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Risk Analysis In Road Construction Using Failure Mode And Effect Analysis

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Abstract

Risk management is defined as process of identification of risk factors, their assessment as well as prioritization of risks along with economical application of resources to minimize and control the occurrence of the risk events. The overall aim of this study is to analyze the practice of risk management, significant risk factors and its ranking in road construction in Sindhupal chowk district with the perspective of global pandemic of coronavirus disease (COVID-19).

This research is conducted through questionnaire survey to collect the primary data. Response obtained from respondents is rated on a 5 point Likert scale and analyzed through MS Excel. The data are analyzed to find out mean and ranking of each risk factors for the severity of risk based on FMEA model regarding their probability of occurrence, its consequence and its detectability.

Major risk factors based on risk priority number are time overrun risk, Safety Health and Environmental risk, cost overrun risk, financial and economic risk, force majeure and ecological risk, political legal and social risk, organizational risk, contractual risk, quality risk and design and specification risk in descending order of risk severity.

Keywords: Risk Management Practice, Risk Occurrence, Risk Consequences, Risk Detectability, FMEA, Risk Identification, Risk Assessment, Risk Response.

1. Introduction

1.1 Background

Risk management is defined as process of identification of risk factors, their assessment as well as prioritization of risks along with economical application of resources to minimize and control the occurrence of the risk events. Risk management activities is set of coordinated activities that directs an organization in response to the risk events (ISO 31000). Themain goal of risk management is to ensure that uncertainties do not deviate the project as per planned output.

Risk management is an ongoing process that allows the project manager to take control of project throughout its life cycle and be prepared for the unseen problems that might occur at any

point of project life. Project team needs to establish standard risk management practice from its earliest phase that helps in proper and timely identification of risk and deal with it in an efficient manner. (Petrovic, 2017). This facilitates in clearer understanding of potential risk factors associated with project, detail assessment methods and appropriate response strategy. It also helps to establish well documented historical record that serves as a reference for evaluating future projects.

Risk can be categorized based on its nature, occurrence, severity and many other purposes. Different authors have classified risks based on different categories. PMI (2009) has categorized risk into two broad categories as internal and external risks. As per Alesh in (2001), risk is categorized into numerous categories like market risk, financial risk, political risk, social risk, intellectual property risk and safety risk. Similarly, Ahmed & Dikbas (2013) have categorized risk based on project being local level or international level. The internal risk depends within the constraints of project and is independent of project being local or international level where as external risk depends upon the environment where the project is being constructed and depends on political scenario, social environment, applicable regulations, legal authorities and procedural formalities.

Failure Mode & Effect Analysis (FMEA) is a structured technique which is recognized as one of the most suitable technique to analyze risk factors. FMEA technique was developed by reliability engineers of U.S.A for their army works. But now it is used in several industrial and research fields. In this analysis, each risk is considered as failure mode. Here, risks are prioritized on the basis of Risk Priority Number (RPN). RPN is multiplication of occurrence, consequence and detectability of risk. A risk having higher RPN than others means that it has higher severity and requires more attention for responses than others (Sharma & Trivedi, 2019).

Risk has mainly three components, Occurrence (O), Consequence (C) and Detectability (D). RPN is function of O, C & D i.e. RPN= O×C×D
Risk Occurrence (RO) refers to probability of occurrence of risk factor.
Risk Consequence (RC) refers to impact of occurred risk on objectives of project.
Risk Detectability (RD) refers to likelihood of discovering and correcting a risk event prior to harm occurrence.

1.2 Statement of the Problem

The projects belonging to construction industry is characterized as fragmented and complex activities and procedures that possibly brings upon huge risk exposure. Project team needs real time and reliable information regarding project environment for proper identification of risk and consider systematic approach for risk response strategy. Selection of appropriate risk management standards in very essential to manage risk associated with the project and ensure successful completion of project within its desired quality.

The coronavirus (COVID-19) pandemic has become a global challenge fo rcurrent economy and has huge impact on human life, their society and the global economy as a whole. The characteristics of COVID-19 pandemic has created uncertainty in control over the spread. It is very contagious and challenging to control its spread. Few studies even show that infected people can be asymptomatic as well, limiting the control of COVID-19 through expansion of

testing and isolating capacities. It is not known how long vaccine immunity reliably lasts, thus multiple-wave cannot be ignored for long time. The need to comply with social distancing limits the efficiency of construction works on sites. Under such circumstances, to carry out construction activity as well as ensure safe working environment with effective risk management strategy is a big challenge worldwide.

Risk management determines success and failure of the project. In Nepal, most of the construction company does not make any risk management teamwork before the startup of the construction project. The common practice of risk management is thumb method, common sense, sharp judgment and trial and error method which cannot be considered as scientific method of risk management. So, the aim of this study is to analyze various risk factors and its ranking in road construction project of Sindhupal chowk district, Province 3, Nepal along with COVID-19 perspective.

1.3 Research Objectives

- To analyze risk factors and their ranking at workplace with the perspective of COVID-19 based on Failure Mode and Effect Analysis (FMEA).

1.4 Significance of the Study

The study is significant to draw the attention of construction companies/professionals for better evaluation of risk factors and their management for ensuring project's success. The study is also significant for documenting the risk management practice to make it systematic by identifying significant factors and analyze the impact of risk management practice on success of urban road construction projects as well as other construction projects.

2. Literature Review

The construction industry, with the development of science and technology has modified rapidly over the past condition within a decade. Construction firm are facing more risks and uncertainties as compared to past events. The expectation of owner has increased to more and more safe working environment and surety towards deliverables yet contractors are facing high risk event and their occurrence. Risk management has thus, become major highlight of the construction firms for any construction projects. Risk in construction industry is major focus topic in current time as time and cost overrun within the construction projects has become high impact risk factors.

2.1 Risk Management Practice

Mishra & Malik (2017) in their paper "Factor and impact of risk management practices on success of construction project of housing developers, Kathmandu Nepal" concluded that major risk factors in housing construction projects in Kathmandu valley were time over run risk, project scope risk, financial risk, economic risk, organization risk, leadership risk and safety and health risk.

The research also concluded that independent variables of risk management process (identification of risk, assessment of risk and risk response) had significant impact on eight out of ten project success criteria viz. well defined project scope, compliance to technical requirements, project within planned budget, compliance with the quality standard, project within schedule, controlled financial & economic risk, compliance to safety health and environmental

requirements, overcome leadership risks. The independent variables had no impact on two out of ten success criteria viz. overcoming contractual risks and controlled organizational risk. Hence, it was concluded that risk management practice has significant impact in the success of project.

Adhikari and Mishra (2020) in their paper "Urban Road Construction Risk Management", risk factors were investigated to measure the severity and allocation. Based on the contractor's perspective, land acquisition delay-shared with client, strike-avoided, payment problem-accepted by contractor, cash flow problem-transferred to client and corruption-avoided were identified as high risk factors with allocation. Based on client's perspective, most severe risks and their allocation were land acquisition delay-shared with contractor, strike-avoided, payment problem-shared with contractor, cash flow problem-accepted by client and corruption-avoided.

2.2 FEMA Model

Sharma &T rivedi (2019) in their paper "Risk Analysis in Highway Construction Projects using Failure Mode & Effect Analysis" adopted FMEA model for ranking the risk factors and determine the major risk factor that needs specialized attention. Questionnaire Survey was carried out to find Occurrence, Consequence and Detectability of each risk factor in terms of linguistic terms "Very High, High, Medium, Low& Very Low" and with the help of highway construction experts assigned crisp rating from 5 to 1 respectively. Risk factors were ranked based on Risk Priority Number(RPN) which was the product of Occurrence, Consequence and Detectability. FMEA table was designed in the last step of research which showed not only the rank of risk factor but also to whom risk should be allocated and which type of response should be given to each risk factor. In this research it was concluded that risk should be allocated to either clients or contractors or consultants related to project. It was clear from FMEA table that about 90% risks were allocated to contractors, so contractors were the most risks affected among project related parties.

2.3 Coronavirus Disease (COVID-19)

Mishra (2020) in his paper "Maintaining Productivity and Safety during COVID-19" has focused on the importance of safety in construction industry and its influence on productivity of construction project. Corona virus disease first appeared in Hubei, China in January 2020. Due to rapid spreading and lack of vaccine to treat the disease, WHO declared COVID-19 pandemic on 11th March, 2020. This pandemic has affected entire world economics and construction industry is not exceptional. This paper highlights the effects of corona virus disease in work site and suggests following measures of control as:

a) Elimination/ Substitution: Working remotely, Virtual meetings, online trainings.
b) Engineering Control: Isolation, Installation of physical Barriers.
c) Administrative Control: Awareness/ Training, Posture/Sign/Symbol/Signage.
d) PPEs: Safety Gloves/Mask/Googles/Face Shield, Safety Shoes/boots, Apron.

The study concludes that ensuring workplace safe from corona virus disease is a challenge and thus proper preparatory actions must be undertaken before resuming works.

3 Methodology

The study summarizes various risk factors and ranks them based on risk priority number as per FMEA Model. It also analyzes the impact of risk management practice on success of road construction projects.

3.1 Study Area

The study is conducted at various areas of Sindhupal chowk district, Province 3, Nepal. Many studies have been conducted at central valley on nation however such research have been lacking in other areas. Geology of Sindhupal chowk is characterized by loose soil, frequent large scale landslides and flood like Jure Landslide and Melamchi Flood. With a total death count of 156, Jure landslide was one of the devastating landslides in history of Nepal. The reach of landslide was 1.26 km height and 0.81 km width at the bottom. Along with other destruction of infrastructures, it created a 55 m-high dam in the Sunkoshi River with the potential to cause huge flood and destruction. For construction of roads, hilly region with such land characteristics induces huge amount of risk which is the main region for selecting Sindhupal chowk district as the study area.

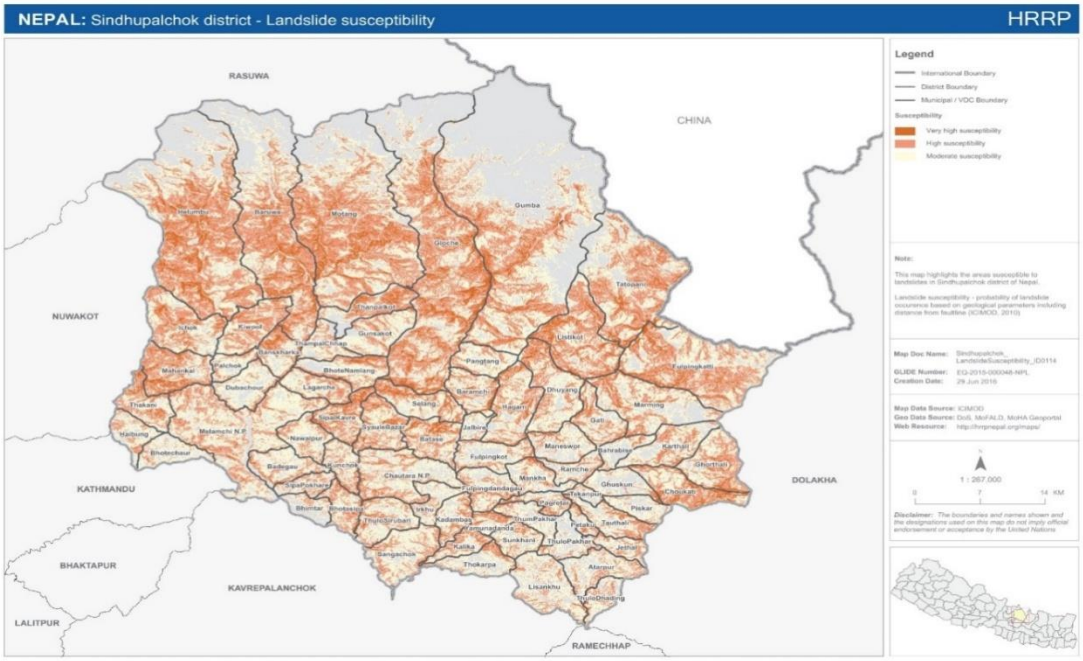

Fig. 3.1Landslide Susceptibility of Sindhupalchowk District

The selected road projects are: -

- "Construction of Black Top of Sukute-Chapagaun-Meldanda-Thokarpa-Bhanjyang Road, Sindhupal chowk (Contract No: -DROCHT/3371234/073/74-191)". The Employer is Ministry of Physical Infrastructure Development, Provincial Road Division Office, Khurkot and the Contractor is GauriparbatiNirmanSewa Pvt. Ltd. The total length of roadway construction is10.5 KM with estimated cost of 415.24 million rupees.
- "Construction of Black Top of Barabise-Thotanaari-Ratamate-Chulthidamar-Ghunde-Om Park Road, Sindhupalchowk (Contract No:- DROCHT/3371234/073/074-192)". The Employer is Ministry of Physical Infrastructure Development, Provincial Road Division Office, Khurkot and the contractoris Lumbini/ Bandan Bhagwati/ Dragon JV. Total length of roadway to be construction is 8 KM with an estimated cost of 475.35 million rupees.
- "Construction of Black Top Work of Filmcity Access Road, Dolakha (Contract No: -DROCHT/3371234/073/074-123)". The Employer is Ministry of Physical Infrastructure Development, Provincial Road Division Office, Khurkot and the Contractor is M/s Lama

Construction and Suppliers Pvt. Ltd. The total length of roadway construction is 6 KM with estimated cost of 113.97 million rupees.

- "Widening and Upgrading of Khagdal-Kukure-Kalleri-Sigarche Road, Sindhupal chowk (Contract No: - DROCHT/3371234/073/74-194)". The Employer is Ministry of Physical Infrastructure Development, Provincial Road Division Office, Khurkot and the Contractor is Rautaha/Himali Devdhunga/Om Buddha J.V. The total length of roadway construction is 4.5 KM with estimated cost of 153.18 million rupees (Gain et al, 2022; Gain and Mishra, 2021).

3.2 Study Population

For this research, study population are technical staffs of Ministry of Physical Infrastructure Development, Provincial Road Division Office, Khurkot, consulting firms, engineers, technical staffs of contractor working in road construction projects at Sindhupal chowk district.

3.3 Sample Size

Sample is part of population chosen for the purpose of study. Sample of smaller size may not accurately portray the actual site condition whereas very large sample size though gives better result may be way beyond time and budget constraints. Thus sample size of 30 is chosen for this study based on budget constraints and time available to conduct the research.

3.1 Data Collection

Data is collected from primary and secondary source which are both qualitative and quantitative to analyze the risk management practice adopted at Sindhupal chowk district, Province 3, Nepal.

3.1.1 Primary Data

The primary data for the study was obtained by:

a) Key Informant Interview: To find out the managerial aspects, planning aspects, construction safety plan adopted, project in-charge and project manager will be interviewed.
b) Questionnaire Survey: A simple set of questions will be prepared regarding hazard and risk associated with the construction project.
c) Field Observation: Field visit will be done for visual assessment of the construction procedure.

3.1.2 Secondary Data

The secondary data were collected through detailed engineering project design report, published journals, published articles, different websites and existing legal provisions from concerned regulatory departments.

3.2 Data Analysis

A. To analyze risk factors and their severity at workplace based on Failure Mode and Effect Analysis (FMEA).

The analysis of data is done to rank the risk factors based on its severity in urban road construction project. As per FMEA model following steps will be carried out.

Step 1: Identification of Risk Factors

Risk Factors is identified through literature review and discussion with highway construction experts. Questionnaire survey is performed to obtain rating in Likert Scale for Risk Occurrence (RO), Risk Consequence (RC) and Risk Detectability (RD). Likert rating will be in the scale of 1 to 5 where "1 means Very Low probability, 2 means Low probability, 3 means Medium probability, 4 means High probability and 5 means Very High probability".

Table 3.1 Linguistic Definition for Numerical Rating

Rating	Linguistic Term	Linguistic Definition	
5	Very High	RO	Risk has high certainty of occurrence.
		RC	Extreme consequences, unable to meet project goal.
		RD	Very less chances of discovering risk prior it does any harm.
4	High	RO	Risk is expected to occur.
		RC	Major consequences affecting most part of project goal.
		RD	Less chances of discovering risk prior it does any harm.
3	Medium	RO	Risk may occur.
		RC	Medium consequences, affecting small part of project output.
		RD	Medium chances of discovering risk prior it does any harm.
2	Low	RO	Risk is unlikely to occur.
		RC	Few consequences, project outputs are slightly affected.
		RD	Good chances of risk to be detected prior it does any harm.
1	Very Low	RO	Risk is highly unlikely to occur.
		RC	Negligible consequences, project outputs are met.
		RD	Very high chances of discovering risk prior it does any harm.

Step 2: Index calculation based on Relative Importance Index (RII) Method

As per RII concept ROI, RCI & RDI of each risk factor is calculated using following formulas.

Risk Occurrence Index (ROI) = $\frac{\sum W}{A * N}$

Risk Consequence Index (RCI) = $\frac{\sum W}{A * N}$

Risk Detectability Index (RDI) = $\frac{\sum W}{A * N}$

Where, ∑W= Sum of responses i.e. sum of crisp rating of factor given by respondents,

A = Maximum value of crisp rating which is 5

N = No. of respondents

Step 3: RPN Calculation

Risk Priority Number (RPN) is multiplication of Risk Occurrence, Risk Consequence and Risk Detectability. In this research ROI, RCI and RDI are calculated using relative importance index

formula. Values of ROI, RCI and RDI are less than one, so the multiplication of ROI, RCI and RDI will be in decimal. To understand and compare the RPN of different-different risk events, resulted multiplication of ROI, RCI, RDI is multiplied by 100. Thus proposed formula to calculate RPN is-

RPN= ROI×RCI×RDI×100

Step 4: Ranking of Risk Factors

After calculating RPN of each risk factor using above formula, to determine the severity of Risk Factors, its ranking is done on the basis of Risk Priority Number (RPN) of risk factors. Higher the RPN, Higher the Risk. Thus Ranking of Risk Factors will be done as per decreasing order of RPN in such a way that the rank of maximum RPN is one with highest severity. (Sharma & Trivedi, 2019).

❖ **Reliability Test:**

Cronbach's alpha is used to measure the reliability and validity of the response obtained during the questionnaire survey. It is the function of variance of the total score, variance of the item pair and number of question for a given set of data. The value of alpha lies between 0 and 1 where higher value of alpha closer to 1 is more desirable. Value of alpha less than 0.6 shows unreliability of data obtained, value of alpha between 0.7 to 0.8 means acceptable response, value of alpha between 0.8 and 0.9 means good response and value of alpha above 0.9 shows excellence in reliability of data obtained through questionnaire. Formula to calculate Cronbach's alpha is shown below (Gain and Mishra, 2021).

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum Vi}{Vt}\right)$$

Where,

K = No. of Questions

V_i = Variance of score on each question

V_t = Total Variance of overall scores on entire set of question

4 Results and Discussion

This research was conducted through questionnaire survey to analyze the practice of risk management on the urban road construction project at Sindhupal chowk District, Province 3, Nepal. The result obtained from this research concludes that there exist impacts between the risk management practice with success of project. This research also evaluates significant risk factors based on their probability of occurrence, consequence and detectability in case of urban road construction project. MS Excel was used to analyze the collected data and findings are presented below.

4.1 Significant Risk Factors and their Ranking based on Failure Mode and Effect Analysis

To identify the significant factors of risk and their ranking for risk priority, respondents were asked to respond for Risk Occurrence(RO), Risk Consequences(RC) and Risk Detectability (RD) for each risk factors based on Likert Rating from 1 to 5. The average response for the risk factors were analyzed to determine Risk Priority Number (RPN) as per FMEA Model and thus risk rank was established. Various categories of risk, their factors and RPN for each risk factor is shown in the tables below.

Table 4.1 Significant Risk Factor

1	**Project Scope Risk**	8.2	Special equipment and materials, transport delay
1.1	High Complexity	8.3	Low productivity
1.2	Ill- defined project scope	8.4	Bad weather and working condition
1.3	Frequent changing scope requirements	8.5	Damage during construction due to negligence
1.4	No extra work control	8.6	Accidents
1.5	No analysis of changes in problem	8.7	Waste
		8.8	Thief and Fraud
2	**Design and Specification Risk**		
2.1	Inadequate design information	**9**	**Technology Risks**
2.2	Incorporation of new construction technology	9.1	Inadequate information on new technology
2.3	Unrealistic specification	9.2	Non- replacement of old technology
2.4	Likelihood of design changes	9.3	Non-availability of competent and professional staff to use new technology
2.5	Difficulties in interaction of design changes	9.4	Lack of managerial skills
2.6	Poor design		
2.7	Non-conformity with national standard and local specifications	**10**	**Contractual Risks**
2.8	Inaccurate quantities	10.1	Non-standard condition of contract
		10.2	Lack of time to prepare bid document
3	**Quality Risk**	10.3	Delay in site possession
3.1	No Quality Assurance Plan	10.4	Errors/omission in BOQ
3.2	No soil investigation	10.5	Payment issues
3.3	No method statement	10.6	Lack of insurance
3.4	Poor quality materials	10.7	No documentation of claims/disputes
3.5	Untrained manpower	10.8	Rush bidding
3.6	Problem in quality control		
3.7	Unachievable quality control	**11**	**Force Majeure and Ecological Risks**
3.8	Lack of soil and material testing laboratories	11.1	Act of god such as earthquake , floods, landslide, etc.
		11.2	Ecological damage
4	**Time Over Risk**	11.3	Epidemics
4.1	Inaccurate activity time estimates		
4.2	Unrealistic time schedules	**12**	**Political , legal and social risk**
4.3	Incomplete WBS	12.1	Change in government, policies, regulations, rules , laws
4.4	No formal sequencing plan	12.2	Local regulation
4.5	Inaccurate estimation of project schedule, resources and quality assurance plans	12.3	Crime and insecurity
4.6	Inefficient control system	12.4	Corruption

4.7	Inflexible & unrealistic project goals	12.5	Land acquisition delay
4.8	Inability to take timely the corrective action	12.6	Strike
		12.7	Permits and regulations
5	**Cost Overrun Risks**	12.8	Dispute among parties
5.1	Inaccurate cost estimates	12.9	Delay in dispute resolutions
5.2	Inadequate cost control planning		
5.3	No control of extra work	**13**	**Financial and Economic Risk**
5.4	Constantly change market conditions	13.1	Investment risks
5.5	Delay payment on contract	13.2	Inflation
		13.3	Escalation of prices
6	**Leadership Risks**	13.4	Local and national taxes
6.1	Lack of project vision	13.5	Cash flow problem
6.2	Lack of team building	13.6	Effect of time and cost overrun
6.3	Poor motivation of stakeholders	13.7	Demand scenario and constantly changing market conditions
6.4	High turnover of critical team members		
6.5	Unrealistic expectation	**14**	**Safety , Health and Environmental Risk**
6.6	Poor communication	14.1	Unsafe working condition
6.7	High rate of sickness and absenteeism	14.2	Pandemics and Viral Infection (like COVID-19)
6.8	Absence of safe working condition resulting site accidents	14.3	Non- conformance Safety Health and Environmental requirements
		14.4	Accident/ Strikes/ work stoppage and worker perceptions
7	**Organizational Risks**	14.5	Absence of safety audit
7.1	Inappropriate organizational framework		
7.2	Poor assignment/allocation of tasks and responsibilities	**15**	**Communication and network failure risks**
7.3	No project manual/documented procedures	15.1	Non availability of anti-virus software to safeguard office computers
7.4	Project being too complex for the resources available	15.2	Loss of data due to network problem
7.5	Inadequate communication infrastructure	15.3	No backup of data available
7.6	Wrong selection of project management	15.4	Lack of resources
7.7	Inflexible and unrealistic project plans	15.5	High electricity fluctuation
		15.6	Internet server breakdown
8	**Physical Resources Mobilization and Utilization Risks**	15.7	Ineffective information management system

8.1	Inadequate and low quality procurement of resources		

Table 4.2FMEA Table for the Risk Factors

S.N	Risk Factors	Risk Occurrence		Risk Consequences		Risk Detectability		Risk Priority Number
		∑W	ROI= $\frac{\sum W}{A * N}$	∑W	RCI= $\frac{\sum W}{A * N}$	∑W	RDI= $\frac{\sum W}{A * N}$	RPN=ROI * RCI * RDI * 100
1	Project Scope Risk	101.80	0.678	102.40	0.682	97.20	0.648	29.96
2	Design and Specification Risk	100.68	0.671	105.30	0.702	97.05	0.647	30.47
3	Quality Risks	106.05	0.707	103.19	0.687	96.43	0.642	31.18
4	Time Overrun Risk	110.44	0.736	106.83	0.712	107.20	0.714	37.41
5	Cost Overrun Risk	114.20	0.761	107.00	0.713	100.60	0.670	36.35
6	Leadership Risk	101.80	0.678	103.56	0.690	94.69	0.631	29.51
7	Organizational Risk	97.31	0.648	104.35	0.695	104.63	0.697	31.39
8	Physical Resources Mobilization and Utilization Risk	101.81	0.678	101.70	0.678	95.18	0.634	29.14
9	Technology Risk	100.75	0.671	100.25	0.668	99.00	0.660	29.58
10	Contractual Risk	106.08	0.707	97.80	0.652	101.82	0.678	31.25
11	Force Majeure and Ecological Risks	101.94	0.679	104.56	0.697	103.60	0.690	32.65
12	Political Legal and Social Risk	104.00	0.693	104.92	0.699	100.46	0.669	32.4
13	Financial and Economic Risk	107.16	0.714	102.60	0.684	101.17	0.674	32.91
14	Safety Health and Environmental Risk	111.00	0.740	107.00	0.713	105.00	0.700	36.93

15	Communication and Network Failure Risk	95.18	0.634	92.46	0.616	93.08	0.620	24.21

Note: A = 5 (Highest Likert Rating) & N = 30 (Total Number of Respondent)

FMEA Table 4.2 shows the risk priority number of the given 15 risk factors based on product of Risk Occurrence, Risk Consequences and Risk Detectability. Higher value of RPN shows higher severity of risk factors. Based on the value of RPN, risks are ranked where most severe risk is the one with highest Risk Priority Number. Risk ranking is shown in the table below.

Table 4.3 Risk Ranking of the Risk Factors

S.N.	Risk Factors	Risk Priority Number	Risk Rank
4	Time Overrun Risk	37.41	1
14	Safety Health and Environmental Risk	36.93	2
5	Cost Overrun Risk	36.35	3
13	Financial and Economic Risk	32.91	4
11	Force Majeure and Ecological Risks	32.65	5
12	Political Legal and Social Risk	32.4	6
7	Organizational Risk	31.39	7
10	Contractual Risk	31.25	8
3	Quality Risks	31.18	9
2	Design and Specification Risk	30.47	10
1	Project Scope Risk	29.96	11
9	Technology Risk	29.58	12
6	Leadership Risk	29.51	13
8	Physical Resources Mobilization and Utilization Risk	29.14	14
15	Communication and Network Failure Risk	24.21	15

From Table 4.3, time overrun risk is observed as most severe risk with risk priority number of 37.41. This indicates most of the urban road construction projects in hilly region suffer from time overrun i.e. project not completing within specified time limit. Inaccurate time estimate, incomplete work breakdown structure, variations and uncertainties, no effective control system are the major causes for this risk factor. Similar study conducted by Mishra and Malik (2017) for housing projects, time overrun risk stands at top rank which shows the uniformity of risk factor irrespective of construction project. Time overrun risk leads to numerous other risk like cost overrun risk, quality risk, ineffective organizational management and so on. Hence, major focus

has to be addressed to accurate time estimate and work execution within specified work schedule.

Similarly, Safety Health and Environmental risk stands at second priority risk factor with the priority number of 36.93. Unsafe working condition, accidents, non-conformance to legislative standards are the reasons for this risk factor. In addition, current global pandemic of COVID–19 is another major reason for increased severity of this risk factor. Safety audit, necessary precaution measure to ensure sound health at work site still remains a challenge at construction project of Nepal.

Cost overrun risk and Financial & Economic risk stands at third and fourth priority with priority number 36.35 and 32.91 respectively showing fluctuation and variations in cost estimate as well as market prices. Amount variation is widely seen in road construction projects of Nepal raising doubt in cost estimate of the construction project. Rush bidding and low bidding may be another reason for project not completing within the agreement amount at the time of bidding. Study conducted for housing projects by Mishra and Malik (2017) shows similar result where cost overrun risk stands at second priority.

Since, geology of Sindhupal chowk district is comprised of loose and fragile rock, steep gradient and excessive rainfall, natural disaster like flood and landslide is quite common resulting in huge loss of life, property and infrastructure. Jure Landslide, Melamchi Flood are the magnificent examples which supports fifth risk factor as Force Majeure and Ecological risk with risk priority number of 32.65.

Political Legal and Social risk is the other priority risk with rank sixth and risk priority number 32.4. Constantly changing government policies related to construction activities, legal legislation, Corruption, strike, land acquisition delay, delay in permit and regulation are the major causes for such risk factors. Similarly, dispute among the contracting parties and delay in dispute settlement is next major highlight for such result.

Organizational risk and contractual risk are next in line with priority number of 31.39 and 31.25 respectively. This basically shows management issue within organization and understanding among the contracting parties. Inappropriate organizational network, poor allocation of task and responsibilities, not effective documentation procedure and inadequate communication infrastructure are the major reasons of organizational risk. Similarly, non-standard contract clause, lack of time to finalize bid documents, delay in site possession, payment problems, insufficient documentation of claims and rush bidding are the major reasons of contractual risk occurring in urban road construction project.

Project specific risk like quality risks, design and specification risks and project scope risk comes at lower priorities with risk priority number of 31.18, 30.47 and 29.96 respectively. This shows project design features and quality in construction are comparatively less important factors affecting the performance of project. Quality risk occur due to absence of quality assurance plan, untrained manpower, poor quality of materials, no soil tests and inadequate quality control methods. Similarly, design and specification risk occurs due to unrealistic specification, probability of design change, difficulties in incorporation of design changes and poor design as a whole. Likewise, high complexity, ill-defined project scope, no extra work control and frequent changing scope requirements are the major cause for project scope risk.

Risk factors based on their weightage of risk priority number can be analyzed through pie chart shown below. This pie chart is typical representation of risk factors based on urban road construction projects of Sindhupal chowk district, Province 3, Nepal.

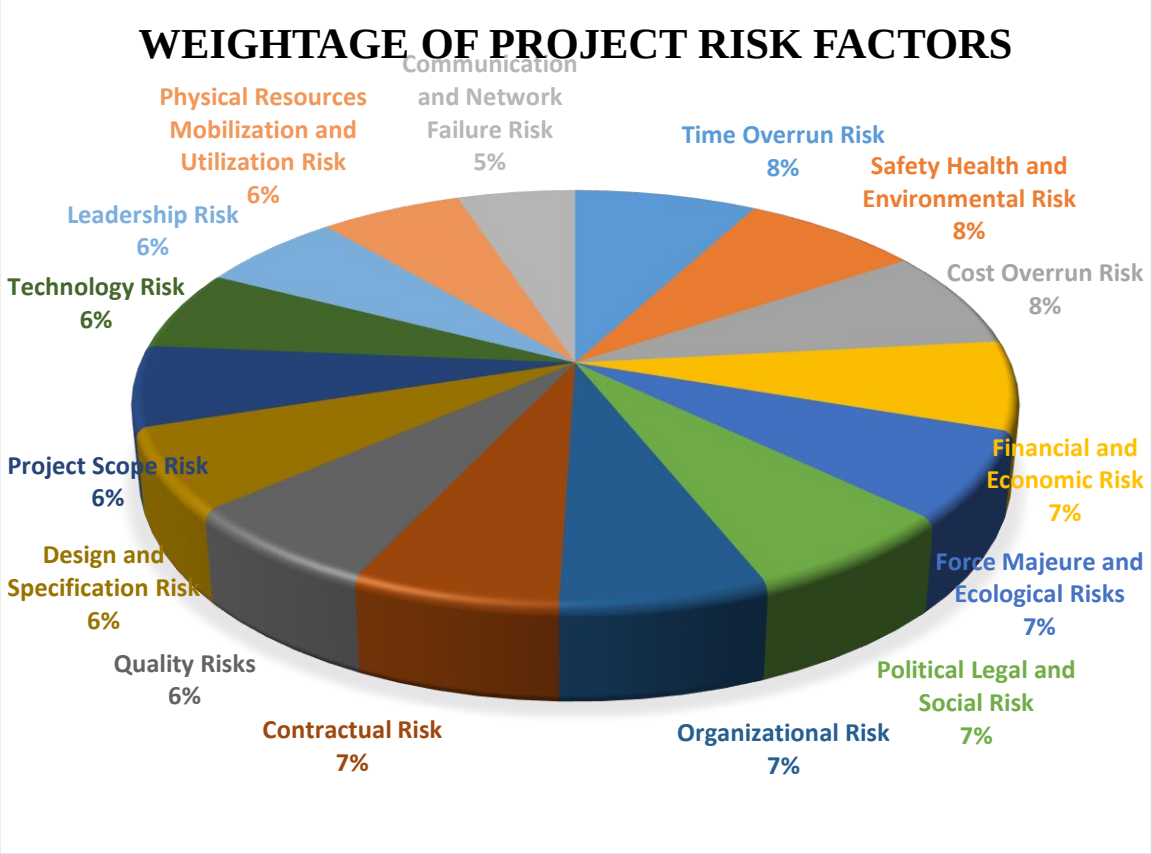

Fig 4.1 Weightage of Project Risk Factors

From the pie chart figure 4.1, it is seen that each risk factor has significance impact on output of project. However, risk factors like technological risk, leadership risk, physical resource mobilization and utilization risk as well as communication and network failure risk possess relatively less impact and stand at bottom of risk ranking list. Similar result is seen in study conducted for housing project by Mishra and Malik (2017), where communication and network failure risk is seen at the bottom of risk ranking list.

Cronbach's alpha was calculated to determine the reliability of response collected for significant risk factors. The value of Cronbach's alpha is shown below.

Table 4.4 Reliability Statistics for Significant Risk Factor

S.N.	Parameters	No. of Questions (K)	No. of Respondents (N)	Value of Cronbach's Alpha
1	Risk Occurrence	15	30	0.903
2	Risk Consequences	15	30	0.920
3	Risk Detectability	15	30	0.928

Here, all the values of alpha for response related to significant risk factors are greater than 0.9. Hence, internal consistency of data is excellent.

5. Conclusion and Recommendation

The focus of study was ranking of the various risk factors based on its severity. Risk factors were ascertained based on relevant literatures and key informant interview. Ranking of the risk factors was done through its score on occurrence, consequences and detectability.

5.1 Conclusion

This research also evaluates significant risk factors and its ranking for road construction project. Time overrun risk is the most significant risk factor with highest severity. Similarly, Safety Health and Environmental risk, Cost overrun risk, Financial and Economic risk, Force Majeure and Ecological risk, Political Legal and Social risk, Organizational risk, Contractual risk, Quality Risks and Design and Specification risk are the significant risk factors based on descending order of risk priority number as per FMEA Model. Other risk factors include Project Scope risk, Technology risk, Leadership risk, Physical Resource Mobilization and Utilization risk and Communication and Network Failure risk that stands at bottom of the ranking list in case of road construction projects of Nepal.

All the three independent variables of Risk Management Practice (Risk Identification, Risk Assessment and Risk Response) have significant impact on nine out of ten success criteria as well planned project schedule, compliance with Safety Health and Environmental standards, well assured financial and economic provisions, provision made for force majeure situation, compliance with Political Legal and Social requirements, well-structured organizational management, no issue in contractual agreement, compliance with quality standards and compliance with technical design requirements. For the remaining success criteria, project within estimated budget, Risk Identification and Risk Assessment have no impact whereas Risk Response has significant impact. Hence, even one fails to identify risk, if appropriate Risk Response strategy is selected, success of project can be insured.

5.2 Recommendation

- Risk register should be maintained at site and updated on regular basis. Meetings among stakeholders should be conducted to identify the significant risk factors.

- To manage the risk effectively and efficiently, organization should focus on its occurrence, its consequences as well as its detectability.

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