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Risk Assessment in Selected Hydropower Projects of Nepal under Engineering, Procurement and Construction (EPC) Contracts

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Abstract
This research primarily focus on the risk assessment and the possible risk management measures through risk allocation and other measures. To achieve the objective of this research,risks has been identified from the literature review and from the experts of relevant fields to find the applicability in the context of Nepal, EPC contracts. Furthermore, the identified risks are finalized and grouped into nine groups. The questionnaires were targeted to the professionals from Employer, Contractor and Consultant of selected hydropower projects. The set of questionnaires were sent to 74 number of respondents from of 4 projects and 62 responses were received and only 60 were found to be valid. For ranking of the risks as per their significance, the Relative Importance Index (RII) has been used. The significance of possible risk management measures have been evaluated from questionnaire survey using RII. As a part of risk management measure, the KII is done to find the risk allocation to Employer risks, Contractor risks, shared risks and transferred risks. The RII of each risks along group and overall RII is calculated and ranked to find the correlation between the catagories and the testing of hypothesis has been done to find out the significance of correlation. The major 46 risks grouped into 9 groups are identified and further analysis is proceeded for their significance. The total risk score is calculated as the product of probability and impact. The most significant risks identified are “Risk of subsurface geology”, “Force majeure” and “Construction delays”. From the study it is found that the major risks has been shared by “the Parties” and been transferred to other party as risk management measures. The other most significant risk management measures identified as “Preparation of contract documents by highly experienced personnel”, “Competent project management team” and “Conduct sufficient investigations and feasibility before procurement”. This study has recommended to work out on the detailed risk management of projects during project formulation, Design and documentation and implementation and minimizing the unforeseeable risks and alocate those shall be taken by “the Parties”.

Keywords
Risk Assessment, Contract Management, EPC Contracts, Hydropower

1. Introduction

1.1 Background

Global energy demand is expected to increase by 48% in the next 20 years owing to the precipitous increase in the global population. Currently, 80% of the energy demand is met by fossil fuels (Preshanthan Moodley, Cristina Trois, in Sustainable Biofuels, 2021).

The hydropower sector in Nepal is driven by the Government of Nepal, Independent Power Producers of Nepal (IPPAN), Foreign Direct Investments (FDIs).Despite the huge capacity of the nation, the operating projects have installed capacity of about 3000 MW only. The growth and attraction towards the hydropower sector can be estimated by the huge capacity of survey license issued by DoED for more than 15,000 MW projects and the construction license for (7905.865) MW projects till January 2022 as per DoED [1]. The Engineering, Procurement and Construction contract is a type of contract in which is applied where the certainty of final price and time is required and most of the tasks till completion and handover of the project key is allocated to the contractor. In this type of contract, the Contractor shall meet the key functional requirements of the project. Anuja, 2020 [2] argues that the risks are inherent to any construction projects. Risk management in projects aims to increase the probability and impacts of benefits (positive events) and decrease the probability and impacts of harms (negative events). Crispin, 2020 [3] argues that the risk management is process of identification, analysis and response to the project risks.

1.2 Problem Statement

Hydropower development itself from the initial phase of project concept formulation, feasibility studies, designs, procurement, construction to successful testing and commissioning is a multidisciplinary and very complex task. Hydropower project also involves substantial amount of unforeseeable physical underground works which may not be fully determined during study and procurement stages. It also utilizes huge amount of resources and time. Being complex and multidisciplinary, the risks associated in hydropower projects are more. As the risks associated till the construction phase is mainly borne by the Employer, the risks after procurement need to be shared and well managed. The risks assessment is the most important thing for the project to success but, in Nepal, this is ignored during project studies. Risk identification works as a early warning system and helps

in developing the management plans which ultimately helps the project to success. But in case of Nepal, this has been ignored, and the past information is limited. There has been very little research in this context. Therefore, there is a need of research to identify the risks, their scores, sharing mechanisms and to analyse the possible measures to manage the risks in the hydropower projects under EPC contracts in Nepal.

1.3 Objective

The objectives set out for this study are:

1. To identify the major risks of Hydropower projects in Nepal under EPC contracts,
2. To identify the probability and impact of risks and rank them as per their scores in Hydropower projects in Nepal under EPC contracts, and
3. To suggest the risk management measures for Hydropower projects in Nepal under EPC contracts.

1.4 Limitation

As per the scope and methodology of this study, it has the following distinctive limitations:

1. The study has been conducted on selected Hydropower projects under EPC contracts only.
2. The study has been conducted on run-off river projects only. The peaking runoff river and storage projects are excluded in this study.
3. This study is qualitative in nature with limited number of respondents only.

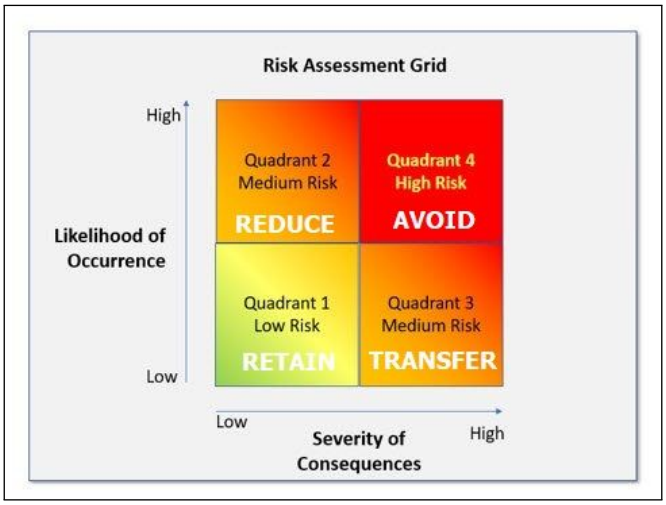

Figure 1: Risk management strategies
(Source: https://www.linkedin.com/posts/ken-chua-a666a249_how-to-deal-with-risk-four-quadrants-of-activity-7094238539684462592-89y8/)

2. Literature Review

Risk is the likelihood for a certain problem to occur (an unwanted situation) with the corresponding value (impact) of the damage caused. Project risk can be defined as "An uncertain event that, if it occurs, has a positive or a negative effect on at least one project objective, such as time, cost, quality, or scope." PMI, USA [4].Risk management is the systematic process of identifying, analyzing and responding to project risk. It includes maximizing the probability and consequences of positive events and minimizing the probability and consequences of adverse events to project objectives. The Constructor (Anon., 2022) [5] suggests that the risk valuation is done in two ways as: Qualitative method and Quantitative method. The risk management process is suggested by (Anon., 2022) as follows and as shown in Figure 1:

1. Identification of risk
2. Prioritize risks in order of importance
3. Determine your risk response strategy
   (a) Avoid the risk
   (b) Transfer the risk
   (c) Mitigate the risk
   (d) Accept the risk
4. Execute the risk management plan
5. Involve members of the team
6. Create contingencies and revise

Risk management has higher opportunity in earty stages of project with minimum impact and vice-versa as shown in Figure 2. In general, Contractors or Subcontractors may add higher contingencies to their bids to cover the costs of identified risks. If the risks and liabilities are not properly shared, claims and disputed may be the associated consequences during construction (Chotchai Chareoenngam, 1999) [6].

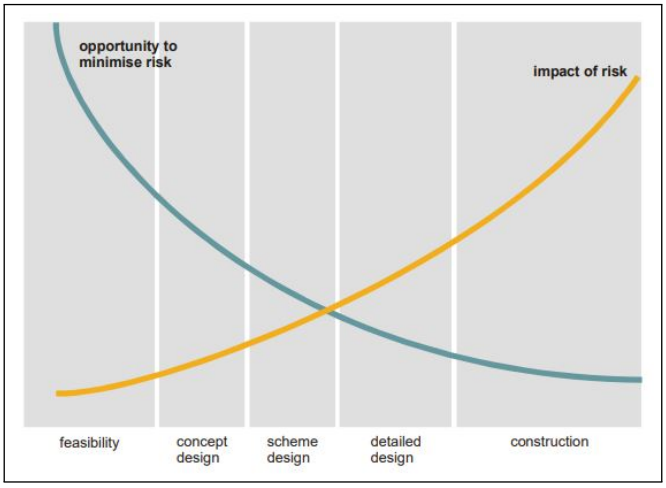

Figure 2: Risk management opportunity at different stages of project cycle
(Source: HKSAR Bureau. "Risk Management for Public Works Risk Management User Manual."https://www.devb.gov.hk/filemanager/technicalcirculars/en/upload/28/2/C-2005-6-0-1-User.pdf)

An EPC contract typically covers project management, site management and supervision, engineering, materials and equipment, civil works, foundation and site infrastructure works, transport and installation, and commissioning, as well as scheduling and performance guarantees for the entire solution [7].EPC contracts will further play a predominant role

in large infrastructure projects in most jurisdictions. Construction Industry research and Information Association (1977) recommends that the risk allocation on conditions of contracts should be based on: a) describing the specific nature of risk and their expected incidence; b) indicating whether they may arise; and c) making provision for liability, should they arise. Casey, 1979 [8] categorizes construction risks into six groups and those groups may be attached to particular type of construction activities.

Construction Risk Factor

1. Construction Delay
2. Change in the Work
3. Availability of Resources
4. Delayed site access
5. Damage to person and Property
6. Late drawings and instructions
7. Defective Design
8. Cost of tests and samples
9. Actual quantity of works

Physical Risk Factor

1. Sub-surface condition of Geology
2. Sub-surface condition of ground water
3. Act of God

Performance Risk Factor

1. Defective work
2. Productivity of equipment
3. Productivity of labor
4. Conduct hindering of work performance
5. Suitability of materials
6. Accidents
7. Labor disputes

Contractual and legal Risk Factor

1. Delayed dispute resolution
2. Change order negotiations
3. Delayed payments on contract and extras
4. Insolvency of contractor or owner

Financial and Economic Risk Factor

1. Inflation
2. Funding
3. National and international impacts (Devaluation)

Political and Society Risk Factor

1. Environmental Issues
2. Regulations (safety and labor laws)
3. Public Disorder

Chotchai Chareoenngam, [1] 1999 identified three major construction related risks in hydropower constructions as:

1. Construction delays;
2. Change in the work and
3. Sub-surface conditions of geology

Benyamin, 2016 [7] identifies 26 identical recurring risks which are grouped in four internal and four external groups and suggests the mitigation measures for each group of risks. The authors also measured the effectiveness of proposed strategies of risk management through statistical means to compare between Owner's and Contractor's perception. The Author suggests implementing FEED before bid, extensive clarification meetings between project participants, providing comprehensive project definition package through RFP, adding provision in contractor to over of unpredictable fluctuation by the Owner, and right selecting of contractor are the most prominent risk management strategies for recurring risks in EPC Contracts.

Bilal Ayub, 2016 [9] identifies 50 risks in EPC hydropower projects, rank them as per their significance and identifies the most severe risks as sub-contractor's performance followed by local population resistance. Li (2012) identified the major risks in hydropower projects with EPC Contracts in Vietnam as the financial and environmental risks that had significant impact on the progress of the project. Sy Hung Mai, 2019 [10] has taken into consideration of some relevant experience in EPC Contracts and with thirty years older of the respondent. The authors identified 21 risks in 7 groups in EPC hydropower construction in developing countries of Asia. R A. Bahamid, 2019 [11] identified the 57 mostly affecting risks factors for construction projects in developing countries from 45 previous publications.

Shrestha, 2008 [12] identified the risks in hydropower projects in Nepal as:

- Foreign exchange risk
- Repatriation risk
- Sovereign risk (country risk)
- Interest risk
- Inflation risk
- Legislative change risk
- Market risk
- Revenue risk
- Payment risk
- Construction risk
- Hydrological risk

The list of risks identified form study of relevant literatures and the final list of risks after expert's interview and suggestions is presented in following Risk groups

Construction related risks

1. Changes in work,
2. Availability of resources,
3. Delay in possession of site,
4. Defective works,
5. Poor quality of works,
6. Incapability of sub contractor,
7. Construction delays,
8. Difficulty in transportation of goods,

Physical Risks

1. Risk of Sub-surface Geology,
2. Risk of Groundwater,
3. Force Majeure (Act of God) events

Contractual Risks

1. Unclear and ambiguities in the Contract,
2. Defaults of either parties (Employer/ Contractor),

3. Delayed payments by the Employer,
4. Contractor not familiar with the requirements of EPC contracts,
5. Insufficient feasibility, inadequate and inaccurate investigations,
6. Major errors in Employer's requirements,
7. Disputes not settled at time

Financial/Economic Risks

1. Inflation,
2. Uncertainty of project fund,
3. Devaluation of money/ exchange rate risk,
4. Changes in taxes,
5. Adverse change in interest rate,
6. Low Financial capability of contractor,
7. unbalanced and unrealastic payment milestones,

Political Risks

1. Changes in law and regulations,
2. Drastic change in policy and shifting of government priority

Design Risks

1. Design changes,
2. Contractor not familiarization with codes and standards,
3. Defective design

Socio-environmental risks

1. Disputes in land acquisition,
2. Obstructions by the Public,
3. Environmental issues,
4. Safety and security

Planning and Performcane Risks

1. Low productivity of equipment,
2. low productivity of labours,
3. Accidents,
4. Unrealistic plans,
5. Poor monitoring team,
6. Poor coordination and management of EPC contractor,
7. Performance criteria not achieved

Other risks

1. Delay in obtaining permits,
2. Employers restriction for innovation by contractor in design and methodology meeting the performance criteria,
3. Problem in obtaining work permit for foreign manpower,
4. Delay in Custom clearances,
5. Technological risks

3. Methodology

The methodology of research is qualitative. The study focuses on the Rasuwagadhi Hydro-electric Project (111 MW), Middle Bhotekoshi Hydro-electric Project (102 MW), Trishuli 3B Hydro-electric Project (37 MW) and Nyadi Hydro-electric Project (30 MW).

The data collection for this research is done through qualitative approach. As the research is subject to the detailed analysis of contract documents, inputs from the relevant person from the Employer, the Employer's Representative and Contractor were used during this study. The primary data was collected from the questionnaire survey, Expert's interview and key informant interviews and the secondary data is collected from the study of contract documents of respective projects, standard forms of contracts adopted by the projects, the guide to contracts published by the FIDIC [13], research articles, books, journals and national news papers, previous researches in NEC CPS [14] library etc.

The methodology of this research is as follows in chronological order:

1. Identification of research problem,
2. Identify relevant risks in hydropower sectors with EPC contracts from relevant literature and suggestions from the Experts' of relevant fields.
3. Prepare questionnaires
4. Float the questionnaires to Employer, Contractor, Engineer (Consultant) with due consideration to the experience in EPC contracts and education level of the respondents.
5. The respondent shall choose, impact, probability and allocation of risks of each risks.
6. Calculation of risk score of each risks from probability and impact of the risks.
7. Identify the risks allocations in hydropower with EPC contracts in Nepal from key informant interview and study of contract documents.
8. Identification of risk management measures from questionnaire survey and expert's suggestions.

3.1 Research Approach

The approach of this research is qualitative and quantitative. The primary data for this research was collected from the questionnaire survey to the Employer's personnel, Engineer's (consultant) personnel and Contactor's personnel, Experts' interview and Key Informant Interviews (KII).

3.2 Study Area

There are many hydropower projects under construction, operation and under study phase in Nepal. Those projects follow different types of contracts for construction. This study

Figure 3: Study Area
Map source http://ncthakur.itgo.com/map15.htm

is conducted with selected projects with EPC/turnkey contracts due to time and budget constraints. The four projects have been selected for this study which location is shown in Figure 3.

3.3 Study Population

The population for this research is the all-qualified personnel from each selected hydropower projects. The under-construction hydropower projects has adequate numbers of Respondents from Employer/Employer's Representative and Contractor side whereas there are few Respondents from the Contractor and Employer's Representative in operating projects as shown in Table 1.

Table 1: Study Population

S.N.	Project	Employer	Contractor	Employer's Representative / Consultant	Total
1	Rasuwagadhi HEP	10	5	6	21
2	Middle Bhotekoshi HEP	8	4	6	18
3	Upper Trishuli 3B	10	4	3	17
4	Nyadi HEP	8	2	8	18
	Total				**74**

3.4 Sample Size

As the population is finite, the whole population has been taken for this study.

3.5 Data Collection

As the research is qualitative in nature, the primary data for this research is collected from the questionnaires survey of personnel involved in the selected projects and expert's interview. The secondary data is collected from the contract documents of respective projects, FIDIC documents, progress reports, other research articles and publications related to this type of research, text books and records related to the projects.

3.6 Primary Data Collection

Experts Interview:The risks identified from the past researches have been finalized with the outcome of interview with the experts of respective field. The all risks listed were filtered and some new risks were included by experts.

Questionnaire Survey :After completion of experts interview, the risks were discussed with the supervisor to finalize and grouped them. The list of 46 risks grouped into 9 groups were proceeded for study, the questionnaire survey was conducted to determine the impacts, probability and possible management measures. The questionnaire survey was focused on the personnel from Employer, Employer's Representative and Contractor. The questionnaires were sent through emails or interview was conducted to collect the data. The questions were same for all Respondents to reduce the bias of the interviewer.

Key Informant Interview : The KII was carried out to find out the allocation of risks to Employer, Contractor, shared risks, third party or not clear allocation of risks in EPC contracts. The key KII was conducted with Project Managers, Contract experts or Consultant higher level personnel of respective projects.

3.7 Secondary Data Collection

The Secondary data collection for this research was done through the publications, journals, research articles, past thesis from NEC CPS library, FIDIC documents, books etc. The list of risks were collected from the past research articles and FIDIC documents before consultation with experts for finalization of list of risks for study.

3.8 Questionnaire Design

Section 1: General information: This section aims to obtain the general information of the respondents through following questions:

a) Respondent full name:
b) Name of project involved:
c) Role from:
d) General experience:
e) Experience in EPC contracts

Section 2: Risk Assessment: This section aims to obtain the risk scores from probability and impact of each risks. The responded were requested to choose the probability of risk ranging from "extremely unlikely" to "extremely likely" for each risks and impacts ranging from "insignificant impact" to "severe impact" with the help of 5 point likert's scale.

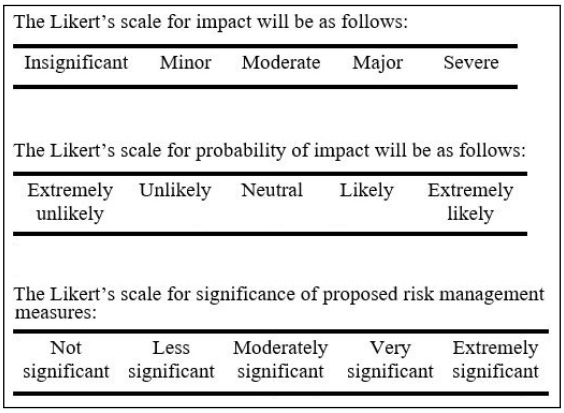

Figure 4: Standard Likert scale

Section 3: Possible Risk Management measures The separate set of questionnaires were prepared to find the allocation of risks. This questionnaire was distributed with the KII to figure out the allocation of the risks.

3.9 Questionnaire Distribution

The questionnaires were distributed to the Respondents from the Employer, Employer's Representative and Contractor of

selected projects. The questionnaire of risk allocation was distributed to the KII. The questionnaire was prepared in Google forms, email and hard copy. The questionnaires were distributed to total of 74 personnel which is composed of 36 professionals from Employer, 15 from Contractor and 23 from Employer's Representative.

3.10 Validity and Reliability of the research

The validity of research can be explained as an extent at which requirements of scientific research method have been followed during the process of generating research findings (Anon., 2022).

3.11 Method validity

Chotchai Chareoenngam, 1999 [6] had identified the risks with groups from the previous literature and the significance of those risks have been identified in hydropower construction in Taiwan with the help of questionnaire survey. Benyamin Sadeghi, 2016 [15] had identified 26 most recurring risks from extensive literature review and consultation with the experts with extensive experience in PEC contracts. Author classified those risks into groups and evaluated the effectiveness of the risk response strategies through questionnaires. Bilal Ayub, 2016 [9] had identified the 50 risks from 16 literatures and classified into 9 groups.The probability and impact of each risks was identified through the questionnaire survey with the Engineers, Managers, Contract/Procurement Personnel, Designers and Contractors and Employers.

3.12 Result validity

Comparison with other research results Chotchai Chareoenngam, 1999 [6] has identified the most three significant risks as Sub-surface conditions of geology, Construction delay and Changes in the work.Benyamin Sadeghi, 2016 [15] has identified the suing experienced contractual experts to write clear contract clauses and attention and accuracy in selecting and evaluation of contractor as "very high" effectiveness for risk response.The top 3 significant risks identified from this study are:

1. Risk of subsurface geology
2. Force majeure (Act of God) events
3. Construction delays.

Comparison with actual scenario of projects Rasuwagadhi HEP has faced the risk of subsurface geology, especially in tailrace tunnel which hampered the progress of construction significantly. The average progress of tailrace tunnel excavation was less than 1m per day. The slope stability on powerhouse area was a serious problem in Trishuli 3B HEP and had effected the project significantly. The variation in predicted versus actual rock class has found significant in all construction projects. Majority of projects under study are suffering from the huge amount of time overrun. The earthquake and floods had huge impact on the Rasuwagadhi and Bhotekoshi hydropower projects; the flood had also entered to the powerhouse of these projects. The "Acts of God" event had serious impact in the project. From the example of these projects the result obtained is reliable in comparison with the actual problem faced by the projects.

3.13 Reliability

Reliability refers to the extent to which the same answers can be obtained using the same instruments more than one time (Anon., 2022) . The reliability test for the obtained data has been evaluated with the help of cronbach's alpha.

3.14 Cronbach'S Alpha

According to (Miller, 2010), Internal consistency is used to measure the consistency of items within a single test form. The formula for cronbach's alpha coefficient is:

$$\alpha = \frac{K}{K-1}\left[1-\left(\frac{\sum \sigma_k^2}{\sigma_{\text{total}}^2}\right)\right]$$

where,

K is the number of items,

$\sum \sigma_k^2$ is the sum of the k item score variances, and

σ_{total}^2 is the variance of scores on the total measurement.

According to Ritter, 2010 [16] it is interpreted based on the level of reliability as follows:

- 0 to 0.19: less reliable
- 0.20 to 0.39: rather reliable
- 0.40 to 0.59: quite reliable
- 0.60 to 0.79: reliable
- 0.80 to 1.00: very reliable

The cronbach's alpha calculated for probability is 0.95 and for impact is 0.95 respectively, which is above 0.90 and it is considered as excellent internal consistency and the data is reliable. Thus the data can be used for further analysis for this research. The cronbach's alpha calculated for risk management measures is 0.89 which is above 0.80 and it is considered as reliable internal consistency.

3.15 Data Processing and Analysis

The data obtained from the questionnaire survey was entered in MS Excel & SPSS Software. The data obtained from the respondent was processed to separate the probability and impacts for each questionnaires. The responses of management measures are also separated. The respondents has chosen the probability of each risks ranging from "Extremely unlikely" to "Extremely likely" and the impacts from "Insignificant impact" to "Severe impacts". After completion of reliability test, the data obtained was found to be reliable. The risk score will be calculated as suggested by Bilal Ayub, 2016 as follows:

Risk Score (R) = Risk Impact (I) × Probability (P)

Where probability (P) and impact (I) are the weighted average values of all respondents calculated from relative importance index.

3.16 Relative Important Index (RII)

$RII = \sum W/(A \times N)$

$A \times N = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5\times N}$

Where,
W is the weighting given to each factor by the respondent, ranging from 1 to 5, (n_1 = number of respondents for strongly disagree, n_2 = number of respondents for disagree, n_3 = number of respondents for neutral, n_4 = number of respondents for agree, n_5 = number of respondents for strongly agree). A is the highest weight (i.e., 5) and N is the total number of samples.

3.17 Spearman's Rank Order Correlation

The correlation coefficient $\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$

Where, ρ = correlation coefficient
$\sum d_i^2$ = difference between two ranks of each observation
n = number of observations

The spearman rank order correlation was calculated between "the Parties" in EPC contracts to examine the views.

4. Data Analysis,Results and discussion

4.1 Responses to Questionnaire

The response rate show in Table 2 is the rate of respondents to whom the questionnaire has been floated. The questionnaire was sent to 74 number of respondents where only 62 number of respondents responded and response from 2 respondents was not valid. The total 60 number of valid respondents has been taken for further study.

Table 2: Response rate of The parties

Category	**Response rate**
Employer	86.11%
Contractor	73.33%
Employer's Representative / Consultant	86.96%
Overall	83.78%

The mean response rate from the Employer's personnel is 86.11 %, response rate from Employer's Representative personnel is 86.96 % and response rate from Contractor's personnel is 73.33 % for all projects. The overall response rate for this research is 83.78 %.

4.2 Correlation of Responses for probability and impact

As shown in Table 3 the correlation between the parties about their views is found to be significant.

Table 3: Correlation Coefficient between parties

Correlation coefficient	r (1,2)	r (1,3)	r (2,3)
Probability	0.76	0.78	0.85
Impact	0.77	0.75	0.84

Where,
r (1,2) = correlation between Employer and Contractor
r (1,3) = correlation between Employer and Consultant
r (2,3) = correlation between Contractor and Consultant

The correlation coefficient calculated for different groups between, Employer, Contractor and Consultant is more than 0.70, so the views of them is relatable to each other's.

4.3 Hypothesis testing using p-value

Hypothesis was established to further validation of views on probability and impact of three parties using T-statistics (p-value approach). The p-value is significantly lower than 0.05, level of significance in all cases as shown in Table 4. The result confirmed rejection of null hypothesis of no relationship to accept alternative hypothesis of strong relationship between Client, Consultant and Contractor's view.

Table 4: p-value for Probability and Impact

	p-value for	
Parties	Probability	Impact
Employer and Contractor (r1,2)	9.76/10^10	3.03/10^10
Employer and Consultant (r1,3)	8.47/10^11	1.58/10^9
Contractor and Consultant (r2,3)	7.05/10^14	2.3/10^13

4.4 Discussion on Overall Ranking of Risks

The overall ranking of risks suggests the most significant 5 risks as: Risk of Sub surface Geology, Force Majeure (Act of God) events ,Construction delays,Disputes in land acquisition,Delay in possession of site. The result obtained from this research has been compared with the past researches, and seems reliable. (Chotchai Chareoenngam, 1999 has also identified the construction delays and risk of sub surface geology as top 3 risks. Bilal Ayub, 2016 also identified the risk of local population resistance in top 3 risks.

4.5 Risk Allocation

The separate questionnaires were prepared for identification of risk allocation between the parties. The questionnaires were sent to the KII to identify the risk allocations.

Employer's risks and (overall risk ranking):

Delay in possession of site	(5)
Delay payment by the employer	(30)
Uncertainty of project fund	(28)
Changes in tax	(46)
Land acquisition	(4)
Obstruction by public	(6)
Poor monitoring team	(26)

Contractor's risks with (overall risk ranking):

Availability of resources	(15)
Defective works	(27)
Poor quality of works	(13)
Incapability of Sub contractor	(10)
Construction delay	(3)
Contractor not familiar with the requirements of EPC contracts	(34)
Insufficient feasibility inadequate and inaccurate investigations	(25)
Major errors in Employer's requirements	(22)
Inflation	(9)
Low financial capacity of contractor	(23)
Unbalanced and unrealistic payment milestones	(17)
Contractor not familiarization with codes and standards	(34)
Defective design	(16)
Safety and security	(19)
Low productivity of equipment	(36)
Low productivity of labours	(29)
Accidents	(41)
Unrealistic plans	(32)
Poor coordination and management of EPC contractor	(11)
Performance criteria not achieved	(14)
Employers restriction for innovation by contractor in design and methodology meeting the performance criteria	(26)

Shared risks overall risk ranking)

Change in work	(43)
Sub surface geology	(1)
Default of either parties	(20)
Risk of Devaluation of money/ exchange rate risk	(7)
Construction delay	(3)

Third party risks (overall risk ranking)

Force Majeure (Act of God) events (2)

4.6 Risk Management Measures

The third section of questionnaires was the possible risk management measures. The respondent had chosen the significance level of proposed risk management measures in Likert's scale from 1 to 5. The top 10 risk management measures are shown in Table 5.

Table 5: Risk Managment Measures

Measures	RII	Rank
Preparation of contract documents by highly experienced and independent personnel	0.913	1
Competent project management team	0.91	2
Conduct sufficient investigations and feasibility study before procurement	0.903	3
Setting the proper qualification criteria of the contractor	0.867	4
Set the qualification criteria of the designer during tendering	0.867	4
Supervision from experienced personnel	0.863	6
Timely payment to the Contractor	0.847	7
Design review by panel of experts from Employer	0.837	8
Purchase land and distribute compensation at once for whole project	0.837	8
Public ownership in project through shares	0.833	10

5. Conclusion and Recommendations

5.1 Conclusion

The study's major conclusions are summed up as follows:

- The 46 risks have been identified from different literature, interview with experts and finalized in consultation with the supervisor and were grouped into 9 groups.
- The top most significant risks in hydropower projects with EPC contracts have been identified as:
  - Risk of sub-surface geology,
  - Force majeure (act of God) events,
  - Construction delays,
  - Disputes in land acquisition,
  - Delay in possession of the site,
  - Obstruction by public,
  - Devaluation of money/exchange rate risk,
  - Disputes not settled at time
  - Inflation, and
  - Incapability of sub-contractor.
- As a part of risk management measure, the risk sharing and allocation is also the one of the most suitable risk management measures.Most significant identified risks are allocated as: "Disputes in land acquisition", "Delay in possession of the site", and "Obstruction by public",have been allocated to the employer, risk of "Construction delays", "Inflation", and "Incapability of sub-contractor" have been allocated to the Contractor whereas "Risks of sub-surface geology" and "Devaluation of money/exchange rate risk" has been shared between the parties. The risk of "force majeure (act of God) events" has been transferred to the other parties.
- The other possible significant risk management measures except risk sharing through allocation were "Preparation of contract documents by highly experienced and independent personnel", "Competent project management team" "Conduct sufficient investigations and feasibility study before procurement", "Setting the proper qualification criteria of the contractor" "Set the qualification criteria of the designer during tendering" etc.

5.2 Recommendations

The following recommendations have been made based on the study:

1. The risk assessment and management of the risks is the important aspect that need to be taken into consideration from the project formulation stage.

2. There exist different unforeseeable risks in Hydropower projects and the risk of unforeseeable geology should be shared by the employer as he is the ultimate beneficiary of the project.
3. The most significant risks identified from this study and the real risks faced by the project are exactly same, those risks have affected the project very significantly, thus for the construction of future Hydropower projects, the risk assessment and management should be studied and implemented as per the risk management strategies before implementing the projects.
4. Better risk management also helps in reducing the project costs and unnecessary loading of the cost by the Contractor in his bid for unforeseeable risks. So, the risk assessment and response are highly recommended for Hydropower projects.

6. Further Research

The limitations of this study area as recommendations for further work.

1. Similar study with other risks not included in this study.
2. Risk assessment for overall hydropower sector in Nepal.
3. Preparation of risk matrix and study of risk response strategy adopted as avoid, transfer, mitigate and accept for each risks and compare with the philosophy of risk matrix.

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