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Identification of Risks Associated with Strategic Road Network Construction in Karnali Province from the Perspective of Employer and Contractor

Jitendra Kumar Sah[1], Uttam Neupane[2,*], Santosh Kumar Shrestha[3]

[1]Mid-West University, Birendranagar, Surkhet Nepal, j4avay@gmail.com
[2] Mid-West University, Birendranagar, Surkhet Nepal, uttam.neupane@mu.edu.np
[3]Tribhuvan University, IOE Pulchowk Campus, Chakupat, Lalitpur, Nepal, skshrestha@ioe.edu.np

Abstract

Completion on time, within the allocated budget, according to the specifications, and with stakeholder satisfaction is a key to a successful project. Stakeholders, including the contractor, consultant, and employer, in almost all construction projects including highways, fail to give the risk assessment due consideration in Nepal. The purpose of this study was to determine the risks related to the key road network construction in Karnali province. Using purposive sampling, a questionnaire survey was administered to the stakeholders. The opinions of the participants were evaluated under five distinct categories: public sector management risk, engineering risk, construction risk, resource procurement risk, and social risk. Based on its RII value, each heading was rated after undergoing a distinct study. Authorization to use the forest land and remove or cut down trees (RII value: 0.90) was the highest risk that was obtained. This was followed by approval to move the electric pole from within the right-of-way (RII value: 0.88), "Lack of coordination between different related organizational parties (water supply, irrigation, building department, etc.)" (RII value: 0.87), "Unavailability of material" (RII value: 0.86), and, finally, "Land acquisition and bad quality of workmanship with RII value 0.85."

Keywords: Risk identification, Highway construction, Karnali province; RII

1. Introduction

In Nepal, the overall management of national highways and feeder roads comes under the responsibility of the Department of Roads (DOR). These roads are collectively called Strategic Roads Network (SRN) roads (NRS, 2070). The Department of Roads (DoR) is the primary authority body for the construction and maintenance of SRN roads. Up to 2020/021, the Department of Roads has the responsibility for 14913 km of SRN (HMIS-ICT Unit, 2021). Around 6836.45 km of SRN road is blacktopped, 1116.36 km of SRN road has a gravel surface, and 3226.12 km of SRN road has an earthen surface (DOR, 2020/21). The SRN highways that have been put in place by the DoR connect all ten of the districts in the province of Karnali. Table 1 lists the different SRN highways in the Karnali Province.

The highway construction in Nepal is the backbone and also plays an important role in economic development, contributing to overall socio-economic growth. Unfortunately, this sector has been plagued with delays, causing significant setbacks to Nepal's economic growth. Construction delays can be observed by several indication factors. One of the significant factors is risk management.

Due to its rugged terrain, the province of Karnali demands extreme caution during the planning, construction, and upkeep phases. One of the most perilous mountain ranges in Nepal is located in the province of Karnali. The region is prone to regular landslides caused by geological instability, seasonal and unseasonal monsoons, and haphazard infrastructure construction. Due to the rugged terrain and lack of alternative transportation options, roadways must be meticulously planned, constructed, and maintained throughout the year to prevent traffic blockages during the monsoon season and to ensure the safety of the public.

* *Corresponding Author*

Table 1. Road Length with Category and Pavement (In Kilometer) in Karnali province (Year2020)

Road classification	Zone	BT	GR	ER	Total	UC	PL
	Dolpa	0	0	107.26	107.26	0	48.15
	Mugu	0	0	27.11	27.11	0	159.23
	Humla	0	0	90	90	0	90
	Jumla	31	0	94.76	125.76	0	36.97
National Highway	Kalikot	65.9	0	36	101.9	0	55.7
	Dailekh	148.81	89	44	281.81	0	129.75
	Jajarkot	37	13	147.44	197.44	0	68.98
	Rukum West	47.4	45	18.73	111.13	0	0
	Salyan	145.08	0	34.42	179.5	21	0
Grand Total	Surkhet	189.28	14	16	219.28	0	82.58
	Sub-Total	664.47	161	615.72	1441.19	21	671.36
		664.47	161	615.72	1441.19	21	671.36

Table 2. Summary of Road Length

Road Classification	BT	GR	ER	Total	UC	PL
National Highway	664.47	161	615.72	1441.19	21	671.36
Total	664.47	161	615.72	1441.19	21	671.36

Source: Internet (http://ssrn.dor.gov.np/road_network/getProvinceCategoryAndPavement/6)

In Nepal, risk assessment for construction projects is given little priority. Mostly, it is not carried out during the design and construction phases, resulting in long-term losses. In Karnali, national highways such as Jamunaha-Nepalgunj-Kohalpur-Surkhet-Khulalu-Hilsa (Karnali Highway), Chinchu-Kudu-Jajarkot-Khalanga-Jumla-Kundari-Mugu-Rara (Rara Highway), Murtiya-Gulariya-Bhurigaaun-Telpani-Surkhet-Maathilo Dungeshwor-Baink-Bayuli-Nagma Sadak, Surkhet-Dailekh-Mahabulekh-Gaalje, Naagma-Gamgadhi-Nakchelaagna, Surkhet-Tallo Dungeshwor-Saatkhamba-Dullu-Pipalkot-Khulallu-Manma-Naagma-Jumla Sadak, Botechaur-Bhedabari-Dhuliyabit, Baddichaur-Gutu-Karnali section of the Madan Bhandari Highway, etc. is a vital transport link and the only primary roadway that connects the remote Karnali region to the lowlands in Mid-Western Nepal. Every year, landslides block the roads in Karnali, making it difficult for vehicles to travel from one part of the province to the other. The area is also known for having a high rate of accidents and fatalities, making it necessary to identify the risks associated with building highways. To reduce losses, the researcher studied the potential risks of constructing highways in Karnali and identified the most critical factors. It is important to identify these risks before, during, and after construction.

2. Literature Review

The construction industry is often associated with a high degree of risk due to its complex nature. A researcher conducted a study to identify and analyze 31 significant risk drivers that impact the construction cost and schedule performance ratings of highway projects in the U.S. The study used risk assessment techniques and tools to evaluate these risk drivers. The responses of highway construction-related professionals from both the public and private sectors were analyzed based on a project survey. The survey included project information, characteristics, project risk cost, and schedule impact ratings. The study found that using risk assessment in the reported projects has improved project and construction management practices (Diab, et al., 2012).

Studies on perceived risks, contractors, and project managers in the UK define perceived risk as the likelihood that unanticipated events will occur and negatively impact the cost, timeline, and quality of a project. They concluded that identifying and managing risks is the key to increasing profit (Akintoye & MacLeod, 1997).

Highways are a crucial part of the infrastructure that plays a vital role in providing social welfare. Different types of deterioration such as pavement ageing, pavement cracking, bridge structure deterioration, rock falls caused by unstable slopes, and potholes can affect highway structures. However, creating a comprehensive model that can successfully minimize the risks for the entire roadway network while considering the corresponding personal and general risks has been overlooked. To address this, an integrated risk management methodology has been developed, which independently evaluates the risk value and the extent of the network impact of each segment. The model identifies the highway segments that require maintenance to significantly reduce the overall risk of the network. The study evaluated Florida's four main highway networks, and the model's effectiveness was confirmed. The network's route analysis results were compared to demonstrate the efficiency of the approach in reducing the total risk of the network. The proposed model can serve as a decision-support tool to determine which highway segments require maintenance to reduce the potential danger to the network (Alshboul, et al., 2023).

Highway projects in developing countries are small and limited; moreover, the statistical distributions of parameters that play a significant role in the projects are generally unknown, and common approaches cannot assist such kinds of problems remarkably. To mitigate the foregoing issues in highway projects, the nonparametric jackknife resampling technique is applied, in which risks are first ranked with a common technique, and then those risks will be ranked with the jackknife technique. The final rankings are conducive to some rewarding results, such as a reduction in the standard deviation and normality of the data. Furthermore, the common risk ranking and jackknife risk ranking are compared in detail, illustrated with the risk data from a highway project, and also compared with the normal probability plot (Mousavi, et al., 2011).

The researcher has studied the concept of sustainable construction projects in the UAE and found that they are riskier than traditional projects. To help project participants manage these risks, the researcher identified and assessed thirty risks, which were grouped into five categories: management, technical, green team, green materials, and regulatory/economic. The thirty risks were ranked based on their severity, taking into account their probability and potential impact. Based on this ranking, the top five risks include a shortage of clients' funding, insufficient or incorrect sustainable design information, design changes, an unreasonably tight schedule for sustainable construction, and poor scope definition in sustainable construction. These findings will help project participants plan and control appropriate risk responses (El-Sayegh, et al., 2018).

Highway construction projects have a high level of risk due to the complex site conditions and high capital costs involved. Although it is impossible to eliminate all risks, they can be minimized or transferred from one project stakeholder to another. The researcher has identified two main risk areas that affect highway projects: company (macro) and project (micro) levels. The aim was to assess their impact on risk and introduce a risk model (R) that can prioritize these projects. The R index model, developed using the analytic hierarchy process (AHP) in four Chinese case studies, shows that political risk has the highest average weight, followed by financial risk. At the micro level (project), emerging technology has the highest average weight, with resource risks coming in second place (Zayed, et al., 2007).

Results showed that the owner side (the majority of construction projects in Egypt are in the governmental sector) is one of the most common risk factors in the construction industry; however, the overall project risk of highway construction projects in Egypt is considered medium. This was determined after a thorough literature review, after which a set of 12 risk groups consisting of 73 risks was selected, and risk evaluation of highway projects was carried out using the software application MATLAB. (Sharaf & Abdelwahab, 2015).

Brainstorming sessions are a widely used technique to identify potential hazards in projects. It's important to properly link the identification process with time and cost management. When evaluating the level of risk involved in large and complex projects, having experienced project managers and considering time limitations are crucial. The most significant categories of risk in construction projects are financial, construction, and demand or product risks (Tadayon, et al., 2012).

3. Research Methodology

3.1. Research Approach

Both qualitative as well as quantitative approaches were adopted for the study.

3.2. Study Area

The study was carried out in Karnali Province, Nepal.

Figure 1. Strategic Road Networks in Karnali Province

Source: Internet (https://dlca.logcluster.org/23-nepal-road-network)

3.3. Study Population, Sample Selection, and Sample Size

The DoR developed many strategic road networks at various sites around Karnali Province, which made up the study population for the research. Respondents were chosen from among the employer's representatives and contractors who were employed in the province of Karnali and had prior experience there. The whole population was taken for the study.

Table 2. Total Population used for analysis

S.N.	Respondent types	Number of Population
1	Employer’s Representative	44
2	Contractor’s Representative	7
	Total	51

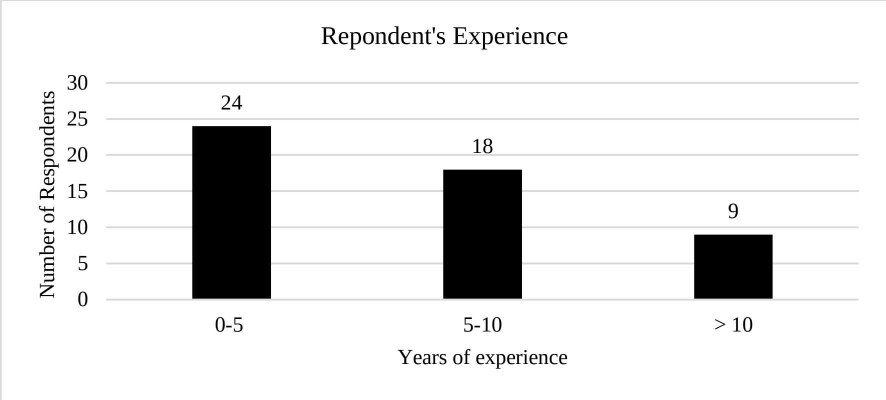

Figure 2. Respondents years of experience in Karnali Province

3.4. Data collection

The study is primarily based on the primary data which is the responses from the questionnaire survey. The questionnaire was prepared based on the review of various literature on risks associated with highway construction in mountainous regions and discussions with experts from the Department of Roads. Studies conducted by researchers (Diab, et al., 2012); (Mousavi, et al., 2011); (El-Sayegh, et al., 2018); (Zayed, et al., 2007) were used to select the factors related to Nepalese construction and develop the questionnaire. Two separate sets of questionnaires were prepared for the employer's representatives and the contractor's representative. These questionnaires were aimed to identify the risks associated with the construction of strategic road networks by the Department of Roads in Karnali province.

3.5. Data Analysis

Once the data was collected, it was analyzed using the descriptive method. Similarly, ranking was done based on their relative importance. Several researchers (Assaf, et al., 1995); (Kumaraswamy & Chan, 1998); (Sambasivan & Soon, 2007); (Doloi, et al., 2012) believe that using the mean and standard deviation of each attribute alone is insufficient to accurately assess overall rankings because they do not consider the relationship between them. Therefore, the RII method was chosen to identify the major risks associated with the construction of strategic road networks in Karnali province.

The relative importance index (RII) has been calculated as follows:

$$RII = \sum_{1}^{N} \frac{W}{A\,x\,N}$$

here, w = weight as assigned by each respondent on the scale of 1 to 5 where 1 implies the least and 5 implies the highest. The highest weight and N is the total number of samples. To aid in comprehension, the findings were presented in the form of charts and tables.

3.6. Reliability of Research Tools

The questionnaire included 25 questions based on the Likert scale. Cronbach's Alpha test was used to determine the internal consistency. Cronbach's alpha (α), created by Lee Cronbach in 1951, is a measure of the reliability of multiple questions to evaluate the validity of various surveys and was calculated using the following formula.

$$\alpha = \frac{N.\underline{c}}{\underline{v} + (N-1).\underline{c}}$$

where N is equal to the number of items, the c-bar is the average inter-item covariance among the items, and the v-bar equals the average variance.

Table 3. Cronbach's Alpha level of reliability (Bujang, 2018)

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

To conduct the Cronbach's alpha test, the questionnaire responses were entered into the analysis program. The respondents' Excel sheet, including overall risks associated with the SRN Roads, was transferred into SPSS for analysis. After conducting the Cronbach's alpha test, an overall alpha value of 0.942 was discovered. The consistency of the questions inside the questionnaire was found to be excellent, as per the stipulated values and range shown by the Table 3 rule of thumb.

4. Results and Discussion

Table 4. Individual RII values and their corresponding rank are given by the respondent.

Risk Factors	RII	Sector-wise Rank	Overall Rank
Public Sector Management Risk			
Land Acquisition	0.85	4	5
Approval from the Forest and Environment Department	0.9	1	1
Approval to transfer electric pole	0.88	2	2
Lack of coordination	0.87	3	3
Corruption practices	0.78	5	23
Engineering risk			
Lack of design quality	0.83	2	10
lack of unclear and inadequate details in the drawing	0.83	2	10
experienced human resources of related fields than a general	0.84	1	7
unforeseen ground conditions (poor preliminary soil/hydrology information and investigation)	0.83	2	10
that lack of attention to market conditions (Expertise, unavailability of material/ equipment)	0.82	5	15
Construction Risk			
change in scope (estimated for one purpose but executed for another purpose)	0.81	4	17
bad quality of workmanship	0.85	1	5
safety at workplace	0.79	5	21
unavailability and improper construction technology	0.84	2	7
environmental and climatic conditions	0.79	5	21
Lack of coordination between team members (including client and contractor)	0.84	2	7

Resource Procurement risk			
unavailability of material	0.86	1	4
unexpected price growth	0.83	2	10
lack of human resources (skilled/unskilled)	0.81	4	17
inadequate & improper equipment	0.83	2	10
availability and reliability of sub-contractors	0.77	5	24
Social risk			
change the scope of work by political pressure (if any)	0.8	3	20
delay due to lawsuits by landowners for higher compensation	0.82	1	15
labour absenteeism	0.77	4	24
conflicting (biased/manipulative) investigations on conflict and dispute settlement	0.81	2	17

The respondents had undergone an assessment process that involved answering 25 questions organized into five distinct categories. These categories include public sector management risk, engineering risk, construction risk, resource procurement risk, and social risk. Each category was analyzed separately and ranked according to its RII value, and the overall risk was also ranked based on the same value.

The responses were recorded based on a Likert scale to determine the frequency of scores received by each variable. The survey results were then tabulated in Table 4 to show the respondents' views on the causes of risk identification for these road networks.

4.1. Most Significant risks associated with the construction of strategic road networks in Karnali province

The most significant risk associated with the construction of strategic road networks in Karnali province is “approval from the forest and environment department to use the forest land and clearing or cutting down the trees," with a RII value of 0.90, followed by “approval to transfer an electric pole from within the right of way," with a RII value of 0.88; “lack of coordination between various related organizational parties (water supply, irrigation, building department, etc.)” with a RII value of 0.87; “unavailability of material," with a RII value of 0.86; and lastly “land acquisition and bad quality workmanship," with a RII value of 0.85.

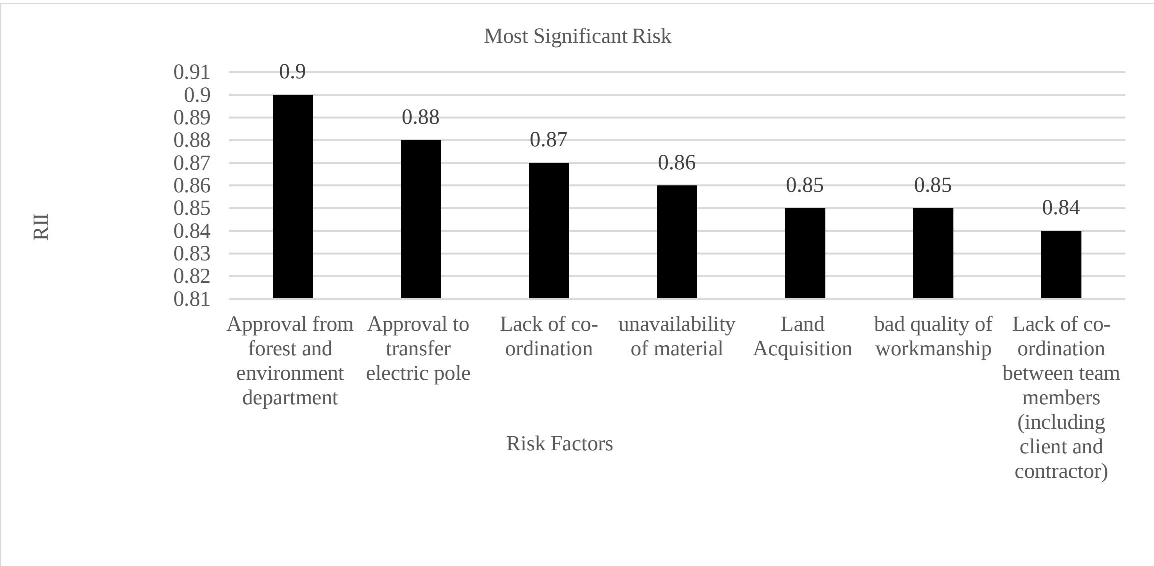

Figure 3. Most significant risk associated with SRN in Karnali province

4.2. Overall risks associated with the construction of Strategic Road Networks in Karnali Province

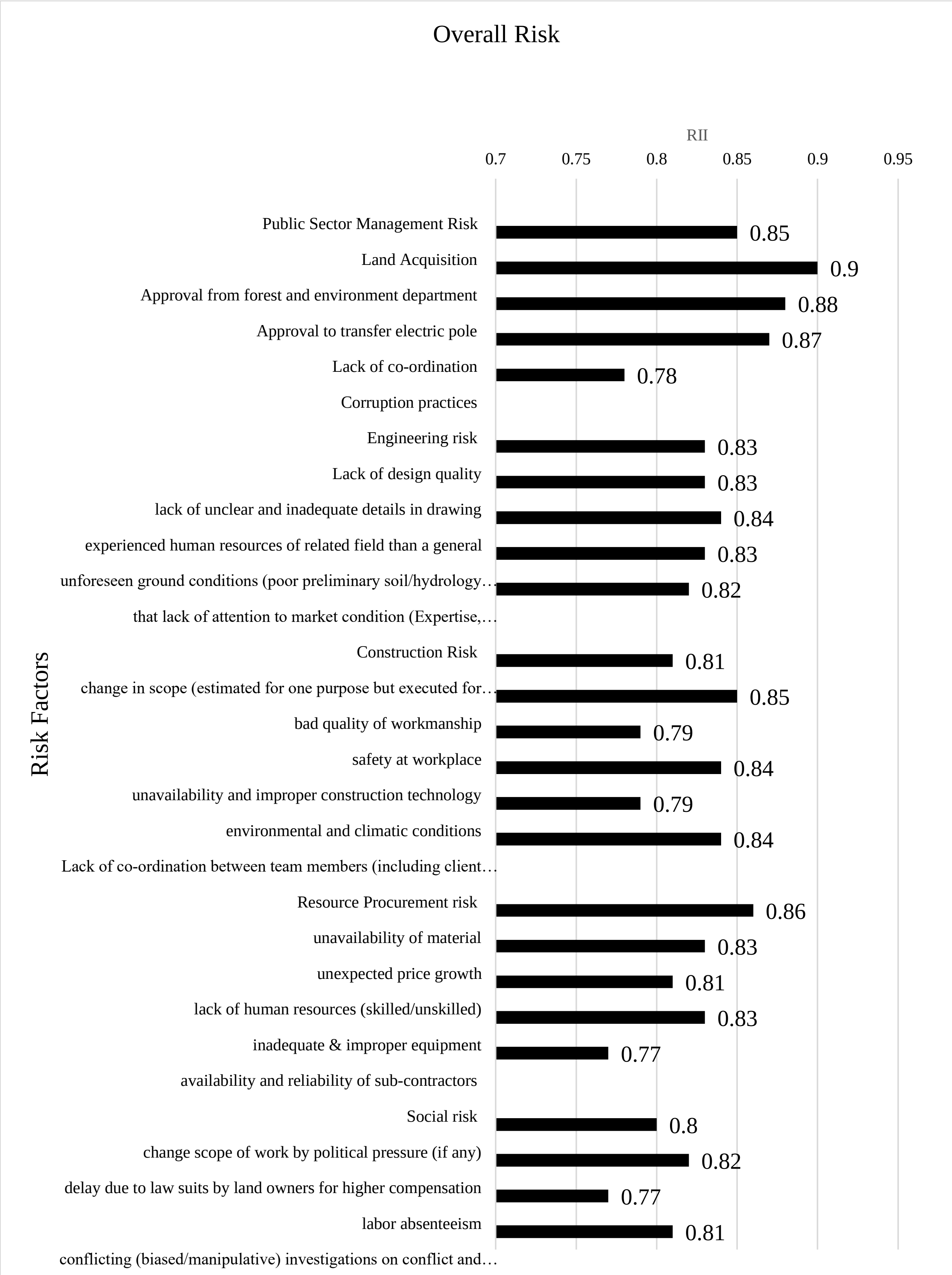

Figure 4. Overall Risk

4.3. Risks associated with the construction of strategic road networks in Karnali province (Sector Wise)

4.3.1. Public Sector Management Risk

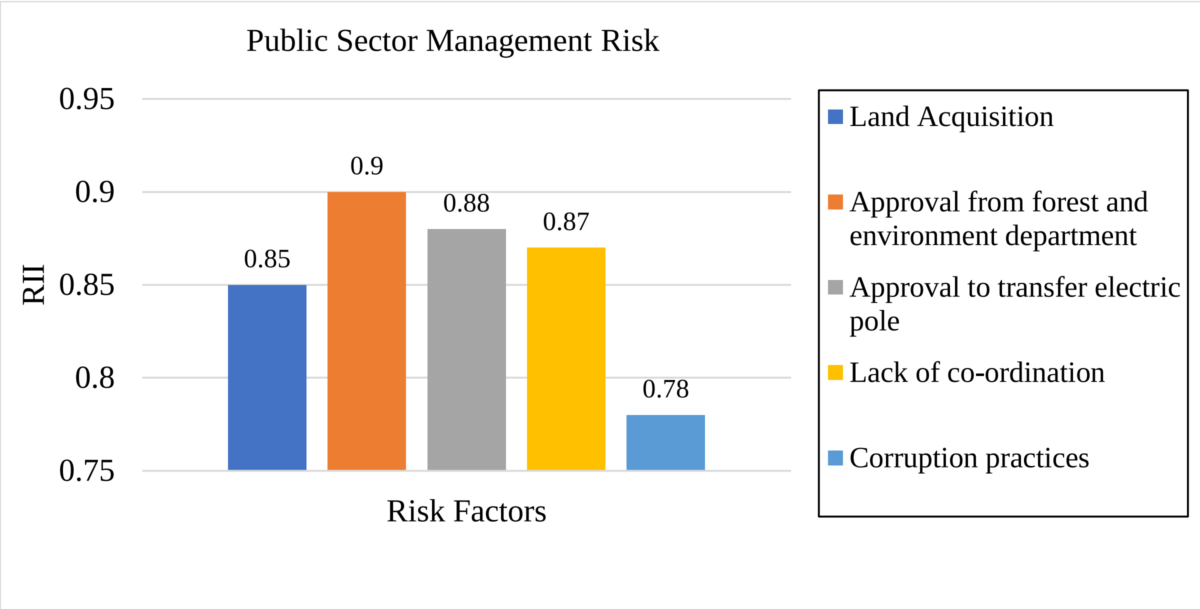

Figure 5 Public Sector Management Risk

According to the respondent, out of five distinct factors, "approval from the forest and environment department to use the forest land clearing or cutting down the trees" (RII value: 0.90) is the highest public sector management risk in the construction of SRN roads in the Karnali province. The least risk factor for construction is "corruption practices," with a RII value of 0.78.

4.3.2. Engineering Risk

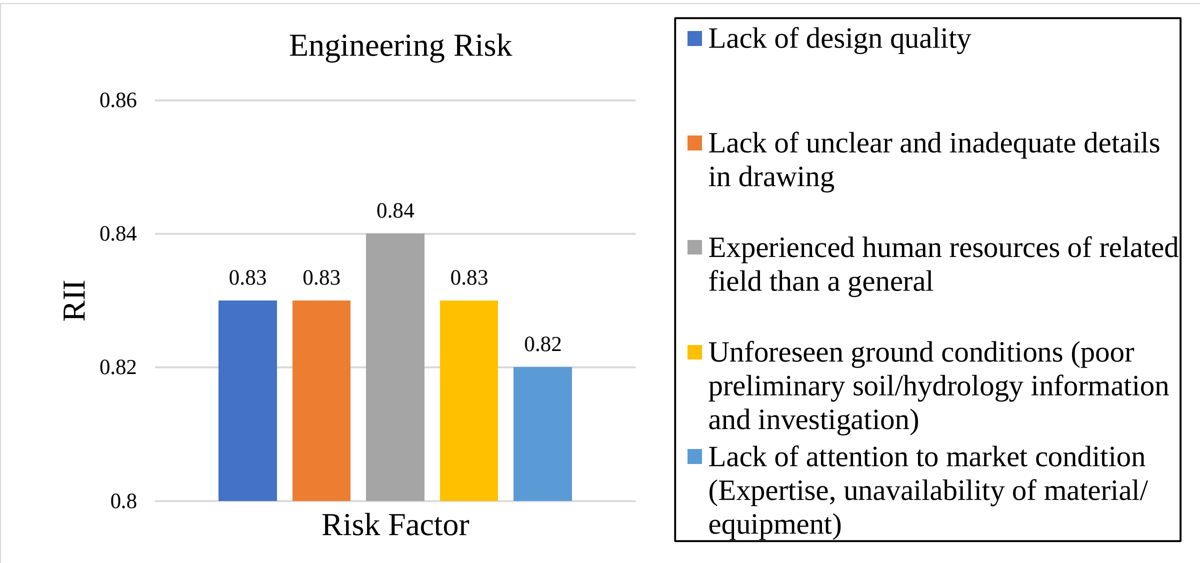

Figure 6. Engineering Risk

The engineering risk factor with the lowest danger towards construction is "lack of attention to market condition (expertise, unavailability of material or equipment)" with a RII value of 0.82, while the component with the highest risk is "experienced human resources in a related field than a general person" with a RII value of 0.84.

4.3.3. Construction Risk

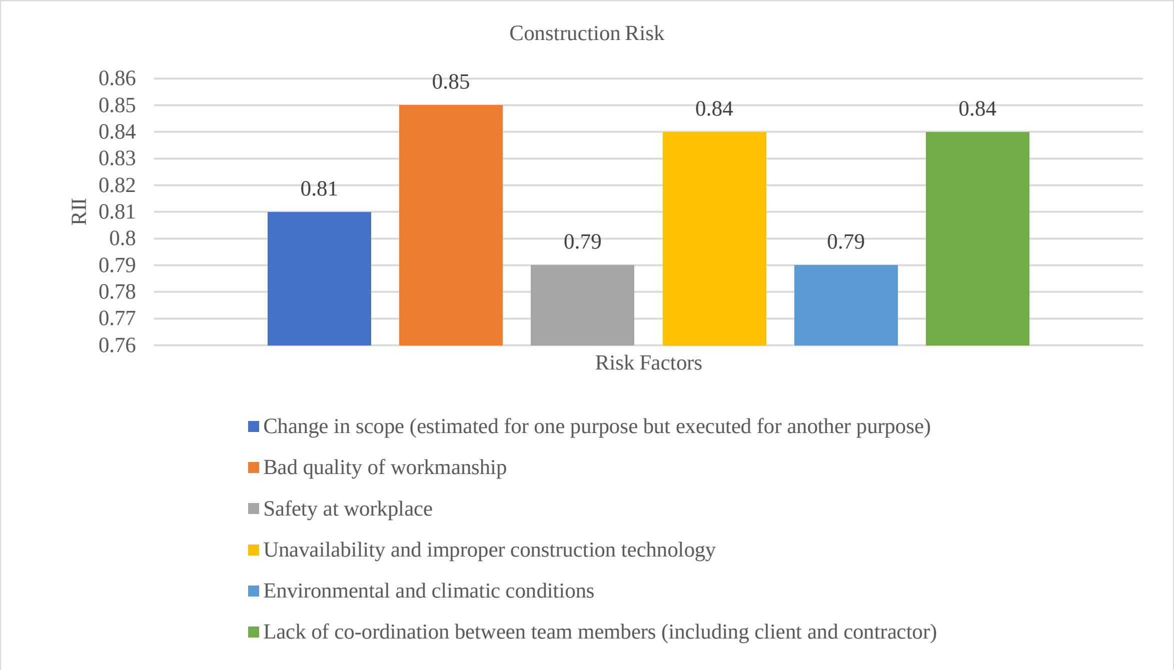

Figure 7. Construction Risk

Out of the six criteria that contribute to construction risk, the respondent believes that "poor quality of workmanship" poses the greatest danger during the construction of SRN roads in Karnali province, with a RII value of 0.85, while "safety at the workplace" poses the least risk, with a RII value of 0.79.

4.3.4. Resource Procurement Risk

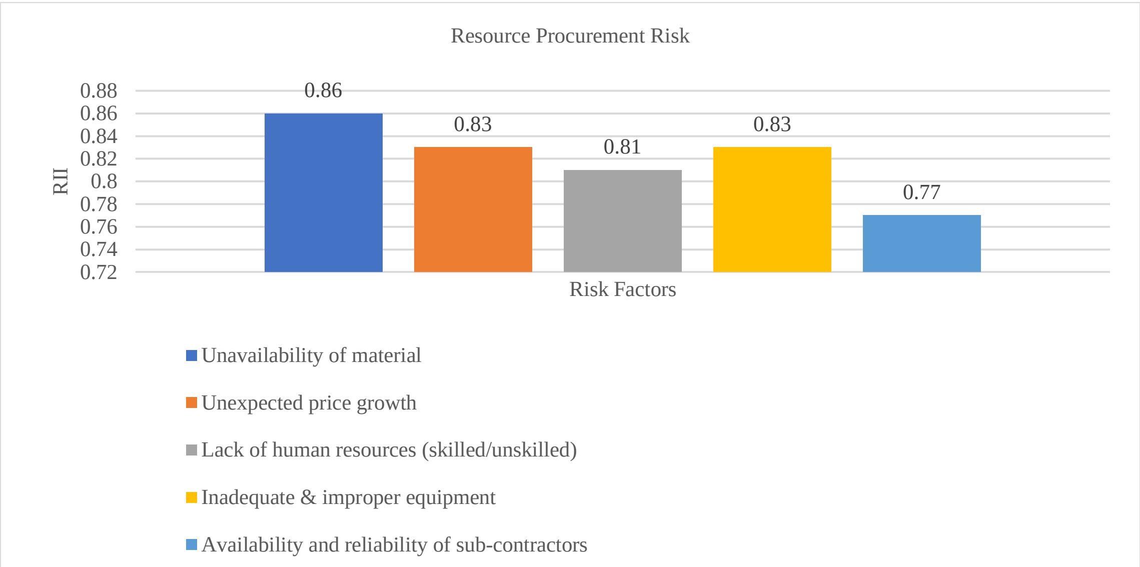

Figure 8. Resource Procurement Risk

Concerning resource procurement risk, The highest resource procurement risk among the five criteria considered in the construction of SRN roads in the Karnali province is "unavailability of material," with a RII value of 0.86, while the lowest construction risk is related to "availability and reliability of sub-contractors," with a RII value of 0.77.

4.3.5. Social Risk

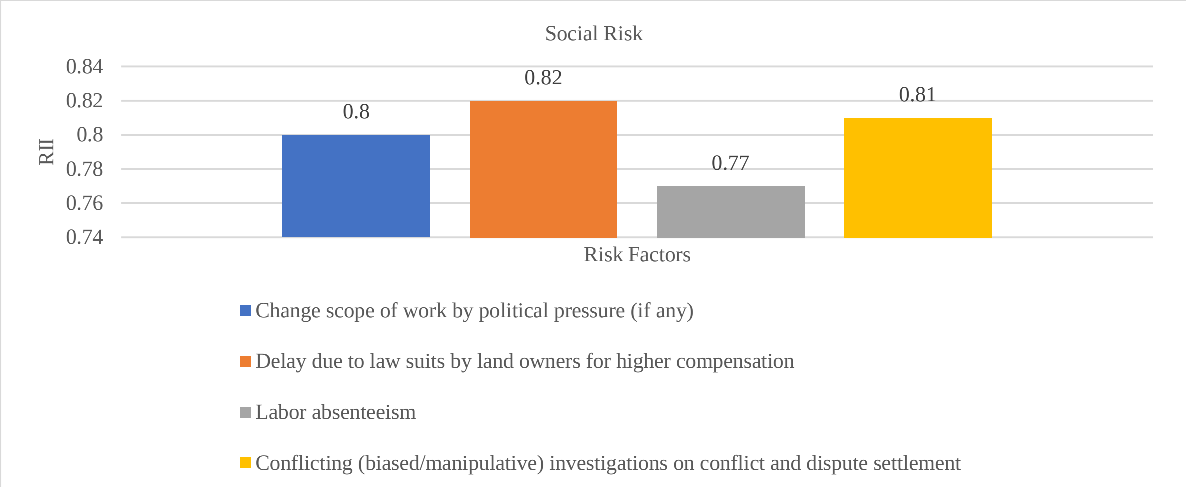

Figure 9. Social Risk

The respondent ranked "delay due to land owners' lawsuits for higher compensation" as the highest social risk among the four factors affecting the construction of SRN roads, with an RII value of 0.82, and "labour absenteeism" as the lowest risk factor, with an RII value of 0.77.

5. Conclusion

The construction of strategic road networks in Karnali province poses significant risks for both employers and contractors, mainly due to public sector management issues. The most prominent risks include obtaining approval from forest and environmental departments to use forest land and cut trees with an RII value of 0.90, getting approval to transfer an electric pole from within the right of way with an RII value of 0.88, and lack of coordination among various organizational parties such as water supply, irrigation, and building departments with an RII value of 0.87. Additionally, other risks include unavailability of materials with an RII value of 0.86, land acquisition and poor-quality workmanship with an RII value of 0.85, and lack of coordination between team members, including clients and contractors, with an RII value of 0.84.

6. Recommendations

6.1. Recommendations from the study

The research lists all of the risks that are connected with constructing SRN highways in the province of Karnali. It provides advice regarding the risks related to construction as well as potential remedies that may be put into practice to prevent or lessen problems related to construction delays in terms of schedule, budget, quality, and safety. The recommendations that follow are drawn from it.

1. The analysis also suggests that the Department of Infrastructure determines the public sector management risk, which is one of the top three hazards related to them. Before the bid publication, some tasks such as obtaining the environment and forest department's consent, moving electric poles, and coordinating with other organizations should be completed.

2. The study indicates that a shortage of materials may also have a detrimental effect on construction. Because of this, before and throughout the bid publishing process, the Department of Roads should work with pertinent agencies like the district administration office, the Department of Forests and the

Environment, pertinent provincial offices, and local-level authorities. This will guarantee that the project is finished on time, help the building process go much more smoothly, and lessen the possibility of cost overrun problems.

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Conflict of Interest Statement

The authors would like to declare that there is no conflict of interest.

Data Availability Statement

The questionnaire data and other relevant data can be made available upon request to the authors.

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