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Risk Assessment Model for Public Private Partnership (PPP) Hydropower Projects of Nepal

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Abstract

Though hydropower is the major sector for implementing Public Private Partnership (PPP) model in infrastructure projects of Nepal, the number of projects under PPP model is very limited due to the risk of failure of Project. To encourage PPP, it is essential to ensure PPP project success through risk assessment prior to any investment to be made. The aim of this research is to develop the risk assessment tool that can provide overall risk rating of project for the different types of risk encountered through different phases of PPP Hydropower project by Analytical Hierarchy Process(AHP).For this, checklist for risk factors was prepared and corresponding weightage was calculated by pairwise comparison .The results shows risk are high in Financial Stage, Contract stage ,Construction and Operation phases where Prefeasibility phase possess less risks and the major five risk factors that affect overall rating are Incompetency of contracting Parties related to PPP ,Inflation ,Unexpected changes in hydrology, Interest rate volatility ,Public Opposition due to high tariff .To test the reliability, tool was tested in Chilime Hydropower Project and satisfactory results were obtained. The research is ultimately aimed at developing a tool that aids in risk assessment of PPP Project within hydropower sector of Nepal.

Keywords

Hydropower, PPP, Project Phase, Risk factors, AHP

1. Introduction

Infrastructure has always been the prominent solution for overall development of the country. Developing countries has always been focusing on Infrastructure development, since only with the development of infrastructure; overall progress of country can be guaranteed. This has also been the case with Nepal and due to huge potential in water resources; more emphasis is given for investments for hydropower development of Nepal. But due to huge investment requirements in hydropower development, government has a limitation to boost such finances on its own .So, to resort that obstacle, an innovative practice called Public-Private Partnership (PPP) model has been encouraged in hydropower sector for past few years.But there are only 39 projects altogether that are defined by PPP Policy 2015 as PPP project in Nepal among which 1 is in distressed state and 34 projects are in Hydropower sector [1]. The reason behind the unsuccessful implementation of PPP modality is the risk of project failure which can cause distress not only to the promoter but also to the lending financing institutions. Thus, proper allocation of risks is must in PPP Hydropower Projects.Without sufficient transfer of appropriate risks from the general public to the private sector, it's unlikely that a PPP project will achieve better value for money than traditional public procurement and delivery.

1.1 Problem Definition

The risks associated with PPP model in Hydropower are diverse and complex in nature and vary for different stage of project life cycle thus Systematic and practical approach for risk management can only successfully assess the diverse and complex type of risks associated with PPP model and can ensure the success of project. Past Studies have only assessed the risk factors in terms of relative importance of common risk factors of specific group but not with risk encountered in different phase of project life cycle and have shown weights of individual risk factors, but have not compare one factor with the others. As risk in different phases of project life cycle are not mutually exclusive events, risks encountered not only impact the project Performance but also influence the other factors, so it is necessary to have pairwise comparisons of the risk factors. Also the risk encountered in different stage of project life cycle are different and also severity of risk also differs for different phases of project, risk assessment need to be done taking consideration of phases of project life cycle. So, it draws attention for in-depth evaluation of the risks related to project as mishandling of any risk threatens sustainability and leads to project failure so, Pairwise comparison of risks starting from prefeasibility phase to transfer phase not only helps to encounter which phase in PPP project life cycle needs better handling ;it also helps to address which risk factors in each cycle have overall and relative influence. Thus, Total Risk Rating(TRR) can be calculated for project before its initiation which inturns helps to mitigate the risk associated with any project or discard the project with the high risk calculated if necesssary.

1.2 Objectives

The primary objective of this study is to develop a risk assessment model for PPP hydropower Projects that aids to quantify overall risk rating of any PPP project. To obtain primary objective, following are the secondary objectives:

1. To identify the risks associated with PPP Hydropower Project in different stage of Project life cycle through

literature review and expert inputs.
2. To prioritize the risk factors and categories on basis of their importance weightage calculated by Analytical Hierarchy Process. (AHP)
3. To generate Total Risk Rating (TRR) Tool by priority values obtained by AHP.

2. Literature Review

The prime step to conduct Risk Assessment Process is the identification of those risks and categorizing the risk into different categories(phases)[2]. Thus here also, first risk factors are to be identified and categorize those risk into different phases of project life cycle. For that ,checklist for risk factors is prepared obtained by comprehensive review of literature. Checklist is prepared by combining the risk factors mentioned in 12 papers which are chosen for the study. Paper on risk assessment of PPP projects of different countries such as UK, China, India, Portugal,Jordan ,Turkey , Saudi Arabia , Nepal are chosen interms of varying economic growth and inclusive purpose.

Singh (2006) classified into risk factors into technical, environmental, social,economic and financial factor forming a defined risk factor framework [3]. Li B (2005)proposed risk assessment to be done in three levels where macro level risks comprise risks external to the project itself and meso level risks include risks occurring within the system boundaries of the project and the risks found in the stakeholder relationships is classified into micro level risks and are classified further according to the sources of risks such as market,natural, construction, etc in the UK [4].

Lemos et al. (2004) studied 2 bridges cases in Lusoponte Portugal and analyses the main risk categories such as Social, Legal, Economic, Environmental, Political and Regulatory and Technological with actual risks encountered and the mitigation measures [5]. Grimsey et al. (2002) analyzed the case study of a waste water treatment facility in Scotland for risk assessment [5]. Wang (2007) classified 50 risks in 6 categories and mitigating measures associated with BOT power projects based on literature review and case studies and then filtered the risks and measures through an unstructured interviews and discussions[6]. Nepal (2021)also classified risk into different nature of risks such as commercial, macro-economic and political risks [1].

From the the study of different papers, it can be observed that mostly risk are divided on basis of source and nature of risk but there are least research carried out for the phasewise risk assessment.Thus in this study, the risks are classified phase wise form Prefeasibility to transfer stage which is complete phase of any PPP project .The risk factors are classified into 8 stages, which include Prefeasibility phase, feasibility study, financing,design, Contract, construction, operation and transfer stage on the basis of probability of risk factors most likely to occur in. With this classification risk factors may be repeated in more than one phase considering the nature of risk.

3. Methodology

As the aim of study is to propose a risk assessment tool for PPP hydropower Projects. The methodology for the research carried out can be summarized in following steps.

1. The risk factors were identified from comprehensive literature review and inputs from the experts.
2. Then, the risk factors were categorized into different phases of project lifecycle and constructing a hierarchy structure for AHP analysis.
3. The risk categories and risk factors were prioritized by computing weightage from pairwise comparison done in AHP.
4. A risk assessment tool was developed.
5. The tool was tested for its performance predictability.

The descriptive methodology is shown in Figure 1.

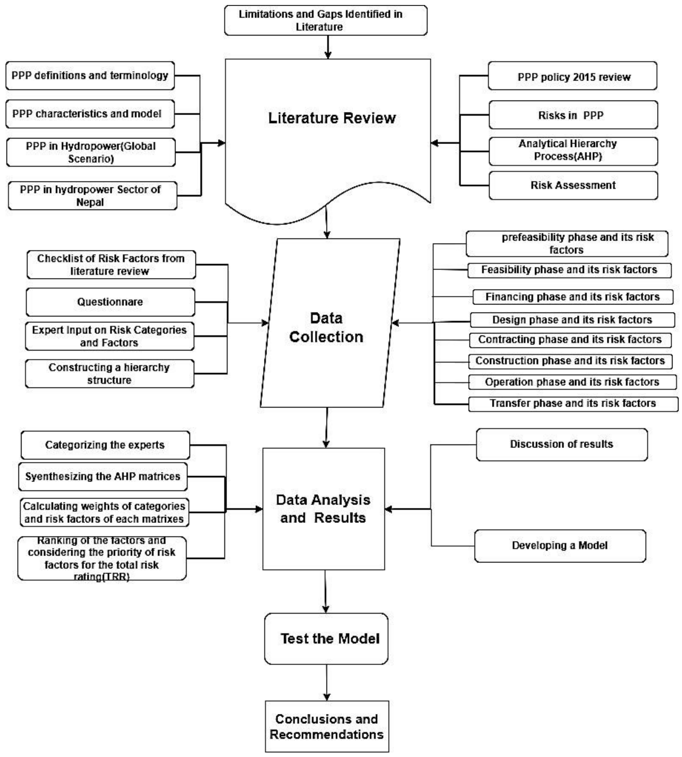

Figure 1: Flowchart for Methodology

3.1 Risk Factor Identification

Risk Factor identification is crucial for Risk Assessment [13]. Here Risk factor Identification was done in two Steps. Firstly, checklist for risk factors was obtained by reviewing the research papers related risk assessment in PPP projects. The checklist of risk factors was prepared from comprehensive study of 12 papers which was mentioned in literature review chapter. Then, the checklist was made available to experts for Delphi interview. Delphi interview was administered survey done with the experts for reliability of questionnaire, output or checklist obtained from literature review. For this research, the expert team of 14 was chosen whose demographic information is provided in Table 2. Experts were presented checklist in form of Google form questionnaire with the option of multiple choice where they were asked to mark those risk factors that are applicable to PPP hydropower projects in Nepal and ignore if felt are not applicable and provided with blank space to add any risk factors missing in the checklist. For sorting the final checklist of risk factors, two round of Delphi process was performed and The

Table 1: Literature Review

Risk Factors	[3] Singh et al.(2006)	[4] Bing et al. (2005)	[7] Lemos et al. (2004)	[8] Grimsey et al. (2002)	[6] Wang et al. (2008)	[2] Akintoye et al. (2021)	[1] Nepal et al. (2021)	[9] Akcay et al. (2021)	[10] Rasheed et al. (2021)	[11] Abdullah et al. (2020)	[12] Osei-Kyei et al. (2017)	[13] Li et al. (2012)
Level of demand								✓	✓			✓
Extreme Weather Conditions								✓	✓	✓	✓	
Public disapproval	✓	✓	✓	✓	✓	✓						
Highly volatile Political environment	✓		✓		✓							
Lack of tradition of private sector		✓	✓		✓							
Risk of not permit/approval	✓	✓	✓		✓	✓		✓	✓			✓
Political Opposition	✓	✓				✓			✓	✓	✓	✓
Exclusivity	✓	✓				✓						✓
Geotechnical conditions	✓							✓	✓			✓
Pre investment Risk	✓		✓			✓						✓
Communication issues between stakeholder	✓	✓			✓	✓			✓		✓	✓
Poor Public Decision Making Process	✓				✓						✓	✓
Credit strength of counter party							✓			✓		✓
Government intervention	✓			✓			✓					✓
Concern relating to global transparency							✓					✓
Exchange rate Mismatch in Revenue & Loan	✓		✓		✓		✓	✓	✓		✓	✓
Inflation								✓	✓	✓	✓	✓
Interest rate								✓	✓	✓	✓	✓
Laws related to taxation and monetary policies	✓		✓				✓					
inappropriate design as per project need	✓	✓	✓	✓		✓			✓	✓	✓	✓
Too many Design Changes	✓	✓	✓			✓			✓	✓		✓
Exclusivity in design												
Design approval delay												
Unproven Engineering Techniques		✓		✓								✓
ownership changes and disputes									✓	✓		
Third party tort liability									✓		✓	
Legislation changes									✓		✓	✓
Incompetency of contracting parties relating to PPP											✓	✓
Contracting authority intervention											✓	✓
Inadequate policies of PPP for Hydropower sector									✓	✓		✓
Policies relating to non-recourse finance										✓		✓
Construction force Majeure Events	✓	✓		✓	✓				✓	✓		
Scarcity of resources							✓		✓	✓		
Poor Workmanship		✓			✓	✓			✓	✓		
Insolvency of contractors		✓			✓	✓			✓			✓
Design Variation							✓		✓	✓		
Contract Variation (cost and time)		✓			✓	✓						✓
Environment Pollution	✓	✓	✓	✓	✓	✓						
Unexpected changes in hydrology							✓					✓
Potential Conflict with other Infrastructure							✓		✓	✓		✓
Unexpected changes in hydrology							✓		✓	✓		✓
Unduly Early Obsolescence due to Technical Advancement							✓					
Revenue Below Expectations	✓	✓	✓	✓	✓	✓		✓	✓		✓	
Operation and Maintenance Cost overrun	✓	✓	✓	✓	✓	✓		✓			✓	
Fluctuating Market Demand	✓	✓	✓	✓	✓	✓						
Public Opposition due to high tariff	✓	✓			✓	✓	✓	✓	✓	✓		
Power market response							✓				✓	
Low Residual Value	✓	✓				✓					✓	
Transmission Failure		✓		✓					✓		✓	
Risk of discontinuation of off-take agreement (PPA)									✓			
Replacement of powers and responsibilities during the transfer							✓				✓	

final checklist of risk factors was prepared with those risk factors that were repeated in both process.

Table 2: The demographic information of the respondents

ID	Sector Position	Experience
Expert 1	Private(Independent Power Producer) Project Manager	12
Expert 2	Private(Energy Sector Assistant Program) Engineer	12
Expert 3	Private(Independent Power Producer) Assistant Manager	10
Expert 4	Private(Independent Power Producer) Project Manager	7
Expert 5	Public(MoEWS) Engineer	16
Expert 6	Private(Independent Power Producer) Project Manager	14
Expert 7	Public(Banking Institution) Head of Department	5
Expert 8	Public(Department of Energy Distribution) Engineer	6
Expert 9	Public (MoEWS) Civil Engineer	7
Expert 10	Private(Independent Power Producer) Mechanical Engineer	8
Expert 11	Public(Nepal Electricity Authority) Civil Engineer	7
Expert 12	Public((Nepal Electricity Authority) Divisional Engineer	7
Expert 13	Public((Nepal Electricity Authority) Divisional Engineer	7
Expert 14	Private(Independent Power Producer) Electrical Engineer	8

3.2 Categorizing the risks into different stages of project life cycle and developing hierarchy structure

This step involved a discussion session with seven experts (a subset of the original fourteen experts with high work experience) to develop a risk matrix that shows the relationships between the risk factors. With the help of these seven experts, the factors were organized in eight project phases of life cycle from prefeasibility phase to transfer phase as seen in hierarchy structure. Following Saaty's (2003) instructions, the risk factors were organized into a network structure that shows the interactions between the factors as shown in Figure 2 [14].

3.3 Prioritizing the risk factors using AHP

For this purpose, another brainstorming session was organized with the same seven experts who participated to the first brainstorming session. A total of 48 pairwise comparisons were made by the experts by using the fundamental scale specified by Saaty (2008) in Table 3 [14]. An example of a comparison matrix for the "Prefeasibility stage " is presented in Table 4. The consistency of the responses was calculated for each stage. This ratio has to be smaller than 0.1 for consistency [14]. The consistency ratios of all clusters satisfied the requirements. Once the 48 comparisons were made, corresponding weightage of each categories and individual weighatage for each risk factors were calculated. Corresponding weightage for risk factors are presented below in Table 5.

Table 3: Fundamental scale of absolute numbers[9]

Scale	Intensity	Description
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	3*Experience and judgments slightly favor one activity over another
3	Moderate importance	
4	Moderate plus	
5	Strong importance	2*Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong	2*An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order
1/2-1/9	Reciprocals of above	If activity i has one of the above numbers then j has the reciprocal value

Table 4: Example for Comparison Matrix for Prefeasibility Stage

Prefeasibility stage risk factors	Level of demand of project	Extreme Weather Conditions	Public Disapproval	Highly Volatile Political Environment	Physical condition of site
Level of demand of project	1	1/5	½	¼	½
Extreme Weather Conditions	5	1	5	1	3
Public Disapproval	2	1/5	1	¼	½
Highly Volatile Political Environment	4	1	4	1	2
Physical condition of site	2	1/3	2	½	1
Total	14	2¾	12 ½	3	7

Consistency check 0.02

3.4 Developing a risk assessment tool

The last step of the study involved developing a risk assessment tool for PPP hydropower investors. Risk Assessment was done by calculating the risk by its priority and quantifying the rating of risk which is known as Total Risk Rating [2]. The total risk rating (TRR) is calculated by considering the priority of each risk factor in equation:

$$\text{TRR} = \sigma P_i \times R_i \quad (1)$$

where,
TRR = Total Risk Rating for any Project and calculated in 0-100 scale (0= no risk in overall project and 100 means highly risked Project)
P_i = Priority of risk factor computed by relative weightage determined by AHP analysis
R_i = Risk Rating of Risk factor which is the potentiality of that risk to occur in the project to be assessed for risk assessment.

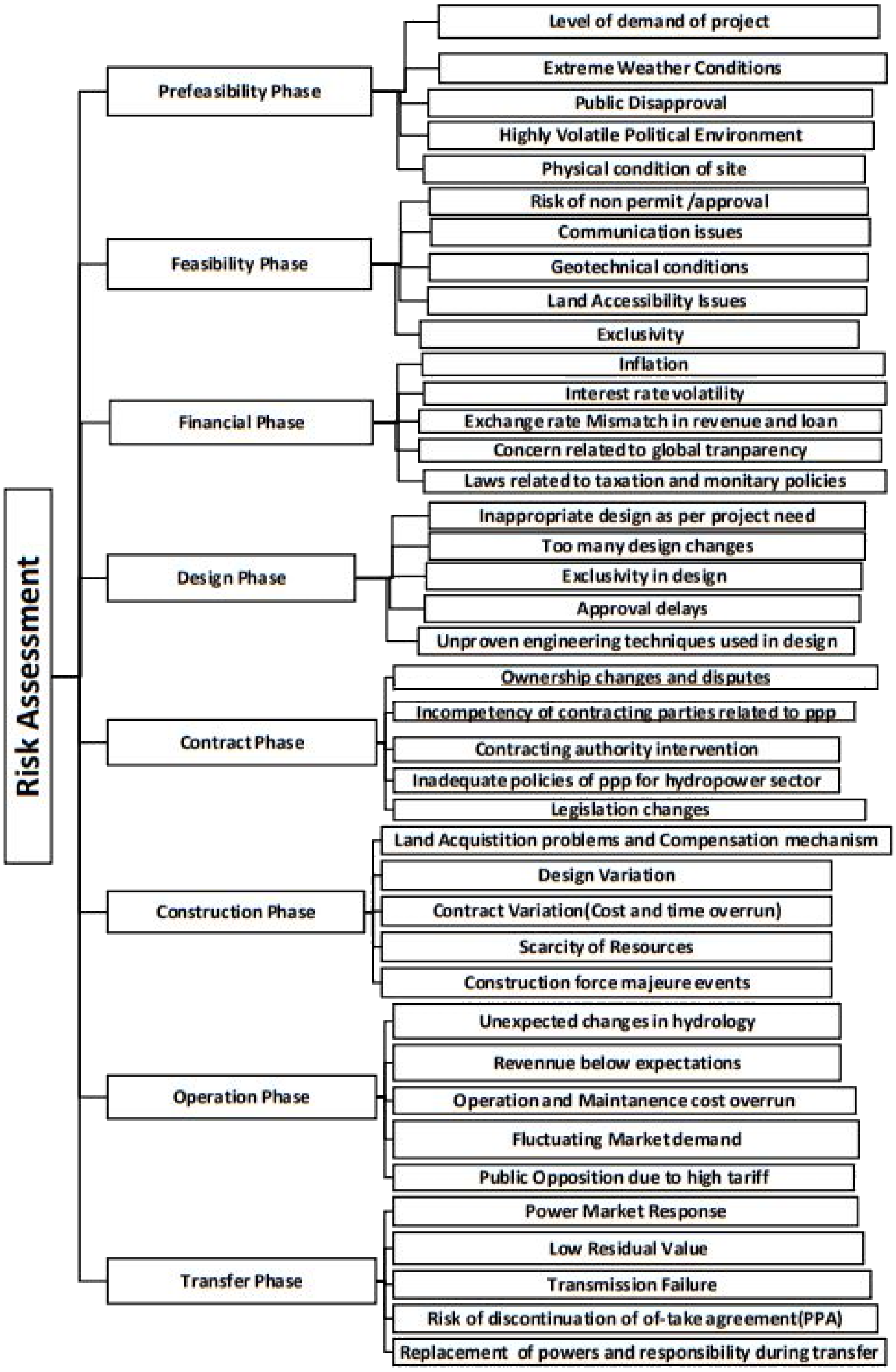

Figure 2: Heirarchy Structure for AHP Analysis)

Risk Rating is done in likert scale of 1 to 5, where 1= No risk 2 = Less Risk 3,4 =Mild to Moderate Risk 5 = Extreme Risk Here, to validate the tool for Risk Rating, Chilime Hydropower Project which is the first PPP Hydropower Project of Nepal. Example for Response 1 is presented to show how risk rating of any project is calculated is shown in Table 5.

Example to calculate Total Risk Rating of Project. The weightage or priority for the risk factor is obtained by the AHP analysis and the rating of project is done in likert scale of 1 to 5. The calculation sheet for Total Risk Rating of Project in terms of Percentage is shown in Table 6.

Table 5: Corresponding weightage for Risk Factors

Categories	Weight	Risk Factors	weight
Prefeasibility Phase	0.05	Level of demand of project	0.228
		Extreme Weather Conditions	0.271
		Public Disapproval	0.199
		Highly Volatile Political Environment	0.158
		Physical condition of site	0.142
Feasibility Phase	0.07	Risk of non-permit /approval	0.288
		Communication issues	0.247
		Geotechnical conditions	0.145
		Land Accessibility Issues	0.174
		Exclusivity	0.151
Financing Phase	0.21	Inflation	0.236
		Interest rate volatility	0.223
		Exchange rate Mismatch in revenue and loan	0.184
		Concern related to global transparency	0.175
		Laws related to taxation and monetary policies	0.184
Design Phase	0.12	Inappropriate design as per project need	0.097
		Too many design changes	0.128
		Exclusivity in design	0.337
		Approval delays	0.201
		Unproven engineering techniques used in design	0.113
Contract Stage	0.18	Ownership changes and disputes	0.245
		Incompetency of contracting parties related to PPP	0.335
		Contracting authority intervention	0.193
		Inadequate policies of PPP for hydropower sector	0.135
		Legislation changes	0.096
Construction Phase	0.13	Land Acquisition problems and Compensation mechanism	0.294
		Design Variation	0.164
		Contract Variation (Cost and time overrun)	0.193
		Scarcity of Resources	0.111
		Construction force majeure events	0.109
Operation Phase	0.15	Unexpected changes in hydrology	0.322
		Revenue below expectations	0.072
		Operation and Maintenance cost overrun	0.092
		Fluctuating Market demand	0.221
		Public Opposition due to high tariff	0.299
Transfer Phase	0.08	Power Market Response	0.172
		Low Residual Value	0.284
		Transmission Failure	0.194
		Risk of discontinuation of of-take agreement(PPA)	0.167
		Replacement of powers and responsibility during transfer	0.189
Total	1		1

Table 6: Calculation of Total Risk Rating for Chilime Hydropower Project

Risk Factors	Weightage	Risk Rating	TRR
Incompetency of contracting parties	0.06	3	0.181
Inflation	0.05	4	0.198
Unexpected changes in hydrology	0.048	4	0.193
Interest rate volatility	0.047	4	0.188
Public Opposition due to high tariff	0.045	3	0.134
Ownership changes and disputes	0.044	3	0.133
Exclusivity in design	0.042	4	0.168
Land Acquistition problems	0.04	5	0.198
Exchange rate Mismatch	0.039	4	0.154
Laws related to taxation	0.039	3	0.116
Concern related to global transparency	0.037	4	0.147
Contracting authority intervention	0.035	4	0.139
Fluctuating Market demand	0.033	3	0.099
Contract Variation	0.026	4	0.104
Design Variation	0.022	5	0.111
Approval delays	0.025	5	0.125
Inadequate policies of ppp	0.024	5	0.121
Low Residual Value	0.022	3	0.067
Risk of non permit /approval	0.021	4	0.084
Scarcity of Resources	0.015	3	0.045
Construction force majeure events	0.015	3	0.044
Communication issues	0.018	3	0.054
Legislation changes	0.017	3	0.052
Too many design changes	0.016	4	0.064
Transmission Failure	0.015	4	0.061
Replacement of powers and responsibility	0.015	3	0.045
Unproven engineering techniques	0.014	3	0.042
Operation and Maintenance cost overrun	0.014	3	0.042
Power Market Response	0.014	3	0.041
Risk of discontinuation of of-take agreement	0.013	3	0.039
Extreme Weather Conditions	0.013	3	0.039
Land Accessibility Issues	0.013	4	0.051
Inappropriate design as per project need	0.012	4	0.048
Exclusivity	0.011	2	0.022
Revenue below expectations	0.011	2	0.022
Level of demand of project	0.011	3	0.032
Geotechnical conditions	0.011	5	0.053
Public Disapproval	0.009	3	0.028
Highly Volatile Political Environment	0.008	5	0.038
Physical condition of site	0.007	4	0.027
TRR of the Project Calculated by Tool			**73**

4. Results and Discussion

As shown in Figure 3, the most important phases of any PPP project are financial ,contract phase which is correct as the modality of PPP project relies on financial accomplishment and how it is managed for the budget deficient issues thus this phase is more risky as inflation ,interest rate changes influences overall monetary status drastically.

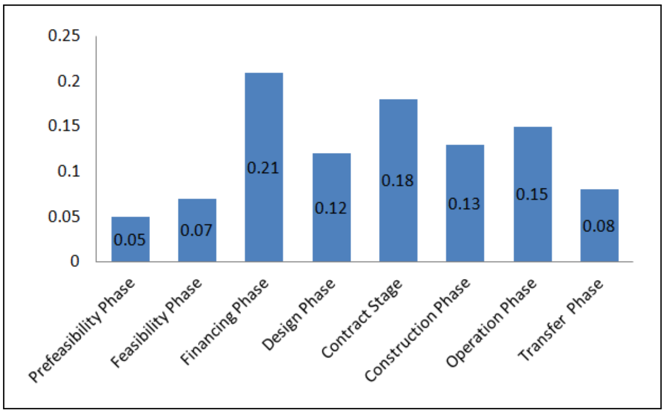

Figure 3: Phases of Project lifecycle with corresponding weightage for risk

Also the modality of PPP project is different than common project, tendering process are also different than normal project. Request for Proposal (RFP) is issued and proceeded for national treasury approval and value for money report is must for tendering process so client might not be qualified enough for PPP tendering process and miss out the most important principle for PPP project which is "value for money".As shown in figure, prefeasibility phase has least rank, the logic behind such is the influence of risks encountered in such phase can be mitigated or avoided as they have least influence on overall project being the the first and last phase of project life cycle.

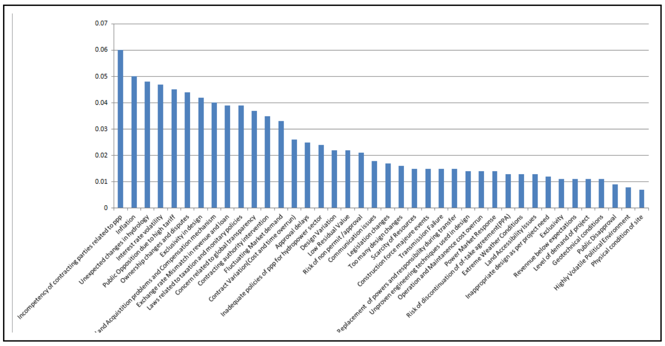

Figure 4: Prioritization of Risk Factors

As shown in Figure 4,the most important risk factor is "Incompetency of contracting parties relating to PPP" which is more likely to occur in contracting phase .This factor hampers overall project as incompetency of public partner results in further incompetent private partner due to lack of qualitative tendering process and inadequate knowledge for PPP policy. This would cause significant delay in construction phase which leads to shorter operation phase which directly affects the revenue guarantee of project.Further second important risk factor was Inflation as the most PPP model Projects are financed by Foreign Investors. As in most cases, the financial risk is shared by private partner and is more responsible than public; issues regarding exchange rate mismatch ,interest rate fluctuation are of major concerns and should be tackled carefully .

As climate change issue is much of a hot concern ,3rd important risk factor is unexpected changes in hydrology which can result in catastrophic situation or in void condition so is the major issue for hydropower related projects . Physical conditions at prefeasibility phase has least importance on the list as these conditions are previously taken into account precisely by qualified geotechnical engineers while making Detail Feasibility Report(DPR) thus is obvious and predictable kind of risk which is most of time mitigated or avoided according to scenario.so this factor has not any unpredictable risk associated that can further harm PPP project.

4.1 Reliability test of Risk Assessment model For testing the performance of the model created first real PPP Hydropower

Project of Nepal i.e Chilime Hydropower Project was chosen as case study .An expert team of six people who are directly involved in project and are engineer and involved in authorizing post. Firstly ,these experts were individually given to rate the each risk factor by using the Likert scale(1-5) taking the considerations for nature of risk. After that ,overall risk rating was determined in scale of 100 by the risk assessment tool created .Secondly ,the experts were asked to assign overall risk rating of project on the basis of their subjective judgments in a group discussion. Thus reliability of tool was determined by calculating the percentage error which have average of 5.1 which is shown in Figure 5. This shows the output provided by tool are consistent with expert judgments thus tool can be reliable as risk assessment tool.

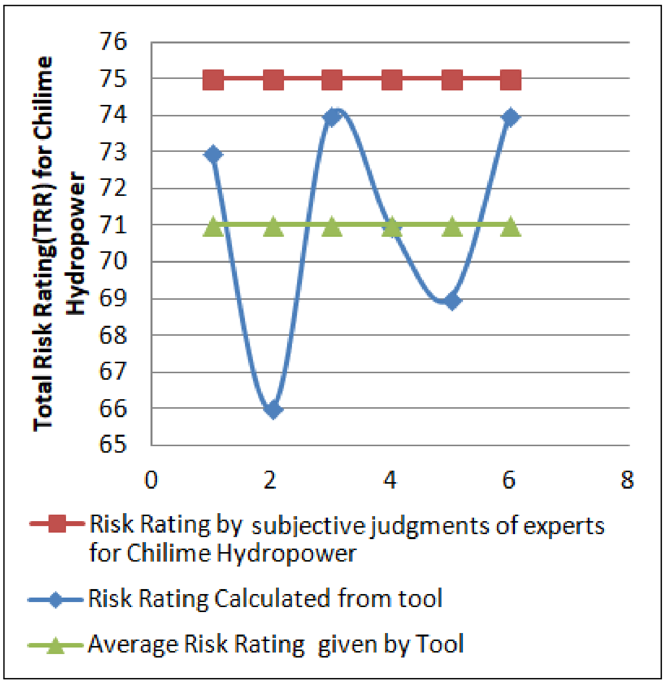

Figure 5: Reliability Test of Tool

5. Conclusion

This paper proposes a Risk assessment tool that can qualitatively quantify the risk encountered in different phases of PPP hydropower project by providing Total Risk Rating of the Project. With this tool, the priorities of risk factors in over all project is determined taking the consideration for the influence of one factor with another. In this study ,risks were first identified and categorized into eight phases where those risks are more likely to occur through extensive literature review and verified by Delphi interview with experts .Then, brainstorming session was organized with experts and hierarchy structure for AHP was constructed to make pairwise comparison and later the input from expert was analyzed. The result presented indicated the phase where risk is more likely to occur is “Financial phase” and most important risk factor is “Incompetency of contracting parties related to PPP. The risk assessment tool created was tested in Chilime hydropower project where average percentage error was found to 5.1

This tool can be used by the developing countries like Nepal who are newly introduced to PPP model and are yet to explore risk associated to PPP and have limited experience for the estimation of risks encountered in different stages of PPP project. This tool can also be a guiding tool for interested investors to acknowledge the risks associated and to plan necessary mitigation measures. It can also be supportive to policy makers for formulating necessary policies for mitigating those prioritized risk factors that influence the project most. The proposed model can also be used to perform the risk assessment of other PPP infrastructural Projects such as road, airports by constructing different hierarchical structure specific to that sector.

References

[1] Achyut Nepal, Vishnu Khanal, and Ruhanita Maelah. Relative importance of risks in hydropower projects and project finance in nepal. *Journal of Advanced Academic Research*, 8(1):1–21, 2021.

[2] Akintola Akintoye, Craig Taylor, and Eamon Fitzgerald. Risk analysis and management of private finance initiative projects. *Engineering Construction and Architectural Management*, 5(1):9–21, 1998.

[3] L Boeing Singh and Satyanarayana N Kalidindi. Traffic revenue risk management through annuity model of ppp road projects in india. *International journal of project management*, 24(7):605–613, 2006.

[4] Li Bing, Akintola Akintoye, Peter J Edwards, and Cliff Hardcastle. The allocation of risk in ppp/pfi construction projects in the uk. *International Journal of project management*, 23(1):25–35, 2005.

[5] Kadir Kuru and Deniz Artan. A canvas model for risk assessment and performance estimation in public–private partnerships. *International Journal of Construction Management*, 20(6):704–719, 2020.

[6] Ying-Ming Wang, Ying Luo, and Zhongsheng Hua. On the extent analysis method for fuzzy ahp and its applications. *European journal of operational research*, 186(2):735–747, 2008.

[7] Maria Carmen Lemos and João Lúcio Farias De Oliveira. Can water reform survive politics? institutional change and river basin management in ceará, northeast brazil. *World development*, 32(12):2121–2137, 2004.

[8] Darrin Grimsey and Mervyn K Lewis. Evaluating the risks of public private partnerships for infrastructure projects. *International journal of project management*, 20(2):107–118, 2002.

[9] Emre Caner Akcay. An analytic network process based risk assessment model for ppp hydropower investments. *Journal of Civil Engineering and Management*, 27(4):268–277, 2021.

[10] Abdulkarim Hasan Rashed and Afzal Shah. The role of private sector in the implementation of sustainable development goals. *Environment, Development and Sustainability*, 23:2931–2948, 2021.

[11] Aminah Abdullah and Iqbal Khadaroo. The trust-control nexus in public private partnership (ppp) contracts. *Journal of Accounting and Public Policy*, 39(6):106768, 2020.

[12] Robert Osei-Kyei, Albert PC Chan, Arshad Ali Javed, and Ernest Effah Ameyaw. Critical success criteria for public-private partnership projects: international experts’ opinion. *International Journal of Strategic Property Management*, 21(1):87–100, 2017.

[13] Jie Li and Patrick Zou. Risk identification and assessment in ppp infrastructure projects using fuzzy analytical hierarchy process and life-cycle methodology. *Construction economics and building*, 8(1):34–48, 2008.

[14] Thomas L Saaty. How to make a decision: the analytic hierarchy process. *European journal of operational research*, 48(1):9–26, 1990.