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Research Article

Factors Affecting Construction Project Performance: Bharatpur Metro Case Study

Shashi Bagale[1], Niraj Bohara[2]

[1]Master's Scholar

[2]Assistant Professor

[1,2]United Technical College, Bharatpur, Chitwan, Nepal

INFO

Corresponding Author

Shashi Bagale

Email

bgl.shashi@gmail.com

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Orcid

https://orcid.org/0009-0005-5800-3380

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ABSTRACT

This study is conducted to evaluate the time, cost overrun, time-cost relationship and to identify and evaluate the major factors affecting the performance of construction projects in Bharatpur metropolitan city. The study of 11 recently completed ward office building construction projects, revealed that all of them experienced time overruns, ranging from 28% to 150% beyond the contract time. Additionally, 9 of the 11 projects suffered from cost overruns, ranging from 18.54% to 41.03% over the contract amount. In Bharatpur metropolitan city, there is a positive but moderately predictive relationship between construction time and project cost, with longer construction durations typically associated with higher project costs. A questionnaire survey involving 61 identified factors categorised into 9 groups was conducted, validated through the Content Validity test, Criterion Validity test and Cronbach's Alpha tests. Analysis using Relative Importance Index (RII) determined that the most significant factors, agreed upon by all stakeholders, included project manager leadership skills, materials price escalation, average delay because of closure and materials shortage, design and drawing changes, subcontractor control, organisation liquidity and delayed payments of Relative Importance Index (RII) ranging from 0.513 to 0.925. The Spearman rank correlation (ρ), there is a significant agreement between the ranking of Client, consultant and contractor.

Keywords: BTC model, Construction, Cost Overrun, RII, Time Overrun

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Introduction

Nepal's construction industry accounts for about 10-11% of GDP and consumes about 35% of the government budget. The sector is estimated to create employment opportunities for about one million people and become the second source of employment in the country after the agriculture sector. Likewise, about 60% of the country's construction budget is spent through contractors (Neupane, 2020).

Construction projects face persistent challenges related to performance, including delays, cost overruns, time overruns and quality issues. These issues are intensified by political, economic, and cultural factors, leading to financial losses, project delays, and decreased stakeholder satisfaction (Acharya, Bhandari and Timilsina, 2021). Bharatpur, the third largest city in Nepal, experiences rapid urban growth and construction activities across various sectors. However, completing projects within the allocated time and budget proves challenging due to unexpected problems and design changes during construction (Thapa and Mishra, 2023). In the Nepalese construction industry, it's surprising for projects to be finished on schedule, within budget, and meeting desired quality standards. This rarity is largely due to the unique, time-consuming, and costly nature of construction projects, which are fraught with uncertainties. Consequently, disputes and claims are frequent, particularly on large civil engineering contracts. In Nepal, there's a rising number of construction projects, however, completing projects within the initially stipulated time and cost has become increasingly challenging. Time and cost overruns are prevalent in nearly all construction projects, often stemming from unexpected problems and design changes during the construction phase (Khanal and Ojha, 2020).

Bharatpur is a city in the central-southern part of Nepal and is the third largest city of Nepal. Bharatpur is one of the fast growing cities of Nepal and serves as a commercial center of Nepal. As one of the prominent urban centers in Nepal, it has experienced a surge in construction activities, ranging from residential and commercial developments to infrastructure and public projects. Generally, it becomes very difficult to complete a project in a stipulated time and cost given in the initial contract document. Time and cost overruns are the common phenomenon in almost all construction projects. Number of unexpected problems and changes from original design arise during construction phase, leading to time and cost overruns. This article is very important to identify and to evaluate the main factors affecting the performance of construction projects in the Nepal. The practices concerning with the Key Performance Indicator's (KPI) such as time, cost, quality and this study would also further produce the time and cost relationship within the project to understand the time and cost progress and their relationship in different phases of the project.

Furthermore, there may be differing insights among clients, consultants, and contractors regarding these factors, which could impact project success. Therefore, this research assesses the occurrence of time and cost overruns and their relationship with BTC Model of ward office building projects, identify the factors affecting building construction project performance, and determine the relations of perceptions among stakeholders to develop effective strategies for improving project management and execution in Bharatpur Metropolitan City in order to assist owners, consultants and contractors to overcome performance problem and to improve performance of their construction projects.

Objective

The research covers the study of understanding the extent of time and cost overruns and the relationship between project time and cost of building construction projects and factors affecting performance of construction projects in Bharatpur Metropolitan City.

Methodology

Research Approach

This study adopted a mixed-methods approach, incorporating both qualitative and quantitative

designs. For the qualitative aspect, standardized structured questionnaires are employed to address factors affecting construction project performance. Additionally, qualitative methods such as site visits, interviews with experts, and observations are utilized to collect data. Quantitative data regarding time and cost overrun are sourced from literature reviews, contract documents, running and final bills and related stakeholders.

Study Area

The study was conducted in the Bharatpur Metro, situated in the southwestern part of Bagmati Province, which is one of the major province of the Nepal. Bharatpur covers an area of approximately 433 square kilometers and is divided into 29 wards. Due to time, resources and data constraint, 11 ward office building construction projects are chosen for the study, which are completed within last five fiscal years (075/076 to 079/080).

Study Population

The targeted populations were of the owners, contractors and consultants of ward office building construction projects in Bharatpur metro are the population of the study. The total population size of the study was 69 (17client engineer, 33 contractors and 22 consultants). The researcher were distributing questionnaire for owner, contractor and consultants of different construction projects.

In this research, stratified sampling method was used for selecting the sample population. Strata were clients, contractors and consultants, in order to analyze the factors affecting the performance of construction projects within Bharatpur Metropolitan city, a wide range of project personnel (including clients, consultants and contractors) involved in the construction of the projects were targeted.

Data Collection

Questionnaire Survey

A questionnaire survey was conducted to determine the perceptions of various project stakeholders on the factors affecting the performance of ward office construction projects as identified from the literature review and interviews. The questionnaire were prepared in a 5-point Likert scale to match the objectives of the research. The obtained data were analyzed using MS Excel and SPSS.

Questionnaire Validation

A pilot study of the questionnaire were conducted by a scouting sample, which consisted of 20 set questionnaires to test validity and reliability of questionnaire. Validity explains how well the collected data covers the actual area of investigation. Reliability refers to the extent to which the measurement of a phenomenon provides stable and consistent results (Taherdoost, 2016).

Validity and Reliability Test

The questionnaire passed through content validity test (CVR) and criterion validity test of validation process to ensure its suitability for distribution to the population. Based on expert feedback, a content validity ratio (CVR) was calculated for each item.

Content validity ratio determination formula (Lawshe, 1975):

$$CVR = \frac{n_e - \frac{n}{2}}{\frac{n}{2}} \quad \ldots (1)$$

Where,

CVR is the content validity ratio,

n_e is the number of panel members indicating "essential"

N is the total number of panel members

The final rating to retain an item based on CVR depends on the number of panels. Lawshe's technique confirmed its content validity, with the calculated content validity ratios (CVR) exceeding the minimum value of 0.42 for all questions as assessed by a panel of 20 experts.

To test criterion validity test, the correlation coefficient (Pearson correlation coefficient) for each item of the group factors and the total of the field

$$\text{Time Overrun} = \frac{\text{Actual Construction Duration-Award Construction Duration}}{\text{Award Construction Cost}} \times 100\% \ldots(5)$$

is achieved. The formula for calculating Pearson correlation coefficient r between i and j respondents (Edwards, 1976):

$$r = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma y2 - (\Sigma y)^2]}}$$

Where;

N is the number of pairs of scores(number of questions)

i and j is the respondents 1 to 20 where i≠j

Σx is the sum of Likert's scale scores of respondents i

Σy is the sum of Likert's scale scores of respondents j

Σxy is the sum of the products of paired scores

Σx^2 is the sum of squared x scores

Σy^2 is the sum of squred y scores

Criterion validity tests revealed significant correlations between items and their respective factors, with all p-values (Sig.) being less than 0.01, indicating high significance.

The reliability of each field and the entire questionnaire was assessed using the Cronbach alpha method, the formula for calculating Cronbach's (Ritter, 2010):

$$\alpha = \frac{K}{K\text{-}1}\left(1 - \frac{K\sigma_K^2}{S_{total}^2}\right)$$

Where;

K is the number of scale items.

$\sum\sigma^2_k$ is the sum of the k item score variances.

σ_2 total^2 is the variance of scores on the total measurement.

A basic rule of thumb for interpreting alpha for Likert scale questions is:

0.9 ≤α ≥ 1.0 Excellent

0.8 ≤α>0.9 Good

0.7 ≤α>0.8 Acceptable

0.6 ≤α>0.7 Questionable

0.5 ≤α>0.6 Poor

0.0 ≤α>0.5 Unacceptable

The Cronbach's Alpha values ranging from 0.603 to 0.897 for individual fields and 0.951 for the entire questionnaire. These values demonstrate high reliability and confirm the questionnaire's validity for distribution to the population.

Analysis of Data

The cost overrun and time overrun was calculated (Shrestha, Burns and Shields, 2013):

$$\text{Cost Overrun} = \frac{\text{Actual Construction Cost-Award Construction Cost}}{\text{Award Construction Cost}} \times 100\% \ldots(4)$$

$$\text{Time Overrun} = \frac{\text{Actual Construction Duration-Award Construction Duration}}{\text{Award Construction Cost}} \times 100\% \ldots(5)$$

A scatter plot of the data was prepared and relationship between construction time and project cost of 11 new ward office building was analyzed. It was then used to test the time-cost model derived by Bromilow et al. (1980) for Australian construction industry using the following equation:

$$T = K * C^B \ldots (6)$$

Where,

T= duration of construction period from date of site possession to practical completion in working days;

K= constant describing the general level of time performance for a million of NRs project; and

C= final cost of building in millions of NRS.

B= constant describing how the time performance is affected by project size as measured by cost.

The relative importance index (RII) is calculated (Ugwu and Haupt, 2007):

$$RII = \frac{\Sigma_{i-1}^{N} n_i w_i}{A \times 1} \ldots(7)$$

Where;

w^i is the rating a factor by ithrespondents that ranges from 1 to

n_i is the number of respondents that rated wi i.e. 1 to 5

i is the number of respondents

A is the highest weight in the scale

N is the total number of respondents

The Spearman (rho) rank correlation coefficient is used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors. The Spearman's Rank Correlation Coefficient (ρ) is calculated using the following formula (Yadeta, 2010):

$$Rho\ (\rho) = 1 \frac{6\Sigma d \frac{2}{i}}{N(N2\text{-}1)} \ldots . (8)$$

Where:

Rho(ρ) is Spearman's rank correlation coefficient.

$\sum^{2}_{i}$ is the sum of difference in ranking between each pair of factors.

N is number of factors (variables).

The value of the Spearman (rho) rank correlation coefficient varies between -1 and +1. A correlation coefficient of +1 implies perfect positive correlation, 0 implies no correlation and -1 implies perfect negative correlation.

Literature Review

Overview of Cost and Time Overrun in Construction Industry

Cost overrun is defined as the excess of actual cost over budget. Cost overruns can also be defined as the change in contract amount divided by the original contract allocation amount (Nyabwari, 2012).

Cost overrun can simply be represented by the following equation (Shrestha, Burns and Shields, 2013).

$$Cost\ Overrun = \frac{Total\ Payment\ Amount\text{-}Original\ Contract\ Amount}{Original\ Contract\ Amount} \times 100\%$$

A construction delay occurs when a project exceeds the agreed-upon completion or delivery date. This situation leads to various unexpected negative consequences, such as missing target time, budget overruns, and compromised quality. The extent of time overrun can be expressed using the following equation (Assaf& Al-Hejji, 2006).

$$Cost\ Overrun = \frac{Actual\ construction\ Duration\text{-}Original\ Construction\ Duration}{Original\ Construction\ Duration}$$

Bromilow's Time–Cost Model

Bromilow's Time Cost Model (Bromilow & Odabasi, 2009), developed in 1969, establishes a quantitative link between project duration and cost, with subsequent research refining its coefficients and applicability. Its adaptability across different countries and project types underscores its significance in diverse construction environments. The model relies on historical data and statistical analysis to estimate project duration under varying cost scenarios, aiding project managers in making informed decisions. Despite ongoing efforts to improve accuracy, the model remains a fundamental tool in construction project management, facilitating resource optimisation and risk mitigation. Its widespread application and modification in numerous studies worldwide further enhance its relevance and usefulness in contemporary construction practices. The provided data presents regression equations from various studies across different countries, revealing the relationship between project duration (T) and project cost (C) within the construction sector. Notably, the equations vary in their coefficients, reflecting distinct factors affecting project outcomes in each context. For instance, in Australia, Mak et al. (2000) found that for all project types, $T = 131C^{0.131}$, while Ng et al. (2001) discovered in both public and private projects, $T = 130C^{0.310}$. In Malaysia, Chan (2001) identified a relationship for public projects as $T = 269C^{0.315}$, whereas in Bangladesh, Choudhry et al. (2002) established $T = 149C^{0.27}$ for private projects. These equations exemplify the shaded dynamics of project duration and cost within the construction industry across diverse geographic and organizational contexts. Mishra, A. K., Sudarsan, J. S., & Nithiyanantham, S. (2020) conducted similar in public health building of Nepal.

Factors affecting Performance of Construction Projects

Based on previous studies and literature reviews, the most important 61 factors affecting performance of construction projects are selected and clustered into 9 groups based on literature review. These groups can give a comprehensive summary of the main key performance indicators. The factors which are considered in the questionnaire, are summarised and collected according to previous studies and other factors are added as recommended by local experts.

Table 1

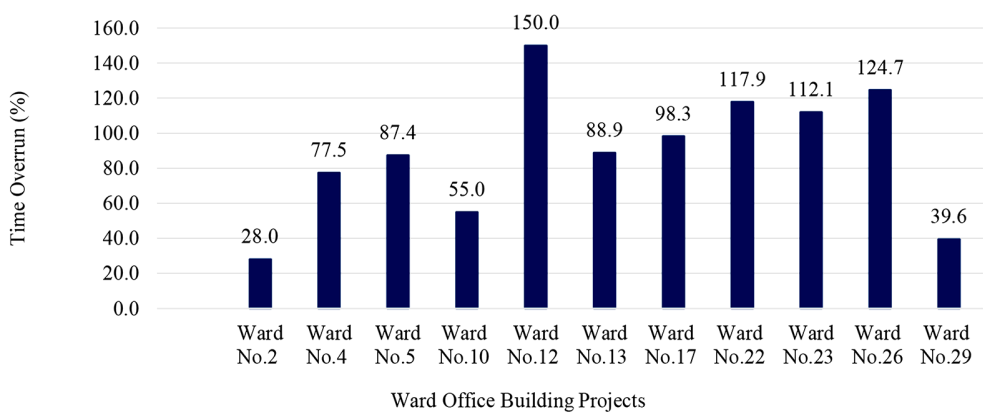
Performance of Construction Projects (KPIs Groups) and Their References

Key Performance Indicators	Cost	Quality	Time	Innovation and Technology	Health and Safety	Client Related Factors	Consultant Related Factors	Contractor Related Factors	Environment Exogeneous Factors
Soewin & Chinda, 2018	√	√	√	√	√	√			√
Stechemesser et al., 2015	√	√	√						
Fidic et al., 2017	√	√	√	√	√	√			√
Chilwal & Mishra, 2018	√	√	√			√	√	√	√
Abidali & Ali, 2018	√	√	√					√	√
Callistus et al, 2014		√					√	√	
Mishra 2018	√	√	√			√	√	√	√
Dixit, 2020	√	√	√						√
Kusi et al., 2018		√			√	√	√		
Bekr, 2017	√	√	√		√	√			√
D. 2013	√	√	√			√	√	√	
EberaLe, GesseYada, 2016	√	√	√			√	√	√	√
Sweis et al., 2014	√	√	√		√	√	√	√	√
Bitamba & An, 2020	√	√	√	√	√	√	√	√	√
Habtmaraim, 2019	√	√	√			√		√	√

Results and Discussion

Figure 1

Scenario of Time Overrun in Ward Office Building Projects

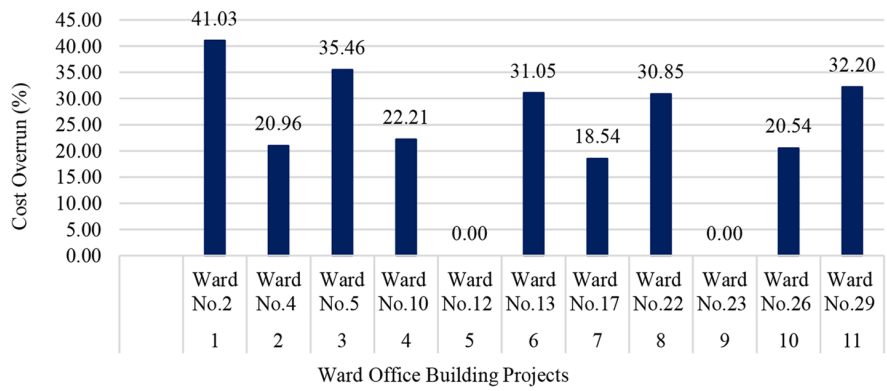


Time Overrun and Cost Overrun of Ward Office Building. The Figure 1 displays the time overrun percentages for 11 newly constructed ward office building projects in Bharatpur metropolitan city. These projects have experienced delays ranging from 28.0% to a significant 150.0% in their completion time, highlighting varying degrees of time overrun beyond the originally projected schedules. Projects such as "Construction of Ward No.4 Office Building" and "Construction of Ward No.12 Office Building" faced substantial delays, with overruns of 77.5% and 150.0% respectively. This trend of time overruns persists across most projects listed, emphasizing the challenges encountered in managing these construction endeavors and the importance of implementing effective project management strategies to address such delays in future projects.

Figure 2 presents data on the cost overrun percentages for 11 ward office building construction projects in Bharatpur metropolitan city over the last five fiscal years (075/076-079/080). The analysis reveals varying degrees of cost overruns, with projects such as "Construction of Ward No.2 Office Building" and "Construction of Ward No.5 Office Building" experiencing significant increases in expenses beyond their planned budgets.

Figure 2

Scenario of Cost Overrun in Ward Office Building Projects



Conversely, projects like "Construction of Ward No.12 Office Building" and "Construction of Ward No.23 Office Building" managed to stay within their initially estimated budgets. The findings underscore the importance of effective cost estimation, budget control, and financial management in construction projects to mitigate financial challenges and ensure successful outcomes. By identifying factors contributing to cost overruns and implementing measures to optimize budgetary planning and resource allocation, project managers and stakeholders can enhance project performance and deliver results within budgetary constraints.

Project Time -Cost Relationship

The results of the analysis indicated a positive relationship between construction time and project cost for ward office building projects in Bharatpur metropolitan city.

The regression analysis conducted on ward office building projects in Bharatpur metropolitan city reveals a statistically significant relationship between project time and cost, with a coefficient of determination (R2) of 0.5548. This indicates that over 50% of the variance in the natural logarithm of time estimation can be explained by the natural logarithm of cost. By adopting Bromilow's time-cost model, with constants K and B determined as 113.12 and 0.3394 respectively, the relationship between project time (T) and cost (C) can be expressed as $T = 113.12 * C^{0.3394}$. The scatter plot in Figure 3 further illustrates this relationship,

showing a good fit of the curve to the data with an R^2 value of 0.5549. However, scattered data points suggest occasional exceptional time overrun instances possibly caused by factors like variation orders, lockdowns, or severe weather conditions.

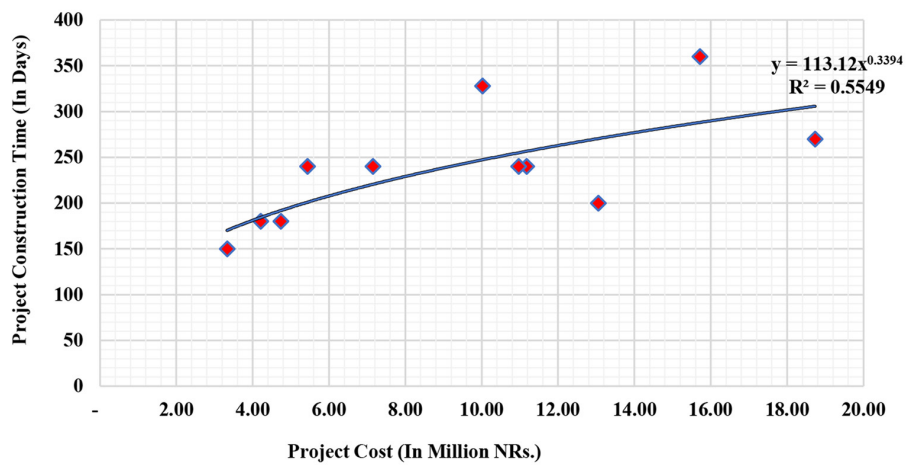
Table 2

Regression Analysis for project time and cost

	Coefficients	P-value
Intercept	4.728430626	5.00021E-09
Log©	0.339366231	0.008530508
Multiple R	0.744899596	
R Square	0.554875408	
Adjusted R Square	0.50541712	

Table 3

Relationship Between Construction Time and Project Cost



Overall, the model allows for the prediction of construction duration based on project cost, aiding in early anticipation and control of time and cost overruns through effective planning and scheduling.

Factor affecting the construction projects in Bharatpur Metropolitan City

The Table 4 presents a comparative analysis of various factors pertinent to a project, possibly within the construction sector, from the perspectives of the client, consultant, and contractor, along with an overarching view. Each factor is assigned a Relative Importance Index (RII) score, ranging from 0 to 1, where higher scores denote greater significance. Notably, Consultant Related Factors hold the highest overall importance with an RII of 0.834, followed closely by Contractor Related Factors at 0.784 and Client Related Factors at 0.782. Conversely, Health and Safety Factors rank the lowest across all perspectives with an RII of 0.581. This assessment underscores the pivotal role of consultants and contractors in project execution, emphasizing factors such as cost, time, and quality from the client's standpoint.

Table 3

Regression Analysis for project time and cost

SN	Group Factors	Client		Consultant		Contractor		Overall	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
A	Cost Factors	0.643	9	0.728	5	0.778	4	0.717	5
B	Time Factors	0.731	4	0.735	4	0.809	3	0.758	4
C	Quality factors	0.685	7	0.581	8	0.773	5	0.680	8
D	Client related factors	0.860	2	0.712	6	0.773	6	0.782	3
E	Consultant related factors	0.863	1	0.790	1	0.849	1	0.834	1
F	Contractor related factors	0.776	3	0.749	3	0.825	2	0.784	2
G	Health and Safety factors	0.650	8	0.505	9	0.589	9	0.581	9
H	Innovation and Technology factors	0.713	6	0.777	2	0.640	8	0.710	6
I	Environment/exogenous factors	0.725	5	0.672	7	0.709	7	0.702	7

Top Most Significant Affecting Factors All over the Group Factors

Strong leadership skills for the project manager emerge as the most critical factor for project success, highlighted by its highest Relative Importance Index (RII) value and rank. Following closely is the escalation of materials prices, emphasizing the significant impact of rising material costs on project performance. Delays due to site closures and materials shortage rank third, underscoring the adverse effects of such delays on project timelines. Effective management of design and drawing changes is crucial, as indicated by its high RII value and fourth rank. Timely availability and sufficient supply of manpower and materials are essential for project execution, ranking fifth in importance. The organization's financial stability and liquidity are vital for project continuity, reflected in its relatively high RII value and sixth rank. Effective coordination and communication between the project owner and involved parties are critical for project success, ranking seventh. Efficient team management is essential for improved performance, while delays in payment from the owner significantly impact project progress, ranking ninth and tenth, respectively.

Table 4

Regression Analysis for Project Time and Cost

Factors affecting the Performance	Factors Group	Overall	
		RII	Rank
Leadership skills for project manager	Client	0.913	1
Escalation of materials prices	Cost	0.905	2
Average delay because of closure and materials shortage	Time	0.896	3
Design and drawing changes	Consultant	0.884	4
Supply of manpower and materials	Contractor	0.870	5
Liquidity of organization	Cost	0.862	6
Information coordination between owner and project parties	Client	0.856	7
Team managements	Contractor	0.824	8
Average delay in payment from owner to contractor	Time	0.820	9
Payment delayed	Cost	0.819	10

Spearman Rank Correlation Test on the Ranking among Client, Consultant and Contractor

A spearman rank correlation test is done between different groups of respondents similar to Yadav and Mishra (2019). The Table 5 below, the correlation coefficient indicates that there is a strong correlation between all groups. This implies that most of the respondents have the same perception about the factors affecting the performance of construction projects. Therefore, there is a strong agreement between client, consultant and contractor.

Hence, it is concluded that there is significant degree of agreement between the ranking of consultant and contractor.

Table 5

Correlation Test on the Ranking of Affecting Factors

Respondents	$Rho(\rho) = 1 - \frac{6\Sigma d_i^2}{(N(N^2-1)}$	Relations of the Respondent
Client Vs Consultant	0.747	Strong relationship
Client Vs Contractor	0.710	Strong relationship
Consultant Vs Contractor	0.780	Strong relationship

Conclusion

The study assessing time and cost overruns in the construction of ward office building projects in Bharatpur metropolitan city over the past five fiscal years has revealed significant insights into the challenges faced by the construction industry in Nepal. The findings highlight the pervasive nature of both time and cost overruns across the projects, with delays ranging from moderate to substantial percentages and cost overruns varying between projects.

One of the most significant findings of this study is the positive relationship between construction time and project cost. The results suggest that increased project cost correlates with longer construction duration, emphasizing the importance of effective time management in controlling project costs. However, the predictive power of the time-cost model is limited, indicating the need for further research and model refinement to better understand the complex interplay between time and cost factors in construction projects.

Furthermore, the comprehensive analysis of factors affecting project performance, based on stakeholders' perceptions, underscores the critical role of effective leadership, cost management, resource supply, and communication in achieving successful project outcomes in Bharatpur metropolitan city. By addressing these key factors, construction project managers can enhance teamwork, minimize delays, ensure financial stability, and optimize project performance.

To address the challenges identified in this study, it is crucial for stakeholders in the construction industry, including project managers, contractors, and government authorities, to collaborate and implement strategies that prioritize effective time and cost management. This may involve the development of robust project management frameworks, the implementation of risk mitigation strategies, and the enhancement of communication and coordination among project stakeholders.

Moreover, the findings of this study highlight the need for further research to explore the specific factors contributing to time and cost overruns in construction projects in Nepal. Such research should aim to develop more accurate predictive models and identify best practices for mitigating these challenges, ultimately leading to more efficient and successful construction projects in the country.

The study on time and cost overruns in the construction of ward office building projects in

Bharatpur metropolitan city serves as a valuable resource for construction professionals and policymakers in Nepal. By addressing the identified challenges and implementing effective strategies for project management, the construction industry can contribute to the sustainable development of Nepal's urban infrastructure and improve the quality of life for its citizens.

Recommendation

The study's findings offer key recommendations for addressing time and cost overruns and improving project performance in Bharatpur metropolitan city's ward office building projects. Suggestions include careful financial planning, strict enforcement of legal regulations, proactive risk management, meticulous planning and resource allocation, workforce training, consultant accountability, strong leadership, stakeholder collaboration, timely budget allocation, and contractor responsibility. These measures aim to enhance project efficiency and minimize delays and cost overruns, ensuring successful project outcomes.

Acknowledgments and Declaration

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