Article on: "Evaluation of Factors Causing Cost Variation in Construction of Water Supply Projects in Nepal"

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Abstract

Cost is one of the major considerations throughout the project management life cycle and can be regarded as one of the most important parameters of a project and the driving force of project success. Despite its proven importance, it is common to see a construction project failing to achieve its objectives within the specific cost. Cost variation is a very frequent phenomenon and is almost associated with nearly constructing all water supply projects. Maintaining steady cost projection on water supply projects had been recently an issue of serious concern, both to the client and contractors. This research work attempts to identify, investigate and rank factors supposed to affect cost variation in the Nepalese water supply construction projects with respect to their relative importance so as to proffer possible ways of deal with this occurrence.

To achieve this objective, the study uses a mixed-method approach, including a structured questionnaire survey and research papers, to gather data. Brain storming was taken into consideration, through which a number of cost variation factors were identified for constructing water supply projects. Totally 25 factors were short-listed to be made part of the questionnaire survey and the survey was conducted with experts, consultants, employers and contractors' representatives. The study further utilizes the Relative Importance Index (RII) to rank factors causing cost variations. It was analytically discovered that several key factors such as: (1) Mistake and errors in design, drawing, estimation and BoQ (2) Change in project design and scope (3) Due to change in scope and additional work (4) Inappropriate preconstruction study and project analysis and (5) Design not finalized before tendering were critical for causing cost variation for the construction for water supply projects, while (1) Domination of construction industry by foreign firms and aids (2) Unavailability of construction materials (3) By selecting lowest bidding procurement method (4) Financing mode and payment difficulties for completed work (5) Involvement of more number of parties in a single project are least responsible factor causing cost variation. The study concluded with recommending implement comprehensive and detailed design and review processes, enhance preconstruction site investigations and proper feasibility studies, introduce stricter project scope control mechanisms and improve client's project management procedures, apply advanced design, cost estimation and project management mechanism and software while designer should be aware of the site problems, strengthen stakeholder engagement and dispute resolution mechanisms, conduct regular capacity building training for staffs on accurate project cost control, planning and risk management in water supply projects for smoother implementation and achievement of desired cost control.

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1. INTRODUCTION

Background

Construction industry play a vital role in the development of the economic growth of a country as it gives opportunity for employment as well as infrastructure to the country and is recognized as one of the largest business worldwide. Construction Industry ultimately uplifts the living standard and maintains Quality of life of its residents. The growth in this business is an indicator of the development of the Country (Elbitangi, 2009). It has been identified that approx. 35 percentage of government project is used for Construction sector and in return the GDP of Nepal is being contributed by 10 to 11 percent. Similarly, about 60 percentages of the nation's development budget is spent through the use of Contractors (FCAN, 2012). Most of the population of Nepal relies on Agricultural works, however, it is estimated that the construction sector is creating employment opportunities to about one million people. Nepal being the developing country, infrastructural development plays the vital role in raising the economy of the country and infrastructural development projects solely rely on construction activities. Substantial amount of cash flow is generated from the construction materials, equipment's which ultimately enhances the economic activities and supports the social and economic development of the nation.

The construction industry has its own characteristics that distinguish it from other sectors of the economy. It is fragmented, sensitive to changing variables such as political and environmental factors, and has a significantly high rate of business failure (Nega, 2008). The iron triangle (cost, time, and quality) is used to measure the project performance and success (Mahamid & Bruland, 2012). In general, the measurement of success of a project is defined by completing the project within specified cost, time and quality. Any faults in those components leads to failure of contract and result in time and cost deviation and sometimes termination of Contract. The projects with extensive delays may end up losing their economic justification, which in turn may result in the termination of the project (Alavifar, 2014). The increasing complexity of the construction projects shows a greater demand on construction managers to deliver projects on time, within planned budget and with high quality (Vaardini, 2016). The major challenge faced by the construction industry in the developing countries is the chronic problem of cost deviations. The construction industry is full of projects that were completed with significant cost deviation (Amehl et al., 2010).

Cost deviation is simply defined as a difference between the final cost of the project and the contract amount without any changes to the original contract. A cost deviation, involves unforeseen costs incurred in excess/deficit of contracted amount due to an underestimation/overestimation of the actual cost during budgeting. A cost overrun is a major problem in both developed and developing countries (Angelo & Reina, 2002). In developing countries, the trend is more severe where the cost overruns sometimes exceed 100% of the estimated cost of the project (Vaardini, 2016). In construction sector, cost deviation is most common undesired evil. Nepalese construction industry is also not an exception (Chitrakar, 2005). Large size and long duration projects have significantly higher cost and schedule overruns than small size and short-term ones (Shrestha, 2013). The situation has become so harsh that no construction project at national level has been completed on time without any delay at the specified cost. Also, most of the projects in the national level are having significant cost deviation (Yadav & Mishra, 2019). The main factors for cost and time deviations are: 1) scope definition, 2) coordination of

roles and responsibilities among involved parties, 3) initial estimation and contingency planning, and 4) monitoring and control systems (Halloum, 2012). In addition to these poor management of the resources may also lead to cost deviations. It is essential to have control on cost performance of projects to ensure if the construction cost is within the estimated budget. Therefore, project cost management is needed to keep the project within its defined budget. Categories of project cost management include project resource planning, cost estimating, cost control and cost budgeting. Cost control has two important components namely, cash flow management and project accounting for determining the projected final cost to consider the projections of future cost involving scope, time and quality.

Department of Water Supply and Sewerage Management (DWSSM) is one of the oldest leading departments in Nepal working in water, sanitation and hygiene (WASH) sector. It has responsibility of planning, implementation, operation, repair and maintenance of water supply and sanitation systems throughout the country, is the lead implementing agency of the WASH sector. It has already been a decade that it is involved in the construction of numerous water supply projects. This research investigates factors perceived to cause cost variance in Nepalese Water Supply projects with respect to identifying and ranking their relative importance. Collecting data of factors from the literature and with input from professionals and previous researches, this research evaluates factors causing cost variance for constructing water supply projects and explores them by using weightage methods

Statement of Problem

Project success is measured by completing the project within cost, in required time and with the desired quality. Any fault in these parameters leads to cost deviation and time extension. Completing a project on time within the estimated budget has become the major challenge in construction industry. Almost all energy related projects are facing time and cost deviations (NPPR, 2015). Time extension itself is the cause of cost deviation.

Many construction projects including road, irrigation, buildings, hydropower and water supply projects cost as well as time deviation (Sah, 2016). In the present context, most of the ongoing and completed water supply construction projects in Nepal are suffering badly from excess time deviation. Timely completion of a construction project is one goal of both the client and contractor because each party tends to incur an additional cost and lose potential revenues when such completion is delayed (Thomas et al., 1995). Most construction projects on Malaysia experience project delivery delays and hence, cost overruns (Ramanathan et al., 2012). This indicates that the cost deviation is directly linked with time deviation as well. Cost variation is considered as a big problem which hinders the project progress, since it decreases the contractor profit leaving the project in a big trouble. The extent of deviations ranges from millions to billions. Researchers on construction projects in some developing countries indicate that by the time a project is completed, the actual cost exceeds the original contract price by about 30% (Al-Momani A., 1996). It is rare to be delivered construction project in Sirya and other countries in the world according to contractual cost, which led to many disputes and claims (Hassan, 2019).

Prosperous WASH facility is the basic need of any individual and to maintain the healthy environment within the nation government is responsible by providing these related facilities. DWSSM is a state institution engaged in construction of WASH related facilities since a decade. High capital is required

for the construction of such projects. Cost variation in the construction may lead to poor economy and such high cost variation may lead to poor project quality. Disputes arouses that hinders the development process. Proper budgeting during the planning phase would be beneficial for community to enjoy the health benefits on time and cost consideration at every aspect during design leads to high project success rate. It is important to predict the cost variations of project in a practical way during the project planning phase to avoid the cost overruns and underruns, which can be obtained through this research. The causes of cost overrun and underrun will help to minimize the cost variation factors.

Research Objective

The aim of this research is to assess an evaluation the factors causing cost variation in construction project especially Water Supply Project constructed by DWSSM. To achieve this objective, practitioners and experts comprising a statistically representative sample to participate in a structured questionnaire survey. Brain storming was taken into consideration, through which a number of cost variation factors were identified for constructing Water Supply projects. These factors were short-listed to be a part of the questionnaire survey and the survey was conducted with experts, employers, consultants, designers and representatives from construction firms. The data were analyzed using Relative Importance Index, ranking and simple percentages to identify their impacts through a survey and were discussed. The specific objectives are:

a. To identify the status of cost variation in water supply projects.
b. Identify and investigate Cost variation factors which effect the construction of water supply projects by conducting survey.
c. Calculate factors efficiency and rank them by using relative importance index and ranking method with respective category.
d. To suggest suitable measure to reduce such identified cost variation.

2. LITERATURE REVIEW

Cost Variations in Construction

All the projects are conceived and planned. When the detailed planning and design of the project is accomplished, the cost estimate of the project can be computed. Cost allocation under various headings requires high level of managerial skills and proper management of resources. It is essential to have control on cost performance of projects to ensure if the construction cost is within the contracted budget. Therefore, project cost management is needed to keep the project within its defined budget. Cost overruns occur in every construction project and the magnitude varies significantly from project to project.

In general, cost variation is defined as the increase/decrease of actual cost over contracted cost. It is the ratio between change in contract costs and final costs (Jackson, 1990). Cost variation deviation occurs when the final cost of the project exceeds or deficit the original estimates (Azhar & Faroouqi, 2008). Cost variation involves unforeseen costs incurred in excess of estimated amount due to an underestimation of the actual cost during budgeting or incurred deficit incurred by not maintaining the quality or completing the full scope of work with the required quality. They observed that the trend of

final cost overrun is worldwide and that is more severe in developing countries. The calculation is in percentage for easier comparison and the equation for calculation cost overrun is:

Cost variation = (change in contract amount)/(original contracted cost)

Kaming et al. (1997) conducted a research on the cost deviation in the construction projects and found some common factors that are weather condition, change in material rates, inaccurate estimation of cost, complexity of projects, contractors less experience about the site geography, contractor less experience about the project and non-familiarity with local regulations. He also studied the cost overrun in high risk construction projects of Indonesia. He pointed out four main factors that affect the cost overrun in construction projects that are increase in material cost, incorrect management of quantity take-off, productivity of labor and increase of labor wages in markets.

Chimwaso (2001) studied the factors causing cost variations in the construction projects. He divided the factors into two groups that are critical and other factors. The nine factors that are considered as critical by Chimwaso (2001) include Design not finalized before tendering, additional work at owner's request, changes in owner brief, lack of cost planning and monitoring during pre and post contract stages, poor soil conditions at site, adjustment of prime cost and provisional sums, re measurement of provisional works, logistics due to site location and lack of cost reports during construction stage.

In ADB Dataset, 16 dam construction had cost underruns averaging 16%. The causes of divergence from projected are: Schedule slippage, divergence of actual inflation rate from projected inflation for projects inputs, change in project components, change in design, geotechnical variations, natural disasters and civil disturbances (ADB, 2004).

Causes of Cost Variations

Many studies have been conducted to identify the causes of cost variation in construction projects. As per Olawale & Sun (2010) main causes of increase in cost deviation in UK construction projects were: Risk and uncertainty associated with the projects, inaccurate evaluation of project time, nonperformance of subcontractors and nominated suppliers, complexity of works, conflict between project parties, discrepancies in contract documentation, contract and specification interpretation, inflation of prices, financing and payment for completed works, lack of proper training and experience of project manager, low skilled man power, unpredictable weather conditions, dependency on imported materials, lack of appropriate planning, unstable interest rate, fluctuation of currency/exchange rate, weak regulation and control, project fraud and corruption, unstable government policies. Le-Hoai et al. (2008) ranked the top three causes of cost overrun in Vietnam as material cost increase due to inflation, in accurate quantity takes – off and labor cost increase due to environment restriction. Similarly, Kaliba et al. (2009) concluded that cost escalation of construction projects of Zambia are caused by factors such as inclement weather, scope changes, environment protection and mitigation costs, schedule delay, strikes, technical challenges and inflation. During a review of public sector construction projects in Nigeria, Dlakwa & Culpin (1990) found that the three main reasons for cost overrun are "fluctuations in material, labor and plant costs, construction delays and inadequate pre-planning."

According to Al-Najjar (2008) increment of materials price, delay in construction, fluctuations in the cost of construction materials, unsettlement of the local currency in relation to Dollar value are the major causes for I, II, III and IV rank for reasons of cost overrun in construction on Gaza strip.

Similarly, main causes of cost overruns in construction projects in Turkey by Arditi et al. (1985) were: increase of material prices, fast growth of inflation, inflation increase make difficult for contractors to produce products at its official price, delays caused by changes in design specification and financial problems project, under estimation of cost now of creating the budget of the project.

Randolph et al. (1987) conducted a study on municipal contracts in Lansing; they found that cost overrun rates decreased as the contract amount increased. While Rowland, (1981) found that cost overrun rates increased with increase in the contract amount of construction projects from a study of Southern United States construction contracts.

Previous Studies on Cost Variations

Mahamid & Bruland (2012) studied the statistical relationship between actual and estimated cost of road construction using data from Palestinian road construction concluded that the all project (169 road construction projects) suffer from cost deviation. It was found the 76% of projects have cost under-estimates and 24% have cost over estimates. The deviation between estimated and actual cost has an average of 14.6%, ranging from -39.3% to 98%.

Odeck (2004) assessed Norwegian toll roads to reveal whether planning procedure shortcomings experienced by Norwegian road agencies had resulted in poorer than projected financial performances for some of the toll roads. They found overestimation of traffic forecasts and underestimation of construction costs. In their small sample of 12 toll projects, they found cost overruns on average at about 5%, but the interval was large from −210% to 170%.

A test was performed with percentage cost underruns and percentage loan cancellations as independent variables, and some project success variables as dependent variables. Sixty-one percent of projects with large cost underruns were rated successful or highly successful in the PCRs. Seventy-six percent of projects with small cost variations, and 80% of projects with large cost overruns, had such ratings. This indicates that cost underruns are a phenomenon caused more by implementation inefficiencies than efficiencies (ADB, 2004).

1.1 Provision Related to Cost in relevant Acts/Standard Documents

The provision of concerning changes in the contract price in the FIDIC (2010) states that "… if the final quantity of the work done differs from the quantity in the bill of quantities for the particular item by more than 25 percent, provided the change exceeds 2 percent of the initial contract price, the Project Manager shall adjust the rate to allow for the change…" (FIDIC, 2010).

The provision of price adjustment in procurement contract in the PPA and PPR-2007 states that "… if price needs to be adjusted in the course of implementation of a procurement contract having duration exceeding fifteen months the competent authority may adjust price…". In addition of concerning price adjustment in procurement contract in the FIDIC (2010) states that "… prices shall be adjusted for the fluctuations in the cost of inputs only if provided for in the SCC. If so provided, the amounts certified in each payment certificate, before deducting for advance payment, shall be adjusted by applying the respective price adjustment factor to the payment amounts due…".

The provision of variation order in the PPA and PPR-2007 states that "… if the circumstances that could not be foreseen at the time of signing of procurement contract arise in the course of

implementation of the procurement contract, the competent authority may, by stating clear reasons thereof, issue as prescribed, a variation order for a variation of up to fifteen percent and for a variation order above it, a variation order may be issued as per the Government of Nepal, Council of Ministers by complying with the procedures as prescribed…". In addition of concerning variation order in the FIDIC (2010) states that "… the contractor shall provide the Project Manager with a quotation for carrying out the variation when requested to do so by the Project Manager…".

3. RESEARCH METHODOLOGY

This research attempts to determine the most influencing factors that causes the construction cost variation in water supply projects in Nepal. This type of research design is usually applicable when studying few cases within an organization. Various literature and articles on related topics were reviewed. The primary and secondary data were collected through the methods of observation and questionnaire. The questionnaire survey obtained from the concerned stakeholders was then analyzed and interpreted to achieve the research objective.

Research Matrix

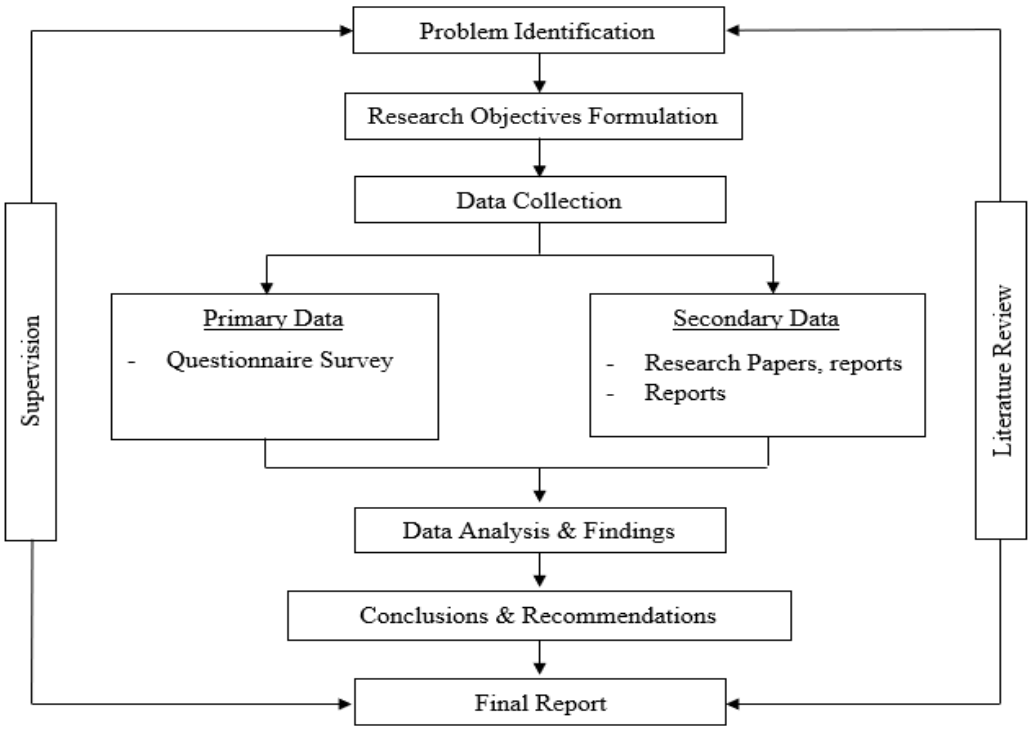
A research matrix is basically a device consisting of rows and columns that forces the researcher to think through the logic of a proposed study, ensuring that the various components of a study link together in a logical manner and that no essential parts of the study are omitted. It provides the summary of research methodology based on the various indicator, variables and data collection method to verify research objectives.

Table 2 Research Matrix

Research Objectives	Data Collection method	Data Source	Expected outcomes
To identify the key factors contributing to construction cost variation.	- Literature Review - Questionnaire Survey	Primary Data & Secondary Data	Identification of factors causing cost variation and ranking them.
To propose effective measures to reduce construction cost variation.	- Literature Review - Questionnaire Survey	Primary Data & Secondary Data	Recommendations for reducing construction cost variation.

Conceptual Framework

The conceptual framework of the research is given as shown below.



Research Methodology Flow Process

Sample Size determination and selection

The studied target population includes consultants, managers, engineers and contractors. A systematic random sample was selected to ensure a representative sample of all targeted respondents using following equation was used to determine the sample size of an unlimited population (Bartlett et al., 2001). Sample is a selection of a case which represents the entire population; it is less costly and saves time when there is a tight deadline than using the entire population.

Sample size for unlimited population, $n = \frac{z^2 * p * q}{e^2}$

Where, n = samples size, z = z value at given confidence level, let z=1.645 at 90% CL, p = percentage of picking a choice, expressed as a decimal (0.5 used for sample size needed), q = 1-p, e = confidence interval /sampling error (let e=10%)

Sample size, $n = \frac{1.645^2 * 0.5 * 0.5}{0.1^2}$

$=67.9$

Hence, take sample size = 68

Table 3 Population Distribution of Sample

S.N.	Respondent types	Sample Size	Percentage distribution of sample (%)
1.	Employer	43	63.64
2.	Contractor	13	19.12
3.	Consultants/Designer	12	17.65
Total		**68**	**100**

Data Collection

A set of different questionnaires were prepared for the responsible officials of employers, consultants and contractors working in the water supply sector. The questionnaires were related to identifying the factors contributing to the cost variation in water supply construction works and possible effective measures to minimize the cost variation along with ranking the factors based on their relative importance. Questionnaire is design in such a way that it contains three section, Section A: General Information, Section B: Likert Scale Questionnaire (Specific Information) and Section C: Project Information

A five-point scale will be used to indicate the relative importance of a contributor in cost variation where "5" represent extremely significant, "4" represent very significant, "3" significant, "2" represents slightly significant and "1" represents not significant.

Journal articles, textbooks, websites and various Literature review were used for the collection of secondary data. Reports and publications regarding the study were studied to gather ideas about the research problem, issues, and other ideas related to the research works. The variables for questionnaire for cause of cost variation were reviewed from literature. Various acts and Standard documents were reviewed for the cost provision. The similar research articles and previous thesis that were reviewed.

Data Analysis

After the process of collection of data from primary and secondary sources, they were analyzed by the descriptive method. For the easier interpretation of data, they are expressed in percentages. Those percentages are implemented for expressing the findings as a proportion of the whole. For easy understanding, the collected data was analyzed using the Excel program. The frequency and the percentage were represented in the form of table, graph and bar chart.

The data collected from the questionnaire was analyzed using the Microsoft Excel application and for ranking the factors overall and by the group of project parties (employer, consultants and contractor) using the RII. Before analysis began, several preliminary processes were adapted: editing data, addressing blank responses, coding data, categorizing data, producing data files, and doing certain statistical calculations. These procedures were designed to assure data consistency and allow for meaningful interpretation of results.

Prior to doing the data analysis, the collected data was cleansed. Screening, diagnosing, and editing were the three stages of data cleansing. Outliers, missing data, errors, and discrepancies were all sought out using these methods. There were several issues with the questionnaire, including missing data, mistakes, and inconsistencies. These issues are unavoidable in surveys, especially when questionnaires are used. To address the issues, the chosen data was erased and corrected properly. The data source and

the identification of the position held by the person who completes the questionnaire were both important factors in data reliability. As a result, it was critical that only those with in-depth knowledge of the project responded to the questionnaire. Only personnel from designated organizations received a copy of the questionnaire, and responses were double-checked to confirm that only these people took part in the study (Love, 2010)

In order to analyze the collected data and information from the questionnaire or interview Relative Importance Index method was used. This analysis was used for ranking the criteria concerning their relative importance. The relative importance index (RII) has been calculated as follows:

$$RII = \frac{\Sigma W}{A * N}$$

Here, w = weight as assigned by each respondent on the scale of 1 to 5 where 1 implies the least and 5 implies the highest. A= highest weight and N is the total number of samples.

4. RESULTS AND DISCUSSION

The information presented in this section relied on questionnaires and various documents which were used to collect data on causes of cost variation in construction industry related to water supply projects. This section deals with the analysis and interpretation of data that had been gathered to meet the objective of the study. Data obtained through the questionnaire were analyzed and demonstrated in the chart, table and diagrams.

Characteristics of respondents

Table 3 Rate of response

S.N.	Respondent types	Questionnaires Distributed	Questionnaires Responded	Percent of respondents
1.	Employers' representative	45	43	63.24
2.	Consultants/designer representative	15	13	19.12
3.	Contractors' representative	14	12	17.65
Total		**74**	**68**	**100**

Source: Field Data, (2024)

4.2.1 Age of respondents

Table 4 Age of respondents

Range	No. of respondents	Percent
Less than 25	5	7.35
26-40	61	89.71
41-55	1	1.47
Above 56	1	1.47
Total	**68**	**100**

Source: Field Data, (2024)

4.2.2 Gender of respondents

Table 5 Gender of respondents

Gender	No. of respondents	Percent
Male	62	91.18
Female	6	8.82
Total	**68**	**100**

Source: Field data, (2024)

4.2.3 Job title (profession) of respondents

Table 6 Job title (profession) of Respondents

Job Title	No. of respondents	Percent
Director	7	10.29
Project Manager	12	17.65
Engineer/Sub-Er	49	72.06
Total	**68**	**100**

Source: Field data, (2024)

4.2.4 Educational level of respondents

Table 7 Educational level of Respondents

Educational level	No. of respondents	Percent
Up to SLC	1	1.47
Intermediate level or 10+2	4	5.88
Bachelor's Degree	42	61.76
Master's Degree or Above	21	30.88
Total	**68**	**100**

Source: Field data, (2024)

4.2.5 Work experience in construction industry of respondents

Table 8 Work experience in construction of Respondents

Work experience	No. of respondents	Percent
Less than 3 year	13	19.12
3 -5 year	30	44.12
6-10 years	14	20.59
>10 years	11	16.18
Total	**68**	**100**

Source: Field data, (2024)

4.3 RII wise ranking for Causes of construction Cost Variation

The objective of the study was to find out and rank the factors causing cost variation for constructing water supply projects in Nepal will be looked at from different perspectives and view of the respondents on it. The view of respondents has been assessed through questionnaires. It will examine the data provided by respondents and that will be the basis for case selection. The Relative Important Index will be calculated as final outlined results. These factors will be ranked and categorized based on their Relative Importance Index report. Questionnaire survey done to 66 respondents.

Each of the causes were assessed through a questionnaire survey with various affecting factors, the frequency of the scores received by each variable based on the Likert scale were recorded.

The relative importance factors have been assessed and ranked as per their value.

RII = $\frac{\Sigma W}{A*N}$ $(0 \leq \text{RII} \leq 1)$

Where,

W – is the weight given to each factor by the respondents and ranges from 1 to 5,
(Where "1" is "Very Low Important / Not significant" and "5" is "Very High Important / Strongly significant");

A – is the highest weight (i.e., 5 in 5-point Likert's scale) and,

N – is the total number of respondents.

Table 9: Individual RII values and their category wise corresponding ranking given by the respondents

SN	Factors	RII	Rank
A.	**Client related factors**		
A.1	By selecting lowest bidding procurement method	0.603	23
A.2	Due to change in scope and additional work	0.750	3
A.3	Financing mode and payment difficulties for completed work	0.606	22
A.4	Unrealistic Contract durations set without time analysis	0.674	15
A.5	Long period between design and time of bidding/tendering	0.697	11
B.	**Contractor related factors**		
B.1	Inaccurate cost and time planning and site management	0.709	8
B.2	Unclear about client needs/ contractual requirements	0.653	19
B.3	Schedule delay (Time overrun)	0.703	9
B.4	Inadequate site investigation	0.724	6
B.5	Contractor experience and performance	0.700	10
B.6	Unavailability of modern equipment's and methods	0.679	13
B.7	Construction mistakes and defective works	0.676	14
B.8	Involvement of more number of parties in a single project	0.650	21
B.9	Delivery time of materials and equipment	0.653	19
B10	Contractual claims like extension of time with cost claims	0.685	12
C.	**Designer/Consultant related factors**		
C.1	Design not finalized before tendering	0.726	5
C.2	Mistake and errors in design, drawing, estimation and BoQ	0.768	1
C.3	Change in project design and scope	0.765	2
C.4	Inappropriate preconstruction study and project analysis	0.741	4
D.	**Factors beyond the party control**		
D.1	Inflation/ Price fluctuations	0.656	18
D.2	Force majeure, shifting of water sources and adverse effect of weather	0.665	17
D.3	Domination of construction industry by foreign firms and aids	0.582	25
D.4	Unavailability of construction materials	0.600	24
D.5	Unpredictable site conditions	0.671	16
D.6	Social disputes and water source conflicts on site	0.712	7

Table 10: Category wise average RII values and their corresponding rank given by the respondents

S.N.	Category	Average RII value	Rank	Remarks
A	Client related factors	0.666	3	
B	Contractor related factors	0.683	2	
C	Designer/Consultant related factors	0.750	1	
D	Factors beyond the party control	0.648	4	

Discussions:

The perceived effect of each of the 25 factors explored on cost variation for constructing water supply projects in Nepal, is determined. The overall factors are classified under four major categories as follows: 4 factors, under the "Client Related category", 10 factors, under the "Contractor Related category", 4 factors, under the "Designer/Consultant Related category"; and 7, under the "Beyond the party control Category". The relative importance indices, rank within the corresponding category, and the overall ranks of the factors investigated are presented, and discussed.

4.3.1. Client related category

The relative importance indices and ranks of the 5 factors that are classified under the "Client Related factor" are shown in (Table 9). The surveyed consultants, managers, engineers and contractors ranked the "Due to change in scope and additional work" factor as the most important factor causing cost variation for constructing water supply projects in Nepal in this category, with a Relative Importance Index equals to 0.750. This top ranked factor is further ranked third in its effect, among all explored factors, which indicates the significant impact of this factor on the cause of cost variation for constructing water supply projects in Nepal.

4.3.2 Contractor related category

The relative importance indices and ranks of the 10 factors that are classified under the ‘‘Contractor Related factor’’ are shown in (Table 9). The surveyed consultants, managers, engineers and contractors ranked the ‘‘Inadequate site investigation’’ factor as the most important factor causing cost variation for constructing water supply projects in Nepal in this category, with a Relative Importance Index equals to 0.724. This top ranked factor is further ranked 6th in its effect, among all explored factors, which indicates the significant impact of this factor on the cause of cost variation for constructing water supply projects in Nepal.

4.3.3 Designer/Consultant related category

The relative importance indices and ranks of the 4 factors that are classified under the ‘‘Designer Related factor’’ are shown in (Table 9). The surveyed consultants, managers, engineers and contractors ranked the ‘‘Mistake and errors in design, drawing, estimation and BoQ’’ factor as the most important factor causing cost variation for constructing water supply projects in Nepal in this category, with a Relative Importance Index equals to 0.768. This top ranked factor is also 1st ranked in its overall effect, among all explored factors, which indicates the most significant impact of this factor on the cause of cost variation for constructing water supply projects in Nepal.

4.3.4 Beyond the party control category

The relative importance indices and ranks of the 7 factors that are classified under the ‘‘Beyond the party control Category’’ are shown in (Table 9). The surveyed consultants, managers, engineers and contractors ranked the ‘‘Social disputes and water source conflicts on site’’ factor as the most important factor causing cost variation for constructing water supply projects in Nepal in this category, with a Relative Importance Index equals to 0.712. This top ranked factor is further ranked 7th in its effect, among all explored factors, which indicates the significant impact of this factor on the cause of cost variation for constructing water supply projects in Nepal.

It might be noted that all these factors are originated either by the owner, designer, contractor or beyond the party control one. This is expected since each party is trying to blame the other for causing cost variation. This research tends to compare the strength or the importance of each category, the weighted average value of the causes composing this category was calculated. The results and overall ranking of all the factors are tabulated in (Table 11)

Table 4 : Individual RII values and their overall ranking given by the respondents

SN	Factors causing cost variation	RII	Overall Rank	Remarks
1	Mistake and errors in design, drawing, estimation and BoQ	0.768	1	
2	Change in project design and scope	0.765	2	
3	Due to change in scope and additional work	0.750	3	
4	Inappropriate preconstruction study and project analysis	0.741	4	
5	Design not finalized before tendering	0.726	5	
6	Inadequate site investigation	0.724	6	
7	Social disputes and water source conflicts on site	0.712	7	
8	Inaccurate cost and time planning and site management	0.709	8	
9	Schedule delay (Time overrun)	0.703	9	
10	Contractor experience and performance	0.700	10	
11	Long period between design and time of bidding/tendering	0.697	11	
12	Contractual claims like extension of time with cost claims	0.685	12	
13	Unavailability of modern equipment’s and methods	0.679	13	
14	Construction mistakes and defective works	0.676	14	
15	Unrealistic Contract durations set without time analysis	0.674	15	
16	Unpredictable site conditions	0.671	16	
17	Force majeure, shifting of water sources and adverse effect of weather	0.665	17	
18	Inflation/ Price fluctuations	0.656	18	
19	Delivery time of materials and equipment	0.653	19	
20	Unclear about client needs/ contractual requirements	0.653	19	
21	Involvement of more number of parties in a single project	0.650	21	
22	Financing mode and payment difficulties for completed work	0.606	22	
23	By selecting lowest bidding procurement method	0.603	23	
24	Unavailability of construction materials	0.600	24	
25	Domination of construction industry by foreign firms and aids	0.582	25	

The above tables declared that respondents' rank the factor number C(1) ''Mistake and errors in design, drawing, estimation and BoQ'' as the most significant cause of cost variation for constructing water supply projects in Nepal from respondents' points of view. It was noticed that this first factor is related to ''Designer/Consultant related category" having most effect with Relative Importance Index equals to 0.768. Whereas the last one ''Domination of construction industry by foreign firms and aids'' factor related to ''Factors beyond the party control category'' the least significant cause cost variation among all causes with Relative Importance Index equals to 0.582.

5. CONCLUSIONS AND RECOMMENDATIONS

This research has been carried out with the objective to analyze, rank and evaluate the factors causing cost variation of water supply projects implemented by Department of Water Supply and Sewerage Management in Nepal. Qualitative and Quantitative approach was applied for the research by collecting the primary data through questionnaire survey (Employers, consultants and Contractors group), key informants' interview and Library, Journals, books, research paper, internet were referred as secondary data.

Conclusion

Cost variation remains a significant and persistent challenge in the construction of water supply projects in Nepal, often undermining project objectives and causing concern for both clients and contractors. From above results we conclude that to improve controlling of cost variation for constructing water supply projects in Nepal; one must identify and recognize the influence of the main factors affecting and causing it. The explored factors were classified under the following four primary classifications: (1) Client originated category; (2) Contractor originated category; (3) Designer/consultant originated category; and (4) Beyond the party control category. This research has identified and, based on the quantified relative importance indices, determined the influence ranks of 25 factors causing cost variation for constructing water supply projects in Nepal. To study the result of participants' experience on the attained results, the results were collected under experience-based group of participants and professional cadre of respondents. The results were compared by studying all participants to cope up with all the factors that cause cost variation for constructing water supply projects in Nepal. The most predictable and significant factor identified by the obtained results is ''Mistake and errors in design, drawing, estimation and BoQ" related to ''Designer/consultant Originated Category'' with Relative Importance Index RII equals to 76.80%; the results showed that the most cost variation can also be made by Change in project design and scope, Due to change in scope and additional work, Inappropriate preconstruction study and project analysis Design not finalized before tendering; while the less effect factor identified by the obtained results is ''Domination of construction industry by foreign firms and aids'' is related to ''Beyond the party control Category'' with Relative Importance Index RII equals to 58.20%.

This study reveals the importance of designer/consultant originated category on causes of cost variation for constructing water supply projects over the other arranged three categories; contractor originated, client originated and beyond the party control respectively. To improve controlling of cost variation for constructing water supply projects in Nepal; one must identify and recognize the influence of the main factors affecting it. This research has identified and, based on the quantified relative importance indices, determined the influence ranks of 25 factors causing

cost variation for constructing water supply projects in Nepal. Addressing these issues is essential not only to safeguard project budgets but also to enhance the overall efficiency and success rate of water supply projects, particularly in regions like Nepal, where such projects are critical to infrastructure development and community well-being.

Recommendation

Based on the findings of this research discussed with main conclusion listed above and the referring to findings of previous studies discussed in the literature review, the following recommendations are made: (1) Conduct third-party reviews and audits of design and estimates.; (2) Establish stringent scope management and formal change request processes; (3) Incorporate contingency budgets and conduct scope risk assessments; (4) Conduct comprehensive feasibility studies and detailed project analysis before initiation (5) Ensure the design is finalized and reviewed before tendering; (6) Improve geotechnical and environmental investigations early in the project lifecycle; (7) Engage in community consultations and mediation to resolve conflicts (8) Use advanced project management tools for precise cost and time tracking; (9) Develop a detailed, realistic project schedule with built-in buffers and regular progress tracking; (10) Implement stringent contractor prequalification criteria focusing on experience and past performance; (11) Implement periodic design updates and adjust estimates to reflect market changes; (12) Improve contract documentation and dispute resolution mechanisms; (13) Encourage use of modern equipment and methods; (14) Conduct regular quality checks on construction work; (15) Set realistic project durations through proper analysis; (16) Include contingencies for unpredictable site conditions; (17 Plan for force majeure events and potential water source changes; (18) Include inflation adjustments in contracts; (19) Secure reliable suppliers and manage delivery schedules; (20) Clarify client needs and contract requirements upfront; (21) Improve coordination among involved parties; (22) Ensure reliable financing and timely payments; (23) Avoid awarding contracts solely on lowest bid; (24) Secure material supply chains before project start and (25) Promote local firms and reduce foreign firm dominance.

Recommendations for Future Research

- Similar study should be conducted for Public institution of Nepal such as the department of road, irrigation and building projects.
- Similar research on evaluation of time variation with respect to contracted time can be done on public construction projects.
- Research on applicability of final cost and contracted cost can be checked.

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