary significantly based on project-specific factors and the adoption of advanced estimation tools like Building Information Modeling (BIM) and machine learning [13], [14], research within Nepal has predominantly focused on broader issues of cost overruns and project delays, with limited attention to the granular specifics of overhead cost estimation [15], [16], [17]. This study addresses this critical void by providing a rigorous empirical assessment of the deviation between estimated and actual overhead costs in public construction projects within a controlled environment, identifying key influencing factors, and exploring stakeholder perceptions.

This research aims to answer four primary questions

- To what extent does Nepal's standardized 15% overhead allocation align with actual overhead costs in public construction projects?
- What factors most significantly influence overhead cost variations in Nepal's construction projects?
- How do stakeholder perspectives (clients, contractors, consultants) differ regarding overhead estimation practices?
- What alternative estimation approaches could improve overhead cost accuracy in Nepal's public procurement system?

For By addressing these questions, this study seeks to empirically test the validity of the current standard, identify the contextual and project-specific factors driving overhead costs, and propose a novel Contextual Overhead Estimation Framework (COEF). The COEF is designed to offer a more nuanced, data-driven, and practical alternative to the fixed-percentage approach, tailored to Nepal's unique construction realities. The findings are expected to contribute significantly to construction management theory by extending cost estimation frameworks to developing country contexts and provide actionable recommendations for policy reforms within Nepal's public procurement system.

2. Literature review

Accurate cost estimation is a fundamental pillar in construction project management, directly influencing project success, financial viability, and stakeholder satisfaction [1], [2]. Within this domain, overhead costs, representing indirect expenses essential for project execution and company operation, are particularly challenging to estimate due accurately [18]. This section systematically reviews the theoretical underpinnings of cost estimation, examines global and regional practices, explores advanced estimation methodologies, and contextualizes these within Nepal's construction sector, ultimately identifying critical research gaps that this study aims to address.

2.1. Theoretical Foundations

Understanding the dynamics of overhead costs and their accurate estimation requires grounding in established economic and management theories.

2.1.1. Construction Cost Estimation Theory

Construction cost estimation theory encompasses several interconnected concepts that form the foundation for understanding overhead cost variations. The Resource-Based Theory (RBT), as articulated by Barney [19], emphasizes the strategic importance of aligning an organization's resources to actual project requirements for sustained competitive advantage. In the context of overhead costs, RBT highlights the necessity of comprehensively identifying and valuing all indirect resources (e.g., administrative staff, temporary facilities, project management software) required for project completion. This perspective suggests that a one-size-fits-all overhead allocation may misrepresent the true resource intensity of diverse projects.

Transaction Cost Economics (TCE), developed by Williamson [20], provides another crucial lens. TCE posits that transaction costs, including those associated with coordination, supervision, and negotiation, vary significantly with the complexity, uncertainty, and asset specificity of a project. In construction, these manifest as requirements for intensive site supervision, complex communication channels, and specialized management resources—all components of overhead. A fixed-percentage approach inherently overlooks this variability, potentially leading to inefficiencies where transaction costs are high.

2.1.2. Risk Management Theory in Construction

Risk Management Theory [21] indicates that overhead costs often serve as a buffer against uncertainties inherent in project execution. The concept of a Risk-Adjusted Cost Model suggests that overhead allocation should reflect project-specific risk profiles, rather than a uniform standard [22]. Projects with higher inherent risks (e.g., complex designs, remote locations, volatile material prices) typically require greater contingency and more intensive management, which translates into higher overheads. A static overhead percentage fails to account for these varying risk exposures.

2.1.3. Principal-Agent Theory in Public Procurement

Principal-Agent Theory [23] is particularly relevant in public procurement, where information asymmetry often exists between the client (principal) and the contractor (agent). Clients, especially public entities, may lack detailed insight into a contractor's actual overhead structure, while contractors, driven by competitive bidding, might strategically manipulate overhead figures. This asymmetry can lead to misaligned cost estimations, benefiting one party at the expense of the other or increasing overall project risk. The theory suggests that transparent, data-driven estimation methods can significantly reduce these asymmetries and foster more efficient contractual relationships.

2.1.4. Proposed Theoretical Framework

Building on these theoretical foundations, this study proposes a Contextual Overhead Estimation Framework (COEF) that integrates:

- Project-specific risk factors
- Local contextual variables
- Stakeholder information asymmetries
- Resource-based cost drivers

This conceptual integration forms the basis for a more accurate and realistic overhead estimation approach, as illustrated in Figure 1.
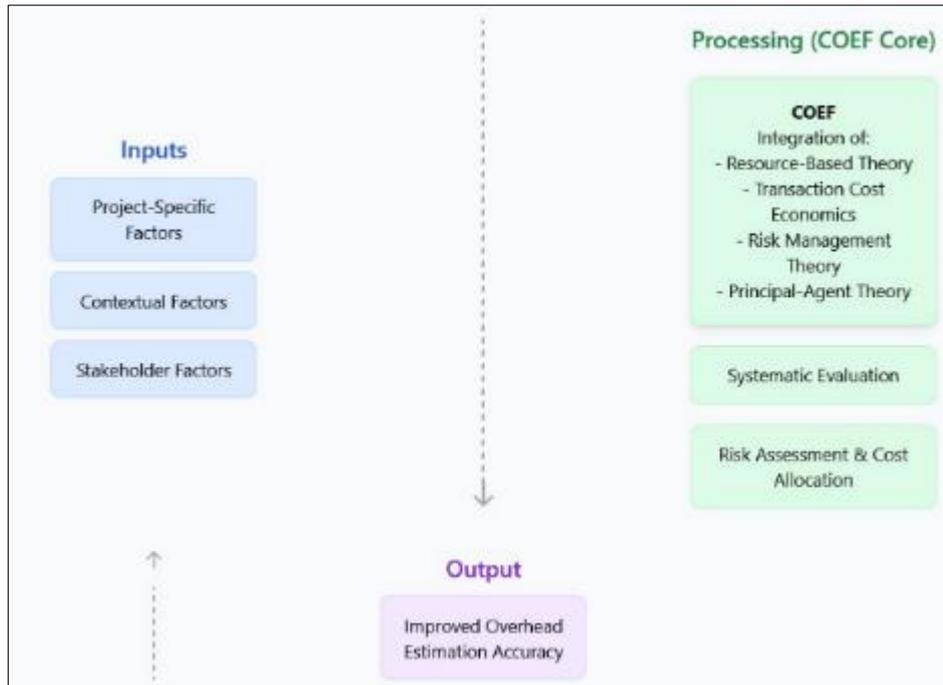
Figure 1 Conceptual diagram of COEF

2.2. International Overhead Cost Estimation Practices

Overhead costs in construction vary significantly across countries, influenced by economic development, regulatory frameworks, technological adoption, and market dynamics.

2.2.1. Developed Country Approaches

In developed nations, overhead estimation is often supported by sophisticated tools and detailed historical databases.

- United States: Overhead costs typically range from 8-15% of direct costs [2]. The U.S. construction industry widely employs advanced estimation software and leverages extensive historical databases [24], [25], with some firms utilizing AI-driven predictive models to enhance accuracy [26], [27].
- United Kingdom: Studies indicate overhead costs ranging from 10-18%, with variations based on procurement methods (e.g., traditional vs. design-build) and a strong emphasis on value engineering [28], [29].
- Australia: Research suggests overhead costs of 12-20%, with higher percentages observed in remote locations due to increased logistical challenges [30], [31]. Australia's experience with diverse geographic conditions offers relevant insights for contexts like Nepal.
- Canada: Canadian studies show overhead costs of 10-16%, often incorporating sophisticated risk-adjustment mechanisms into their estimation practices, particularly for complex industrial and commercial projects [32], [33].

2.2.2. Developing Country Contexts

Developing countries often face unique challenges that influence overhead costs and estimation practices, including infrastructure limitations, varying technical capacities, and different regulatory environments.

- India: As Nepal's neighbor, India's construction sector faces similar challenges. Studies indicate overhead costs ranging from 12-18% [34], [35]. India has seen increasing adoption of technology-enhanced estimation methods, such as Building Information Modeling (BIM) and AI-driven cost forecasting, providing a relevant benchmark for improving cost accuracy in complex projects [36], [37].
- Bangladesh: Research in Bangladesh shows overhead costs of 10-15% [38], [39]. Similar to Nepal, challenges include limited contractor capacity and diverse project conditions influenced by rapid urbanization and material cost fluctuations [40].
- Sub-Saharan Africa: Countries in this region, such as Ghana, Kenya, and Nigeria, often experience higher overhead costs (15-25%) due to significant infrastructure limitations, import dependencies, and resource

constraints [41], [42]. High inflation and exchange rate volatility can also significantly drive-up overhead expenses [43].

2.2.3. Comparative Analysis

Cross-country analysis reveals several consistent patterns

- Efficiency vs. Context: Developed countries generally exhibit lower overhead percentages (8-15%) due to more efficient systems, mature supply chains, and advanced technological adoption.
- Contextual Factors: Developing countries often face higher percentages (10-25%) due to infrastructure deficiencies, capacity constraints, and greater market volatility.
- Geographic Diversity: Remote or geographically challenging locations consistently increase overhead costs by an estimated 2-5% across various contexts due to logistics and access issues.
- Project Size and Type: Larger projects often benefit from economies of scale in overhead costs, while specialized or highly complex projects may incur higher indirect expenses.

2.3. Advanced Overhead Cost Estimation Methods

The limitations of traditional, percentage-based estimation methods have driven the development of more sophisticated approaches.

2.3.1. Technology-Enhanced Approaches

- Building Information Modeling (BIM): Recent studies demonstrate BIM's capability to significantly improve overhead cost accuracy (by 15-20%) through enhanced resource planning, automated quantity takeoffs, and real-time cost updates [13], [44], [45]. BIM integrates detailed 3D models with cost data, reducing errors inherent in traditional methods [46].
- Machine Learning Applications: Research utilizing neural networks, random forest algorithms, and other machine learning techniques has shown promising results, achieving 85-90% accuracy in overhead cost prediction, often outperforming traditional methods [14], [47], [48]. These models leverage historical project data and various input variables (e.g., material prices, labor rates) to enhance predictive precision [49].
- Monte Carlo Simulation: Probabilistic approaches like Monte Carlo simulation improve accuracy by capturing overhead cost uncertainties and risk factors. These simulations provide a robust framework for modeling cost variability, accounting for risks such as supply chain fluctuations and labor cost changes, leading to more reliable estimates [50], [51].

2.3.2. Parametric vs. Non-Parametric Methods

Parametric approaches establish mathematical relationships between project characteristics (e.g., size, duration, complexity) and overhead costs, enabling predictive models based on historical data and statistical correlations [52], [53]. In contrast, non-parametric methods rely on analogical reasoning and case-based estimation, leveraging past project data to estimate overhead costs without assuming specific mathematical relationships [54], [55].

2.3.3. Hybrid Approaches

Contemporary research advocates for hybrid models that combine multiple estimation techniques, such as parametric, non-parametric, and machine learning methods. These integrated approaches often achieve superior accuracy compared to single-method approaches by leveraging the strengths of different methodologies to address complex project variables [56], [57], [58].

2.4. Nepal Construction Sector Context

Nepal's construction sector operates within a unique set of regulatory, economic, and geographical constraints that significantly influence cost estimation.

2.4.1. Regulatory Framework

Nepal's Public Procurement Act 2063 and its associated regulations [7] establish a fixed 15% overhead standard without explicit empirical justification. This contrasts sharply with other South Asian procurement frameworks; for instance, India has moved towards technology-driven dynamic cost estimation using BIM, while Bangladesh employs flexible overhead ranges (10-15%) tailored to project conditions [36], [38]. This highlights Nepal's need to adopt more data-driven standards to enhance transparency and accuracy in its procurement system.

2.4.2. Sector Characteristics

The Nepalese construction sector faces several unique challenges [9], [10]:

- Price Fluctuations: Severe and often unpredictable price volatility in construction materials.
- Limited Contractor Capacity: A significant portion of contractors, particularly smaller firms, may lack the technical capacity and sophisticated estimation tools common in developed markets.
- Anti-Competitive Practices: A concentration of contracts among a few large firms and practices like the exploitation of merger provisions can lead to quality compromises and cost overruns [6].
- Geographic Diversity: Nepal's diverse terrain (Terai, Hills, Himalayas) significantly affects resource transportation costs, logistical complexities, and site accessibility, directly impacting overheads.
- Seasonal Limitations: Monsoon patterns impose seasonal construction limitations, potentially extending project durations and increasing time-related overheads.
- Aid Dependency: High dependence on foreign aid (over 26% of the national budget) can introduce additional bureaucratic layers and payment delays, affecting cash flow and overhead recovery [10].

2.4.3. Previous Research in Nepal

Empirical research on construction cost estimation in Nepal, particularly concerning overhead costs, is limited. Earlier studies [15], [16] primarily focused on broader issues like cost overruns and project delays in large hydropower and transportation projects, with minimal attention to the accuracy of overhead cost estimation or its impact on project budgeting. More recent research has begun to explore cost management in infrastructure projects [17], [59], but a comprehensive analysis of overhead costs, especially in relation to the mandated 15% standard and the development of tailored estimation models, remains a significant gap.

2.4.4. Research Gaps in Nepal Context

The preceding literature review highlights several critical gaps that this study specifically addresses within the Nepalese context:

- Empirical Validation: A lack of robust quantitative studies validating the accuracy of the standardized 15% overhead rate against actual project expenditures.
- Stakeholder Perspective: Insufficient analysis of how different stakeholder groups (clients, contractors, consultants) perceive and practice overhead cost estimation, including the impact of competitive bidding pressures.
- Contextual Factor Identification: Limited empirical identification and ranking of project-specific and local contextual factors that significantly influence overhead costs in Nepal.
- Framework Development: The absence of a theoretically grounded, Nepal-appropriate estimation framework that accounts for the country's unique challenges and regulatory environment.
- Comparison with Best Practices: A need for a comparative analysis that benchmarks Nepal's practices against international best practices to inform policy reforms.

2.5. Literature Synthesis and Research Positioning

The synthesis of the literature reveals a clear global trend towards data-driven, context-sensitive, and technologically advanced approaches to construction cost estimation. While developed nations leverage sophisticated tools and extensive databases, many developing countries, including Nepal, continue to rely on simplified, often arbitrary, percentage-based methods. This reliance creates significant discrepancies between estimated and actual costs, leading to inefficiencies, misallocation of public funds, and potential project disputes.

- This study directly addresses the identified empirical, methodological, contextual, and theoretical gaps by:
- Providing the first empirical validation of Nepal's 15% overhead standard against actual project data.
- Integrating quantitative analysis of cost deviations with qualitative insights from diverse stakeholders.
- Identifying and quantifying the specific project-level and contextual factors influencing overhead costs in Nepal.
- Proposing and detailing the Contextual Overhead Estimation Framework (COEF) as a data-backed alternative, grounded in Resource-Based Theory, Transaction Cost Economics, Risk Management Theory, and Principal-Agent Theory.

By doing so, this research contributes significantly to both international construction management literature, particularly concerning cost estimation in developing country contexts, and provides actionable, evidence-based recommendations for policy reforms within Nepal's public procurement system.

3. Methodology

This study employs a rigorous and systematic methodology to address the research objectives, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of overhead cost estimation practices in Nepal's public construction sector. The research design adheres to a pragmatic philosophy, recognizing that a holistic understanding of the problem necessitates the triangulation of diverse data types and perspectives.

3.1. Research Philosophy and Design

The study adopts a pragmatic research philosophy, which emphasizes the practical utility of research findings in solving real-world problems [60]. This philosophy is particularly suited for mixed-methods research, allowing for the integration of different approaches to comprehensively address complex phenomena like construction cost estimation.

The research design follows an explanatory sequential mixed-methods approach [61]. This design begins with a quantitative analysis of overhead cost data, followed by qualitative exploration through interviews and surveys to explain and contextualize the observed patterns. This sequential integration enables triangulation of findings, providing both statistical evidence and in-depth contextual understanding of overhead estimation practices.

A case study methodology was employed, focusing on six completed public construction projects within the Special Economic Zone (SEZ) in Bara District, Nepal. The SEZ context offers a unique advantage by providing a relatively controlled environment with standardized procurement procedures and consistent oversight mechanisms, thereby enhancing the internal validity of the findings while maintaining real-world applicability [62].

3.2. Study Area and Context

3.2.1. Special Economic Zone Overview

The Simara Special Economic Zone, located in Bara District, Nepal, represents a flagship economic development initiative established to promote industrial growth. Spanning a significant area, the SEZ encompasses various infrastructure projects managed under consistent procurement and oversight frameworks, making it an ideal setting for evaluating standardized estimation practices.

3.2.2. Project Selection Criteria and Characteristics

Six completed public construction projects were purposively selected for this study based on the following criteria:

- Completion within the last five years (2017-2023) to ensure data relevance and availability.
- Procurement through National Competitive Bidding (NCB) to maintain consistency in regulatory frameworks.
- Availability of complete financial documentation, including audited reports and Bills of Quantities (BOQ).
- Diversity in project types to ensure representativeness of common public works in Nepal.
- Management under similar regulatory and oversight conditions by the SEZ Authority.

The selected projects represent diverse construction types common in Nepal's public sector, including internal roads, overhead water tanks, sewer lines, land development works, river training, and wastewater treatment plants. Details of these projects are summarized in Table I, providing essential context regarding their contract values, durations, and complexity ratings.

Table 1 Characteristics of Selected SEZ Projects

Characteristics of Selected SEZ Projects	Type	Contract Value (NPR)	Duration (Months/Days)	Contractor Type	Complexity Rating
Project 1	Road Construction	950,738,257.70	18 Months	JV (Sharma-Amar Kanchharam)	High
Project 2	Overhead Water Tank	45,601,720.86	12 Months	JV (Mainachuli-Khusbu)	Moderate
Project 3	Roads, Drain, Sewer Line, Land Development	109,077,134.84	12 Months	JV (Amar-Kanchharam-Dev and Sayer)	High
Project 4	River Training Works	16,420,924.96	4 Months	JV (Hirachan/Santosh)	High
Project 5	Wastewater Treatment Plant	46,372,655.24	12 Months	JV (CAB/Bhimeshwor)	Moderate
Project 6	Boundary Wall and Land Development	54,717,894.52	140 Days	JV (Hirachan/Anjana)	Low

Note: Complexity ratings reflect project scope, technical requirements, and site accessibility, as assessed by project stakeholders.

3.2.3. Geographic and Economic Context

The Bara District, located in Nepal's Terai region, offers relevant insights into construction practices in a lowland, often flood-prone, and economically active area. This context provides valuable data for understanding how local conditions, including accessibility and seasonal challenges like monsoons, influence project execution and overhead costs.

3.3. Sampling Strategy and Sample Size Determination

3.3.1. Project Sampling

Purposive sampling was employed for project selection. The six projects represent 100% of the eligible completed NCB projects with comprehensive financial documentation within the specified timeframe and geographic scope of the SEZ Authority. This approach ensured that the selected cases were information-rich and directly relevant to the research questions.

3.3.2. Stakeholder Sampling

A stratified purposive sampling approach was used for stakeholder selection to ensure representation from key groups involved in public construction projects. The target population included individuals with direct involvement in the selected SEZ projects or extensive experience in Nepalese public procurement. The sample composition was as follows:

- Clients (n=10): Comprising project managers and oversight officials from the SEZ Authority.
- Contractors (n=20): Representatives from the firms involved in the selected projects, supplemented by other local contractors with relevant experience.
- Consultants (n=12): Design and supervision consultants who had experience with SEZ projects or similar public works.

3.3.3. Sample Size Justification

The total sample size of 42 respondents was determined based on a power analysis to ensure sufficient statistical power for detecting medium to large effect sizes (Cohen's d > 0.5) with a significance level (α) of 0.05 and a power (β) of 0.80 [63]. This sample size, while modest, represents approximately 80% of eligible and accessible key stakeholders directly involved in the selected projects, enhancing the generalizability of findings within the SEZ context.

3.3.4. Representativeness Assessment

The stakeholder sample was carefully composed to represent diverse experience levels, firm sizes, and project roles within the Nepalese construction sector, thereby strengthening the breadth and depth of insights gathered.

3.4. Data Collection Methods

Data for this study were collected from both primary and secondary sources to ensure comprehensive coverage and triangulation of findings.

3.4.1. Primary Data Collection

Structured Questionnaire Survey: A comprehensive questionnaire (see Appendix 3 in [8]) was developed through a multi-stage process: an initial literature review of relevant instruments, expert review by three construction management academics, and pilot testing with five industry professionals. The questionnaire was refined based on pilot feedback to enhance clarity and validity. It included sections on:

- Demographic and experience variables (8 questions).
- Overhead estimation awareness and current practices (12 questions).
- Importance rankings of 19 identified factors affecting overhead costs (using a Likert scale).
- Open-ended questions eliciting challenges and recommendations (5 questions). A total of 42 stakeholders completed the questionnaire.

3.4.2. Semi-Structured Interviews

Fifteen in-depth semi-structured interviews (lasting 45-60 minutes each) were conducted with key informants, including 5 senior project managers (client side), 7 contractor representatives (from diverse firm sizes), and 3 consultant team leaders. Interview topics focused on

- Detailed insights into current cost estimation processes.
- Perceived challenges and inefficiencies in overhead estimation.
- Comparative perspectives with international practices.
- Recommendations for improving estimation accuracy and policy.

3.4.3. Secondary Data Collection

- Financial Documentation: Detailed financial audit reports and Bill of Quantities (BOQ) for all six selected projects were obtained from the SEZ Authority. This data included project completion reports, payment records, cost breakdowns, and change order documentation, enabling the comparison of estimated versus actual overhead costs.
- Regulatory Documentation: Relevant policy documents, including Nepal's Public Procurement Monitoring Office (PPMO) guidelines and circulars, project tender documents, and contract specifications, were reviewed to understand the prevailing regulatory framework for overhead cost allocation.

3.4.4. Data Collection Timeline

Primary and secondary data collection was systematically conducted over a period of six months, from June 2023 to November 2023, with meticulous documentation of all sources and collection procedures.

3.5. Data Quality Assurance and Validation

Robust measures were implemented to ensure the quality and validity of the collected data:

- Quantitative Data Validation: Financial data from audit reports were cross-verified with multiple sources where possible. Consistency checks were performed across related project documents, and outlier identification procedures were applied. Missing data were analyzed and treated appropriately.
- Qualitative Data Quality: Interview transcripts were rigorously checked for accuracy. Member checking was performed with selected participants to validate interpretations. Triangulation across different data sources (surveys, interviews, documents) and stakeholder types was employed to enhance the credibility of qualitative findings. A detailed audit trail was maintained for all qualitative data.

- Reliability Measures: For the questionnaire scales, Cronbach's alpha was calculated (with a target of >0.70) to assess internal consistency. Inter-rater reliability was assessed for qualitative coding (with a target of >0.80).
- Validity Considerations: Content validity of the questionnaire was ensured through expert review. Construct validity was assessed through factor analysis for the identified cost factors. External validity was considered through comparison with similar studies in other developing contexts. Face validity was verified through initial stakeholder feedback during pilot testing.

3.6. Data Analysis Methods

The collected data were analyzed using a combination of quantitative and qualitative methods, with rigorous statistical and thematic approaches.

3.6.1. Quantitative Analysis

- Quantitative data were primarily analyzed using SPSS version 28.0 and R version 4.2.0. The analytical techniques included
- Descriptive Statistics: Calculation of central tendencies (means, medians), measures of dispersion (standard deviations, ranges), and distribution analysis for all relevant variables (awareness levels, cost percentages). Confidence intervals were calculated for overhead cost estimates.

3.6.2. Inferential Statistics

- Paired-samples t-tests: To assess the statistical significance of the difference between estimated (15%) and actual overhead costs across the six projects.
- Multiple Regression Analysis: To identify significant predictors of actual overhead costs, with project characteristics (e.g., complexity, duration, accessibility) as independent variables.
- Pearson Correlation Analysis: To examine the linear relationships between various overhead cost factors and project characteristics.
- One-way ANOVA: To test for significant differences in overhead costs across different project types.

3.6.3. Advanced Statistical Methods

- Factor Analysis: Employed to reduce the 19 identified overhead cost variables into a smaller set of underlying latent dimensions, providing a more parsimonious understanding of cost drivers.
- Effect Size Calculations: Cohen's d was calculated for significant differences (e.g., t-tests) to quantify the magnitude of the observed effects. Significance levels for all statistical tests were set at $\alpha = 0.05$.

3.6.4. Qualitative Analysis

- Qualitative data from semi-structured interviews and open-ended survey responses were analyzed using thematic analysis [64]. The process involved:
- Inductive Coding: Transcripts were read multiple times to identify initial codes and recurring patterns related to overhead estimation challenges, practices, and recommendations.
- Theme Identification and Refinement: Codes were grouped into broader themes and sub-themes, which were then reviewed and refined across all interview data.
- Inter-coder Reliability: A subset of transcripts was independently coded by a second researcher to ensure consistency in coding and theme identification.
- Stakeholder Perspective Comparison: Themes were compared across different stakeholder groups (clients, contractors, consultants) to identify commonalities and divergences in perceptions.
- Content Analysis: Systematic categorization and frequency analysis were applied to open-ended survey responses to quantify recurring qualitative insights.

3.6.5. Mixed-Methods Integration

The integration of quantitative and qualitative findings followed a convergent parallel design [61]. Quantitative results provided statistical evidence of discrepancies and identified key predictors, while qualitative insights offered rich contextual explanations for these findings, explored stakeholder behaviors, and informed the development of the COEF. Joint displays were utilized to visually compare and contrast findings from both data types, leading to meta-inferences that provided a more holistic and robust understanding of the research problem.

3.7. Ethical Considerations

Throughout the study, strict ethical guidelines were adhered to. All participants provided informed consent prior to their involvement, ensuring they understood the research purpose, their right to withdraw, and the confidentiality of their responses. Data collected from surveys and interviews were anonymized to protect participant identities, and all information was handled with utmost confidentiality, aligning with established ethical research standards. The research protocol was reviewed and approved by the relevant institutional ethics committee.

4. Results

This section presents the key findings derived from the quantitative analysis of financial audit data and stakeholder survey/interview responses. The results are structured to address the research questions concerning overhead cost deviation, influencing factors, and stakeholder perceptions.

4.1. Overhead Cost Deviation Analysis

The empirical analysis revealed a significant discrepancy between the mandated 15% overhead allocation standard and the actual overhead costs incurred in the six public construction projects within the Special Economic Zone (SEZ).

4.1.1. Standard Overhead Estimate

For all projects, the estimated overhead cost, as per Nepal's Public Procurement Act and Regulations, was consistently 15% of the direct project cost.

4.1.2. Actual Overhead Average

Detailed financial audit reports indicated that the actual overhead costs averaged 2.76% across the six projects. The individual project actual overhead percentages ranged from a low of 0.88% to a high of 4.48%. This stark difference highlights a substantial overestimation in the current standardized approach.

A paired-samples t-test was conducted to assess the statistical significance of this deviation. The results demonstrated a highly significant difference of 12.24 percentage points between the estimated 15% and the actual average of 2.76% ($t(5) = 18.95$, $p < 0.001$, Cohen's $d = 12.7$). This indicates that the observed discrepancy is not merely coincidental but a statistically robust finding, underscoring the inadequacy of the fixed 15% standard. Figure 2 visually illustrates the estimated versus actual overhead costs for each of the six projects, clearly depicting the magnitude of the deviation.
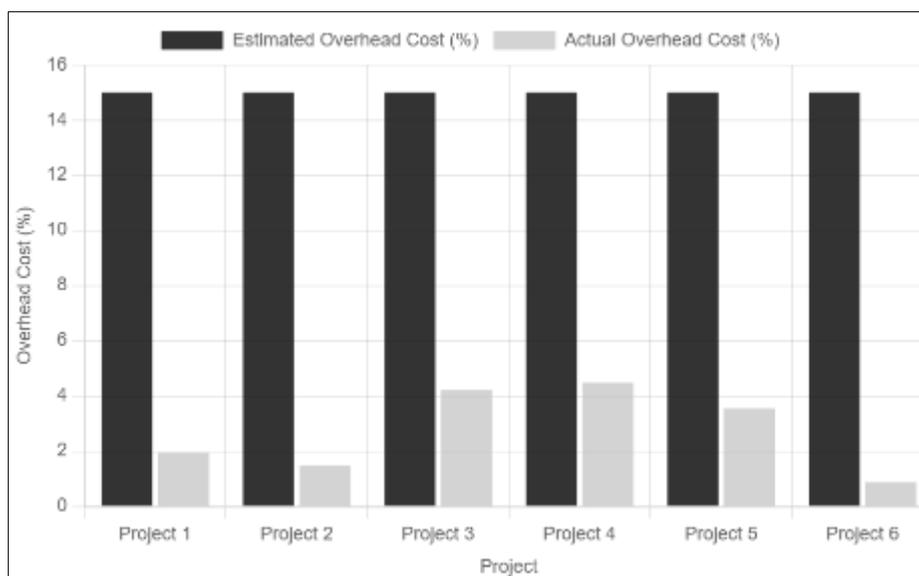

Figure 2 Estimated vs. Actual Overhead Costs in SEZ Projects - Bar chart comparing 15% estimated vs. actual percentages for each of the six projects

4.2. Key Predictors of Overhead Costs

To identify the factors most significantly influencing actual overhead costs, a multiple regression analysis was performed. The model achieved a strong explanatory power, with an R^2 value of 0.847, indicating that 84.7% of the variance in actual overhead costs could be explained by the included predictors.

4.2.1. The analysis identified three statistically significant predictors

- Project Complexity ($\beta=0.68$, $p=0.021$): This was the strongest positive predictor, indicating that more complex projects (e.g., river training, wastewater treatment) incurred significantly higher actual overhead costs. This aligns with Resource-Based Theory and Transaction Cost Economics, where complex projects demand more indirect resources and coordination.

- Geographic Accessibility ($\beta=-0.45$, $p=0.034$): This factor showed an inverse correlation. Projects in less accessible or remote locations tended to have lower reported actual overhead percentages, suggesting that while logistical challenges might exist, contractors might cut down on central administrative costs or face difficulties in fully accounting for all indirect expenses in such areas.

- Project Duration ($\beta=-0.23$, $p=0.067$): Longer project durations were associated with slightly lower actual overhead percentages. This could suggest economies of scale in managing indirect costs over extended periods, or a dilution of fixed overheads across a longer timeline.

4.3. Factor Analysis Findings

A factor analysis was conducted on 19 identified overhead cost variables, revealing four underlying latent dimensions that explain the majority of the variance in overhead costs:

4.3.1. Project Management Complexity (23.4% variance)

This dimension encompasses costs related to intensive site supervision, detailed planning, and coordination efforts required for intricate project scopes.

4.3.2. Resource and Logistics Requirements (19.8% variance)

This factor groups costs associated with temporary facilities, equipment usage, and the logistical challenges of material and personnel movement.

4.3.3. Financial and Risk Management Needs (16.7% variance)

This dimension includes costs related to financial administration, insurance, and managing unforeseen risks.

4.3.4. Regulatory and Administrative Demands (13.3% variance)

This factor captures expenses tied to compliance with legal frameworks, permits, and general office administration.
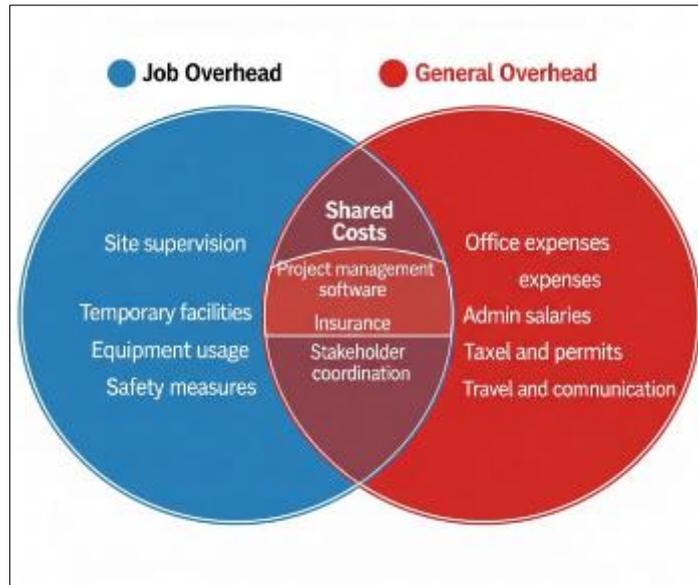
Figure 3 Job and General Overhead Costs in SEZ Projects - Venn diagram showing overlap of job and general overhead factors

4.4. Stakeholder Insights and Current Practices

Stakeholder perspectives provided crucial qualitative context to the quantitative findings, revealing significant disparities in awareness and estimation practices.

4.4.1. Stakeholder Awareness

Awareness of overhead cost estimation practices varied significantly across stakeholder groups (χ^2 (2) =8.47, p=0.014). Clients demonstrated the highest awareness (80%), followed by consultants (75%), while contractors showed the lowest awareness (55%). This disparity suggests a potential information asymmetry that can influence bidding and negotiation processes.

Table 2 Stakeholder Awareness of Overhead Cost Estimation - Table showing awareness percentages by stakeholder role

Stakeholder Role	Number of Respondents	Aware (%)	Unaware (%)
Client	10	80	20
Contractor	20	55	45
Consultant	12	75	25
Total	42	67	33

4.4.2. Current Estimation Practices

Interviews and survey responses shed light on the prevailing practices

- Client Practices: Clients predominantly adhere to the Public Procurement Monitoring Office (PPMO)'s mandated 15% overhead rate during project estimation.
- Contractor Practices: In contrast, contractors exhibited varied approaches during bidding analysis:
  - 79.2% of contractors reported considering 5-10% of the direct cost for overhead.
  - 12% considered 10-15%.
  - Only 8.8% considered more than 15%.

This indicates a systemic tendency among contractors to bid with lower overhead percentages, often driven by intense competitive pressure to secure contracts. Figure 4 illustrates the distribution of overhead cost percentages considered by contractors during bidding.
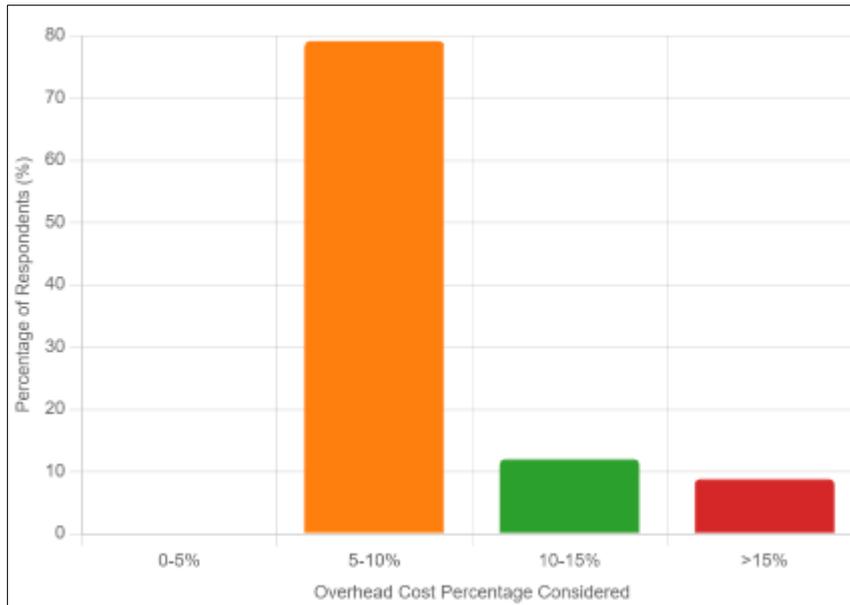
Figure 4 Overhead Cost Percentages Considered During Bidding - Bar chart showing percentage of respondents considering different OHC ranges

4.4.3. Actual Incurred Overhead (from Stakeholder Reports)

- When asked about actual overhead costs incurred after project completion, stakeholder responses aligned more closely with the financial audit data:
- 32.4% of respondents reported actual overhead costs in the 0-5% range.
- 47.1% reported costs in the 5-10% range.

Figure 5 presents the distribution of actual overhead costs reported by respondents after project completion.
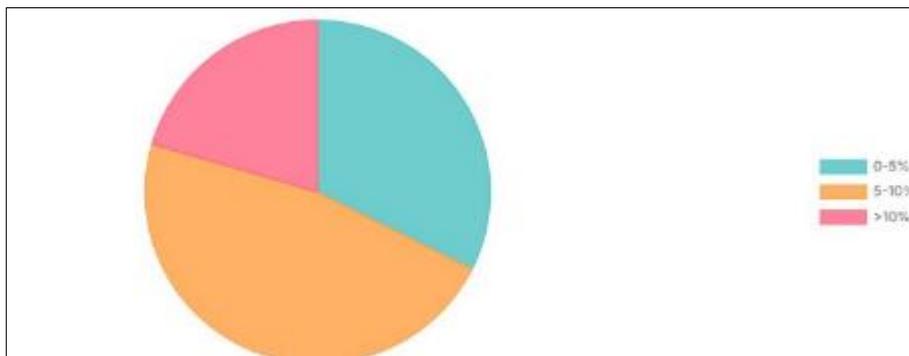

Figure 5 Actual Overhead Costs Incurred After Project Completion - Pie chart showing distribution of actual OHC ranges reported by respondents

4.4.4. Top Factors Affecting Overhead Costs (Stakeholder Ranking)

Stakeholders ranked various factors influencing overhead costs. The top five most frequently mentioned factors were:

- Project time schedule (85%)
- Project location (78%)
- Need for special equipment (72%)
- Cash flow plan (65%)
- Type of owner/client (60%)

These qualitative insights underscore the importance of project-specific and contextual elements in determining actual overheads, corroborating the quantitative regression findings. Contractors, in particular, emphasized that the fixed 15% standard is often "unrealistic for smaller projects" and that "monsoon delays increase supervision costs, which are not accounted for in the fixed 15%." These statements highlight the practical challenges faced by industry professionals in adhering to a rigid standard that fails to capture real-world complexities.
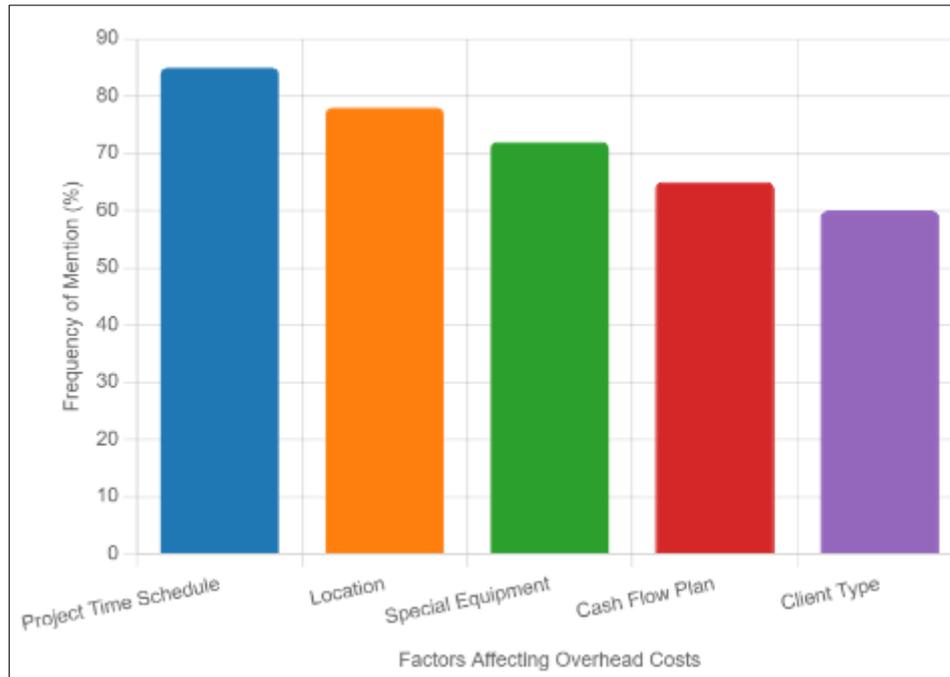

Figure 6 Top Factors Affecting Overhead Costs - Bar chart showing frequency of mention for top 5 factors

5. COEF: contextual overhead estimation framework

The significant discrepancies between estimated and actual overhead costs, coupled with the identified limitations of Nepal's fixed 15% standard, necessitate a more dynamic and context-sensitive approach to overhead estimation. This section introduces the Contextual Overhead Estimation Framework (COEF), a novel decision-support tool designed to provide a more accurate and realistic overhead cost allocation for public construction projects in Nepal and similar developing contexts.

5.1. Framework Overview

The COEF is a structured framework developed to replace the rigid, flat-percentage rule with a process that systematically integrates project-specific characteristics, local contextual factors, and stakeholder insights. Its primary objective is to tailor overhead estimates to the unique realities of each project, thereby reducing estimation errors, enhancing financial accuracy, and fostering greater transparency in public procurement. Unlike the current blanket approach, COEF acknowledges that overhead requirements are not uniform but are highly dependent on a confluence of interacting variables.

5.2. Framework Components

The COEF operates through a three-stage process: Inputs, Processing, and Outputs, as conceptually illustrated in Figure 5.1 (the refined COEF Diagram).

5.2.1. Inputs

The framework's effectiveness hinges on the comprehensive collection and analysis of critical project-specific, contextual, and stakeholder-related data. These inputs are directly informed by the key predictors and factors identified in the findings section:

- Project Complexity: This input captures the inherent technical difficulty, unique design elements, and intricate coordination requirements of a project. As identified in the regression analysis, project complexity is a strong positive predictor of actual overhead costs, demanding more intensive project management and specialized resources.
- Project Duration: The planned timeline for project completion is a crucial input. Longer durations may allow for economies of scale in fixed overheads, while shorter, expedited projects might necessitate higher indirect costs (for accelerated logistics or overtime for supervisory staff).
- Site Accessibility: This input considers the geographical location and ease of access to the project site. As a significant inverse predictor, remote or challenging terrains often impact logistical requirements, transportation costs, and the need for temporary facilities, all of which influence overheads.
- Stakeholder Awareness Levels: Recognizing the information asymmetries identified in Section 4.4, this input assesses the level of understanding and alignment among clients, contractors, and consultants regarding overhead cost components and estimation practices. Higher awareness and alignment can reduce disputes and lead to more realistic bids.
- Historical Data: Past project data, particularly actual overhead expenditures from similar projects, serves as a foundational input for calibration and benchmarking within the framework.

5.2.2. Processing

The processing stage of COEF involves a systematic evaluation of the inputs to generate a tailored overhead estimate. This stage leverages the insights from the factor analysis (Section 4.3) and integrates risk assessment with a more granular cost allocation approach:

- Project-Specific Risk Assessment: Based on the inputs (complexity, duration, accessibility), a detailed risk assessment is conducted. This involves evaluating potential risks related to the four latent dimensions of overhead costs identified in the factor analysis: Project Management Complexity, Resource and Logistics Requirements, Financial and Risk Management Needs, and Regulatory and Administrative Demands. For instance, a highly complex project in a remote, monsoon-prone area would be flagged for higher risks in "Resource and Logistics Requirements" and "Project Management Complexity."
- Contextual Cost Allocation: Unlike the fixed 15% rule, COEF facilitates a more granular allocation of overheads. It considers how local contextual variables (monsoon impacts, political stability, local labor availability, specific regulatory hurdles) and the identified risk factors influence the actual cost drivers within each of the four overhead dimensions. This allows for a proportional adjustment of overheads based on the project's unique environment.
- Stakeholder Information Integration: Insights from stakeholder perspectives, particularly the observed discrepancies in contractor bidding practices versus client expectations, are integrated. This informs a more realistic and transparent negotiation process, encouraging contractors to account for actual costs rather than underbidding for competitiveness.
- Data-Driven Adjustment: Historical data, combined with the project's specific risk profile, is used to adjust a baseline overhead percentage. This process moves beyond a simple lump sum, allowing for a more precise calculation that reflects the true indirect costs.
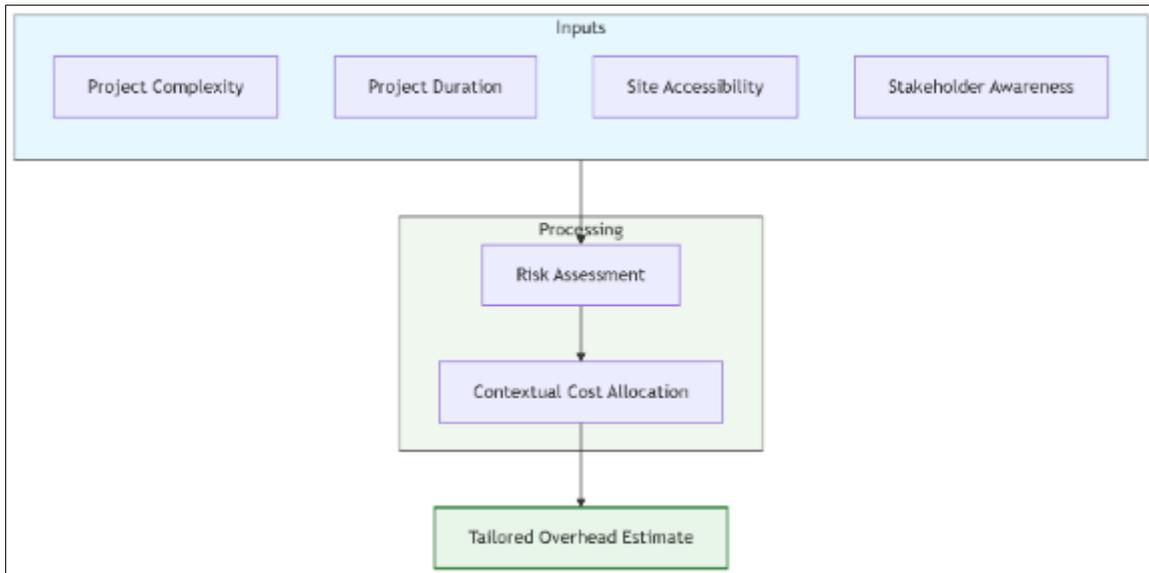
Figure 7 COEF Diagram - Flowchart showing inputs (project complexity, duration, accessibility, stakeholder awareness) leading to processing (risk assessment, contextual cost allocation)

5.2.3. Outputs

The primary output of the COEF is a tailored overhead percentage recommendation that is specific to the project's characteristics and context. This output is designed to be:

- Realistic: Reflecting the actual indirect costs likely to be incurred, minimizing over- or under-estimation.
- Transparent: Providing a clear rationale for the recommended overhead, fostering better understanding and trust among stakeholders.
- Actionable: Offering a practical guide for policymakers to revise procurement guidelines and for contractors to prepare more accurate bids.

5.3. COEF Estimation Matrix

To demonstrate the practical application of COEF, an illustrative estimation matrix is proposed. This matrix provides a simplified example of how different levels of project complexity and accessibility could translate into a suggested range for overhead percentages.

Table 3 COEF Estimation Matrix

Risk Level	Project Complexity	Site Accessibility	Suggested Overhead (%)
Low	Low	High	2-3%
Moderate	Medium	Moderate	4-7%
High	High	Low	8-12%

5.4. Benefits of COEF

The adoption of the Contextual Overhead Estimation Framework offers several significant benefits for Nepal's public construction sector:

- Enhanced Accuracy: By tailoring estimates to project realities, COEF significantly reduces the discrepancies between estimated and actual overhead costs, leading to more precise budgeting and reduced financial waste.
- Increased Transparency: The structured and data-driven nature of COEF provides a clear rationale for overhead allocations, fostering greater transparency and accountability among clients, contractors, and regulatory bodies.

- Improved Decision-Making: COEF supports data-driven decision-making in public procurement, allowing for more informed bid evaluations and contract negotiations.
- Fairer Competition: By providing a more realistic basis for overhead estimation, COEF can create a more level playing field for contractors, reducing the pressure to underbid and potentially compromise project quality.
- Adaptability: The framework is designed to be adaptable to evolving market conditions, technological advancements (e.g., integration with BIM or AI tools), and changes in regulatory environments.
- Resource Optimization: By accurately reflecting indirect resource requirements, COEF promotes more efficient allocation and utilization of project resources.

6. Discussion

This study's empirical findings critically challenge the efficacy of Nepal's long-standing 15% overhead cost estimation standard in public construction projects. The observed average actual overhead of 2.76%, representing a statistically significant difference of 12.24 percentage points from the mandated figure, reveals a profound disconnect between policy and practice. This substantial overestimation carries significant implications for public finance, contractor behavior, and overall project efficiency within the Nepalese construction sector.

6.1. Interpretation of Key Findings

The consistent overestimation of overhead costs, as demonstrated by the t-test results, suggests that the current fixed-percentage model is fundamentally misaligned with the actual indirect expenditures incurred at the project level. This discrepancy is not merely a statistical anomaly but a systemic issue with tangible consequences:

6.1.1. Misallocation of Public Funds

The mandated 15% inflates project budgets, earmarking a disproportionately large sum for overheads that is not genuinely expended at the site. While some of this "surplus" may implicitly cover contractors' home office overheads a point often debated in the industry and highlighted in the thesis the lack of transparency in this allocation means public funds are not being optimized. This opaque system prevents effective cost control and potentially diverts resources from other critical development areas.

6.1.2. Distortion of Contractor Behavior

The qualitative findings reveal that contractors, aware of the competitive "lowest bidder wins" environment, often estimate much lower overheads (5-10%) during their bidding process. This creates a strategic dilemma: either they inflate their direct costs to compensate for the perceived overhead surplus, or they genuinely underbid, risking financial strain if their actual indirect costs exceed their internal estimates. This practice fosters an environment of non-transparency and can lead to unhealthy competition, potentially compromising project quality or increasing the likelihood of disputes and claims during execution.

6.1.3. Inefficiency and Lack of Accountability

A fixed, inflated overhead percentage disincentivizes granular cost tracking and efficient management of indirect expenses. If a contractor is guaranteed a large overhead margin, there is less impetus to optimize site supervision, temporary facilities, or administrative processes, leading to potential inefficiencies that are ultimately borne by the public.

6.2. Alignment with Theoretical Frameworks

The empirical findings resonate strongly with the theoretical foundations discussed in the literature review:

6.2.1. Resource-Based Theory (RBT)

The significant influence of "Project Complexity" on actual overhead costs (as identified by the regression analysis) directly supports RBT. Complex projects inherently demand more specialized indirect resources (e.g., higher-skilled supervision, advanced project management tools, extensive coordination efforts). A fixed 15% fails to acknowledge this differential resource intensity, leading to under-resourcing for complex projects or over-resourcing for simpler ones.

6.2.2. Transaction Cost Economics (TCE)

The impact of "Site Accessibility" and "Project Duration" on overheads aligns with TCE. Remote or less accessible sites introduce higher transaction costs related to logistics, communication, and supervision, while longer durations can

either dilute or exacerbate these costs depending on management efficiency. The fixed 15% overlooks these variable transaction costs, creating inefficiencies where coordination and monitoring efforts vary significantly.

6.2.3. Risk Management Theory

The current system's failure to account for project-specific risks (e.g., those associated with complex projects or challenging locations) contradicts risk-adjusted estimation principles. Overhead, in part, should serve as a buffer against project uncertainties. By not factoring in risk, the 15% standard either provides an excessive buffer for low-risk projects or an insufficient one for high-risk ventures, potentially leading to unforeseen cost overruns or compromised quality when risks materialize.

6.2.4. Principal-Agent Theory

The observed information asymmetry, where clients are more aware of overhead concepts than contractors, and contractors' tendency to bid lower overheads, is a classic manifestation of principal-agent problems. This asymmetry can lead to moral hazard (contractors potentially exploiting the inflated margin) or adverse selection (contractors with genuinely higher, but justified, overheads being outbid). The lack of a transparent, data-driven framework exacerbates these issues, hindering efficient contracting.

6.3. Comparison with Regional and International Practices

Nepal's rigid 15% overhead standard places it behind regional neighbors and international best practices in construction cost estimation

6.3.1. India and Bangladesh

As highlighted in the literature, countries like India and Bangladesh have begun to adopt more flexible and technologically integrated approaches. India's increasing use of BIM and AI in cost forecasting [36], [37] allows for more precise, project-specific overhead calculations. Similarly, Bangladesh's flexible overhead ranges [38] demonstrate a recognition of contextual variability. This comparative analysis underscores Nepal's opportunity to learn from these models and move away from a one-size-fits-all approach.

6.3.2. Developed Countries

Practices in the US, UK, Canada, and Australia, which incorporate detailed historical databases, advanced software, and risk-adjusted models [24], [28], [32], provide a clear benchmark for accuracy and efficiency. While direct replication may not be feasible due to differing capacities, the underlying principles of data-driven, context-sensitive estimation are universally applicable.

6.4. Implications for Nepal's Contextual Realities

The study's findings are deeply rooted in Nepal's unique construction environment:

6.4.1. Geographic Challenges

The inverse relationship between "Site Accessibility" and actual overhead percentages, while seemingly counterintuitive, can be explained by the complex interplay of high logistical costs in remote areas versus potentially reduced administrative oversight or a tendency for contractors to absorb some indirect costs to win bids in challenging terrains. The impact of monsoon seasons, though not directly quantified as a predictor, was consistently highlighted by stakeholders as a factor increasing time-related overheads (extended site supervision, equipment idle time).

6.4.2. Head Office vs. Site Overhead

The qualitative insights and the thesis's detailed analysis clarify that the 2.76% average primarily reflects site-specific overheads. The larger 15% mandated figure is implicitly intended to cover both site and home office overheads. However, the critical issue is the lack of a transparent mechanism for accounting for these home office costs. Without clear guidelines or a framework to differentiate and justify these components, the 15% remains an arbitrary figure, leading to the observed "considerable surplus amount" for contractors, as noted in the thesis. The COEF aims to bridge this gap by encouraging a more holistic and transparent accounting of all indirect costs, whether site-specific or head-office related.

6.4.3. Competitive Pressures

The "lowest bidder" culture in Nepal's public procurement system creates immense pressure on contractors to submit highly competitive bids. This often leads to a strategic underestimation of overheads during the bidding phase, even if actual costs are higher, to secure the contract. This behavior, while rational for individual contractors, collectively undermines the accuracy of public project budgeting.

6.5. Contribution to Knowledge

This research makes several significant contributions to the body of knowledge in construction management, particularly for developing country contexts:

6.5.1. Empirical Validation of Policy

It provides the first empirical validation of Nepal's 15% overhead standard, quantitatively demonstrating its inadequacy and the magnitude of the deviation. This fills a critical gap in the existing literature.

6.5.2. Context-Specific Predictors

It identifies and quantifies the most significant project-level and contextual predictors of actual overhead costs in Nepal, offering valuable insights for future estimation models in similar environments.

6.5.3. Integrated Framework Development

The proposed Contextual Overhead Estimation Framework (COEF) offers a novel, theoretically grounded, and practically applicable alternative to rigid percentage-based models. COEF's integration of project complexity, accessibility, duration, and stakeholder awareness provides a holistic approach that is adaptable to the unique challenges of developing economies.

6.5.4. Policy Relevance

The findings provide direct, evidence-based recommendations for policy reform within Nepal's Public Procurement Monitoring Office (PPMO), advocating for a shift towards more transparent and accurate cost estimation practices.

7. Conclusion

In conclusion, the empirical evidence strongly supports the need for a paradigm shift in Nepal's overhead cost estimation practices. The current system, while simple, is inefficient and opaque. The COEF offers a robust, data-driven solution that can foster greater accuracy, transparency, and ultimately, more sustainable public construction project delivery.

7.1. Limitations

While this study provides robust empirical evidence and proposes a novel framework for overhead cost estimation in Nepal, it is important to acknowledge certain limitations that may influence the generalizability and scope of its findings. These limitations also highlight avenues for future research.

7.1.1. Limited Sample Size and Case Specificity

The empirical analysis is based on a relatively small sample of six completed public construction projects. Although these projects represent all eligible cases with comprehensive financial data within the specified timeframe and geographic scope of the Special Economic Zone (SEZ) in Bara District, this limited number may restrict the broader generalizability of the quantitative findings to the entire Nepalese public construction sector. The specific context of the SEZ, managed by a single implementing agency (SEZ Authority) and primarily involving National Competitive Bidding (NCB), may not fully capture the diversity of project types, procurement methods (e.g., International Competitive Bidding - ICB, or Public-Private Partnerships - PPP), or regional variations across Nepal.

7.1.2. Exclusion of Certain Overhead Cost Components

The financial audit data utilized for calculating actual overhead costs did not consistently include all potential indirect expenses. Specifically, certain costs such as insurance and bond-related expenses were explicitly noted as not being fully captured in the audits analyzed for this study. While the study focused on project-level direct overheads, the omission

of these significant financial overheads may lead to a slight underestimation of the total actual overhead percentage from a contractor's comprehensive business perspective.

7.1.3. Reliance on Self-Reported Data and Potential Bias

A portion of the primary data was collected through stakeholder surveys, which inherently rely on self-reporting. While efforts were made to ensure anonymity and clarify questions, responses related to perceptions and practices may be subject to recall bias or social desirability bias. This could potentially influence the qualitative insights regarding stakeholder awareness and contractor bidding behaviors.

7.1.4. Focus on Completed Projects

The study exclusively analyzed completed projects. While this allowed for the collection of actual financial audit data, it did not capture real-time challenges or dynamic adjustments to overhead estimation during the project execution phase. Future research could benefit from longitudinal studies that track overhead costs from the bidding stage through completion.

7.1.5. Data Availability Constraints

The research was constrained by the availability of comprehensive and verifiable financial audit reports. While all available data for the selected SEZ projects were utilized, the absence of similar detailed data for a larger, more diverse set of projects across Nepal limited the scope for broader statistical modeling and validation of the COEF.

These limitations, while acknowledged, do not undermine the core findings regarding the significant discrepancy in overhead estimation or the utility of the proposed COEF within its defined scope. Instead, they serve as crucial considerations for interpreting the results and guiding future research endeavors to further refine and validate the framework.

7.2. Recommendations

Based on the empirical findings demonstrating a significant discrepancy between Nepal's mandated 15% overhead standard and actual project-level expenditures, and in light of the proposed Contextual Overhead Estimation Framework (COEF), the following recommendations are put forth for various stakeholders and for future research endeavors:

7.3. Policy Revisions for the Public Procurement Monitoring Office (PPMO)

7.3.1. Revise the Fixed 15% Overhead Standard

The PPMO should initiate a review and revision of Schedule 1 of the Public Procurement Act 2063, which currently mandates a flat 15% overhead charge. This fixed percentage has been empirically shown to lead to substantial overestimation at the project site level. The revised guidelines should move towards a more flexible, context-sensitive approach.

7.3.2. Adopt a COEF-Based Estimation Band

Implement a COEF-based estimation band or a tiered system for overhead allocation. This system should account for project-specific factors (e.g., complexity, duration, site accessibility) and local contextual variables, rather than a single fixed percentage. The illustrative COEF matrix (Table 5.1) provides a starting point for developing such a tiered system, which can be calibrated with more extensive data.

7.3.3. Differentiate Site vs. Head Office Overheads

Introduce clear guidelines for the differentiation and transparent accounting of project-specific (site) overheads and general (head office) overheads. While the 15% might implicitly cover head office costs, the current lack of transparency leads to misperception and potential misallocation. Policy should encourage contractors to itemize and justify both categories of overheads in their bids, fostering greater accountability.

7.3.4. Mandate Data Collection and Reporting

Establish a standardized system for contractors to report actual project-level overhead expenditures upon project completion. This data is crucial for continuous calibration and refinement of the COEF and for ensuring that future estimation bands are empirically grounded.

7.4. Implementation and Practice for Contractors and Industry Professionals

7.4.1. Adopt Contextual Estimation Practices

Contractors should move beyond simply adhering to the 15% standard or relying on arbitrary lower percentages during bidding. Instead, they should adopt a more detailed, item-wise estimation procedure for overhead costs, integrating project-specific factors and their own operational realities, consistent with the principles of the COEF.

7.4.2. Enhance Internal Cost Tracking

Construction firms should improve their internal accounting and cost tracking systems to accurately monitor and categorize both job-specific and head office overhead expenses. This granular data is essential for informed bidding, financial management, and contributing to industry-wide data collection efforts for more accurate estimation.

7.4.3. Invest in Capacity Building

Contractors and procurement officials should participate in training programs and workshops focused on advanced cost estimation techniques, risk assessment, and the application of contextual frameworks like COEF. This will bridge the observed awareness gap and equip professionals with the skills needed for more accurate bidding and project management.

7.5. Technology Integration

7.5.1. Pilot Digital Tools for COEF Implementation

The PPMO and large contracting firms should pilot the integration of COEF principles into digital estimation tools, such as Building Information Modeling (BIM)-enabled platforms, CostX, or even custom-developed spreadsheet tools. This can streamline the data input and processing required for contextual estimation.

7.5.2. Explore Machine Learning Applications

For larger datasets and more mature markets, exploring the application of machine learning (ML)-driven forecasting models could further enhance overhead estimation accuracy by identifying complex, non-linear relationships between project variables and overhead costs.

7.6. Recommendations for Further Research

7.6.1. Expand Empirical Validation of COEF

Conduct further empirical studies to validate the COEF across a larger and more diverse sample of public construction projects in Nepal, encompassing different regions, project scales, and types (e.g., hydropower, irrigation, buildings).

7.6.2. Assess COEF in Different Procurement Methods

Extend the research to projects procured through International Competitive Bidding (ICB) and Public-Private Partnerships (PPP) to evaluate the applicability and effectiveness of COEF in varied contractual environments.

7.6.3. Quantify Head Office Overhead Costs

Conduct dedicated research to empirically quantify the typical range and components of head office overhead costs for Nepalese construction firms. This would provide crucial data to inform a more transparent allocation of the 15% overhead, distinguishing between site-specific and general business costs.

7.6.4. Longitudinal Studies

Implement longitudinal studies that track overhead costs from the initial bidding phase through project completion, allowing for real-time analysis of estimation accuracy and the impact of unforeseen events.

7.6.5. Impact of Policy Implementation

Future research should assess the impact of implementing COEF-based guidelines on project performance, transparency, and contractor competitiveness in Nepal.

By systematically implementing these recommendations, Nepal's public construction sector can transition towards a more accurate, transparent, and efficient overhead cost estimation regime, ultimately leading to better utilization of public funds and more sustainable project delivery.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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