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Causes of Delay in the Construction of Transmission Line Projects by Nepal Electricity Authority

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Abstract
The transmission line is used to transmit the generated electricity from the generation station to the substation and from the substation, electricity is distributed to the household and industry using a distribution line. The average amount of electrical energy consumed per capita can be used as an indicator of the development of a nation. In Nepal, the Nepal Electricity Authority is actively engaged in constructing transmission line projects to bolster the nation's power infrastructure and meet the escalating energy demands. However, the timely completion of these transmission line projects is often hindered, leading to energy losses at generation stations and energy deficits at load stations. The study was focused on finding the major factors that cause the delay in the construction of transmission line projects. Delay factors were identified and grouped through the 42 kinds of literature related to the cause of delay in construction. The identified groups and corresponding factors were validated by an expert in the related field in the context of transmission line construction in Nepal. The quantitative data were collected using the Kobo toolbox questionnaire from 70 participants from clients, consultants, and contractors who were involved in the construction of a transmission line with a voltage level equal to or higher than 132kV by the Nepal Electricity Authority that was completed within the last 5 years and granted with at least one-time extension or whose construction is running behind the schedule. The RII method was used to find the major critical group and factors responsible for the delay. In summary, this study offers valuable insights into the key factors causing delays in transmission line construction projects in Nepal. By leveraging both expert opinions and a thorough literature review, the research aims to contribute to the improvement of project management practices and the timely completion of transmission line projects.

Keywords
Nepal Electricity Authority (NEA), Transmission line(TL), kilovolt(KV), Delay

1. Introduction

The major function of the transmission line is to carry the electricity from the power generating station to the demand center. The power carrying capacity of the transmission line increases with the increase in the voltage level of the transmission line[1]. For our electrical supply system importance of high voltage electrical transmission line are increasing [2].

Nepal Electricity Regulation 2050 defines the following voltage level as the high voltage transmission system.

a) 33,000 volt / 33 kV
b) 66,000 volt / 66 kV
c) 132,000 volt / 132 kV
d) 220,000 volt / 220 kV
e) 400,000 volt / 400 kV

In the current scenario, the NEA primarily employs 33 kV lines for its distribution system, whereas independent power producers use 33 kV lines as part of their transmission system to connect their power generation stations to the national grid. Over the past nine years, only 20 circuit kilometers of 66 kV transmission lines have been developed. In recent years, NEA has been focusing its planning and development efforts on transmission lines with voltage levels of 132 kV and higher for the high-voltage transmission system [3].

Table 1: Transmission line Length built by NEA(circuit Km)

S.N	FY	132 kV	220 kV	400kV
1	2071/72	2130		
2	2072/73	2417		
3	2073/74	2596	75	78
4	2074/75	2717	75	78
5	2075/76	3143	255	78
6	2076/77	3240	437	78
7	2077/78	3541	741	78
8	2078/79	3817	897	102
9	2079/80	3979	1101	108

The transmission line carries the electricity at a high voltage level. To increase or decrease the voltage level of the electricity, a substation is required. So, the construction of a transmission line is not sufficient without the construction of a substation to enhance the electricity transmission system. The complete process for the development of the transmission line includes the feasibility study, approval of the project from the concerned department, obtaining the survey license and construction license, contractor selection, design and engineering, construction, testing and commissioning and finally handing over the project to the operation department [4].

Construction of the transmission line includes purchasing the land for the tower foundation, getting approval for cutting of trees from the Department of Forest, compensation for the land and other structures on the Right of Way of the line, construction of an access road for the supply of construction material and tower parts, construction of tower foundation, protection work for tower foundation, erection of tower structure and stringing of conductor to carry the electricity.

Construction of the transmission line is one of the most problematic areas in the construction field. Transmission lines use the land differently than other development projects, considerable land is required for its corridor. This will lead to conflict between the public and the project developer. It is very important to understand the public attitude towards the development of Transmission line projects[2].

For the development and management of electricity in Nepal, the Electricity Act, of 2049 was developed, and based on the same act, the Electricity Regulation, of 2050 was developed. The main aim of this act and regulation is to safeguard and standardize the electricity service and to regulate the survey, generation, transmission, and distribution of electricity.

The strip of land whose center contains the transmission line is known as the right of way. It is required for the safety and functionality of the transmission line. Right of way clear all the buildings, structures, and trees that oppose the path and minimum clearance required for the transmission line. Tower design, line voltage level, speed of wind, and other safety factors affect the maximum width required for the right of way. The right of way of the transmission line varies as per the voltage level.

1.1 Problem of Statement

Every transmission line project is of a unique nature in its construction. In Nepal, completion of the transmission line on the originally estimated time is very hard. Several factors caused the delay. The timely completion of transmission line projects plays a vital role in the development of the nation and the improvement of human daily life.

Nepal Electricity Authority is responsible for the construction, operation, and maintenance of transmission lines. The transmission line is the backbone of the electricity system. Without a transmission line generated electricity from the power station cannot be transmitted to the load station. Generally, the hydro station is located in a remote area and the load centers like industrial and city areas are far away from the generation point.

Due to the non-completion of the transmission line project on time, there is an energy spill in the generation station and an energy deficit in the load station[5].

1.2 Research Objective

The specific objectives of this research are:

a) To find the major and most critical causes of delays in the construction of Transmission line Projects by NEA.
b) Grouping the identified factors and finding their ranking and relative importance.
c) To find the correlation between delay factors.
d) To find the procedure to minimize the major delay factors during the construction of Transmission line projects.

1.3 Importance of Research

The Fifty-seventh Auditor General's report reveals that 95.61 gigawatt-hours (GWh) of electricity, generated by 18 private hydropower companies, went to waste due to the government's inefficiency in upgrading, renovating, and constructing new transmission lines. Calculating the loss at the average rate of Rs. 4 per kilowatt-hour, as per the power purchase agreement, approximately Rs. 38 crores, 24 lakhs, and 59 thousand have been lost due to the unsold 95 GWh of energy[6].

The total loss of energy and money resulting from the delayed completion of TL projects is substantial. Therefore, this research is of utmost importance in identifying the major causes of these construction delays.

1.4 Previous Studies

In a 2021 study conducted by Goutom Kumer Pall, the causes of delays in power transmission projects in Bangladesh were investigated. The study identified the following as the top five causes of delay: right-of-way issues for transmission lines, frequent changes in transmission line routes, accessibility challenges at transmission line tower locations, poor communication and coordination among project parties, and delays in payments. Pall also suggested that further studies could be conducted in other countries to consider additional factors influenced by political, economic, cultural, and financial issues.

In 2021, Arjun Kandel conducted a case study for ADB-funded projects focused on risk management for high-voltage transmission lines of 220kV or above as part of his master's level thesis. He identified a total of 41 risk factors, with foreign exchange risk, interest rate risk, and the reluctance of government officials to coordinate with project teams being classified as higher-risk factors. He acknowledged the study's limitations, noting that it exclusively examined five transmission lines funded by ADB and implemented by the Project Management Directorate of NEA, all with a voltage level of 220kV or above.

2. Literature Review

There is a limited number of literature related to the causes of delays in the construction of transmission lines. However, there is so much literature on the causes of delays in construction projects. So, literature on causes of delay in construction projects closely related to the transmission line was also studied.

Most of the delay occurs in the construction phase of the transmission line project because major parts of contractual time are spent during the construction phase. Construction of the transmission line project involves purchasing the land for the tower foundation, getting approval for cutting of trees from the Department of Forest, compensation for the land and other structures on the Right of Way of the line, construction of an access road for the supply of construction material and tower parts, construction of tower foundation, protection work for tower foundation, erection of tower structure and stringing of conductor to carry the electricity. This means some parts of transmission line construction are closely related to the other types of construction projects. Thus, it can be considered logical to find the delay factor from other non-transmission construction projects[4].

A total of 42 literature related to the causes of delay in construction were studied to find the major factors to cause the delay and their groups. The categories of literature that were studied for this research were categorized as:

Table 2: Types of Literature

SN	Types of Literature	Number
1	Transmission line related	2
2	Power construction related	3
3	General construction related	37
Total		42

After reviewing the literature 13 Major groups and 108 major factors related to the delay causes were identified. The identified factors were rearranged, duplicated factors were combined together and factors non-valid to the transmission line and in the context of Nepal were deleted. After the filtration of factors total of 72 factors with 12 groups were selected for the study. The identified factors were validated in the context of Nepal by the TL experts. To avoid biases, a total of three experts were chosen each from the client, consultant, and contractor. Two factors were added by the experts, “Consultant and contractor from different nations” and “advance payment misuse by the contractor”. After some other minor corrections, the final adopted delay causes and their group for the construction of the TL project were 74 factors and 12 groups as summarized below.

Group 1	**Project Specific**	**G1**
1	Land acquisition problem	G1F1
2	Right of way Problem	G1F2
3	Delay approval for forest clearance	G1F3
4	Inappropriate survey and wrong selection of TL route	G1F4
5	Change in route of TL line due to public and political pressure	G1F5
6	Difficulty in river crossing of TL	G1F6
7	Change in supply vendor	G1F7
Group 2	**Client Related**	**G2**
1	Delayed decision making	G2F1
2	Multiple change order	G2F2
3	Late site handover	G2F3
4	Predominantly dependent on consultant for design and supervision	G2F4
5	Verbal work suspension or postponement	G2F5
6	Ineffective application of liquidated damage to the contractor	G2F6
7	Frequent change in project team	G2F7
Group 3	**Contractor Related**	**G3**
1	Poor site management and supervision	G3F1
2	Inadequate experience	G3F2
3	Ineffective planning and scheduling	G3F3
4	Rework due to error and defective work	G3F4
5	Irrelevant construction method	G3F5
6	Late site mobilization	G3F6
7	Delays in work by sub-contractor	G3F7
8	Multiple number of contract by single contractor	G3F8
9	Diminished incentive system for early completion	G3F9
Group 4	**Consultant Related**	**G4**
1	Delayed review of document	G4F1
2	Involvement of other person than the expert specified in contract	G4F2
3	Delayed inspection and testing by consultant	G4F3
4	Misunderstanding of the owner’s requirements	G4F4
5	Complexity of the design	G4F5
6	Rigidity of consultant	G4F6
Group 5	**Material Related**	**G5**
1	Shortage of construction material	G5F1
2	Late procurement and delivery of materials	G5F2
3	Low quality of construction material	G5F3
4	Changes in materials types and specifications	G5F4
5	Weak material requirement plan and schedule	G5F5
Group 6	**Labor Related**	**G6**
1	Insufficient skilled and unskilled manpower	G6F1
2	Low productivity of worker	G6F2
3	Conflicts between Laborers	G6F3
4	Strikes by site personnel	G6F4
5	VISA issue for foreign worker	G6F5
Group 7	**Construction Equipment Related**	**G7**
1	Shortage of equipment	G7F1
2	Equipment breakdown	G7F2
3	Low productivity and efficiency of equipment	G7F3
4	Lack of advanced equipment	G7F4
5	Unavailability of skilled operators	G7F5
Group 8	**Bid/Contract Related**	**G8**
1	Unrealistic contract period	G8F1
2	Lowest bid award system	G8F2
3	Discrepancies between BOQ and specifications	G8F3
4	Unbalance or front loading on price by contractor	G8F4
5	Tender qualification criteria limited to specific contractors	G8F5
6	Error in contract document	G8F6
7	Misinterpretation of information before bidding by contractor	G8F7
Group 9	**Contractual Relationship**	**G9**
1	Disputes between contracting parties	G9F1
2	Insufficient communication between project parties	G9F2
3	Delay in resolving contractual issues	G9F3
4	Consultant and contractor from different nations	G9F4
Group 10	**Design and Drawing Related**	**G10**
1	Delay in approval	G10F1
2	Error in design and drawing	G10F2
3	Design changes during construction	G10F3
4	Less field experience of the designer	G10F4
5	Designer selected material not available in the market	G10F5
Group 11	**Financial Related**	**G11**
1	Cash flow problem of contractor	G11F1
2	Price escalation/Inflation	G11F2
3	Inadequate fund allocation to the project	G11F3
4	Delay work progress payment to the contractor	G11F4
5	Late payment by contractor to sub-contractor or suppliers	G11F5
6	Advance payment misuse by contractor	G11F6
Group 12	**External**	
1	Inclement weather condition	G12F1
2	Accident during construction	G12F2
3	Law barrier and change in government rules and regulation	G12F3
4	Unpredictable subsurface condition	G12F4
5	Unexpected geological condition	G12F5
6	Force majeure	G12F6
7	Public obstruction	G12F7
8	Inappropriate selection of construction site	G12F8

3. Research Methodology

This research aimed to identify the primary causes of delays in the construction of TL projects by the Nepal Electricity Authority. The research employed various tools and techniques for its investigation. Initially, a comprehensive review of the literature was conducted to identify the different factors and their groupings that contribute to delays in TL construction projects. These factors were subsequently reviewed, modified, and grouped to align with the specific context of Nepal.

To validate the identified factors, expert opinions were sought from three individuals with expertise in TL construction, representing the client, consultant, and contractor perspectives.

To determine the major causes of delays, a questionnaire survey was conducted using a 5-point Likert scale.

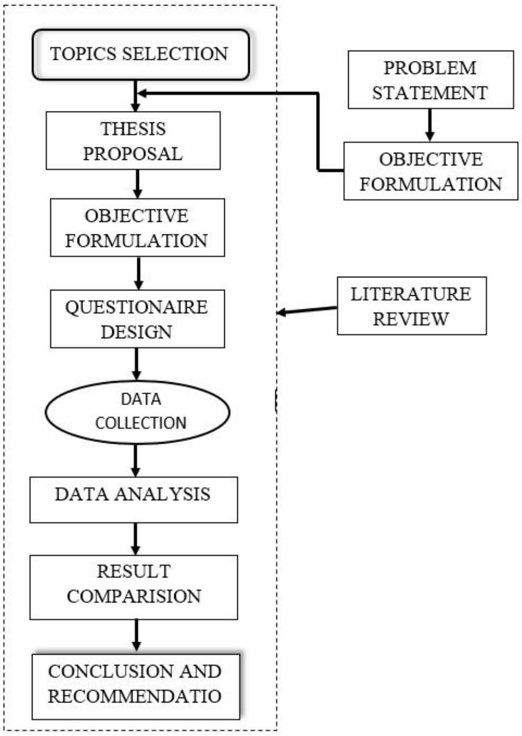

Figure 1: Research Methodology flow chart

3.1 Research Population

The research population comprised all Transmission Line (TL) projects with a voltage level equal to or higher than 132kV, executed by the Nepal Electricity Authority (NEA), which were either completed within the last 5 years and granted at least one-time extension or were currently experiencing delays in their construction schedules.

To identify this research population, an examination was conducted of annual reports and booklets published by the Transmission Line Directorate and Project Management Directorate of NEA over the past five fiscal years. This analysis revealed a total of 28 transmission line projects that were completed with delays during the last five years. Additionally, there are presently 13 TL projects under construction that have not met their initial targeted schedules. Combining these projects, the research population consists of 41 projects.

3.2 Research Sample

The survey samples were drawn from the contracting parties involved in the construction of the transmission line projects identified in the population mentioned above, including the client, consultant, and contractor. The survey sample size as per Cochran's formula is,

$$\text{Sample size } (n_0) = \frac{Z^2 pq}{e^2}$$

Where,
n_0 = Cochran's sample size
e = Desired level of precision (Confidence interval) = 0.1
p = Estimated proportion of population
$q = (1 - p)$
Z = Area of normal curve, value 1.64 for 90% confidence level.
By calculating from the above equation minimum sample size should be 68.

3.3 Questionnaire Development

A questionnaire is a common tool for data collection used to find relation between factors. Questionnaires were developed in five different sections as follows:

Section 1: contains Details about the case project.
Section 2: contains the ranking of Delay factors.
Section 3: contain ranking of delay groups.
Section 4: contains general information of the respondent
Section 5: contain additional comments (if any)

Respondents are asked to consider the project case that was completed within the last 5 years and granted with at least one-time extension or whose construction is running behind the schedule with a voltage level of 132kV or higher. Respondents answered the question based on their selected project case

3.4 Data Collection

This study uses the questionnaire survey to collect data from clients, consultants, and contractors who were involved in the construction of research population TL projects. Data were collected from 70 participants from three different project parties. Out of these 34 were clients, 19 were consultants and 17 were contractors.

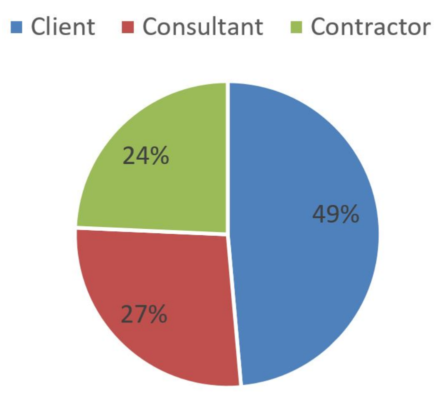

Figure 2: Percentage of Participant

All respondents were asked to rate the delay factors according to a five-point Likert scale. Kobo toolbox was used to collect the data from the sample population in the standard format.

Among 70 respondents 19 chose the TL project with the voltage level of 132 kV, 32 chose the voltage level of 220kV, and 19 chose the voltage level of 400kV as shown in Figure 4.

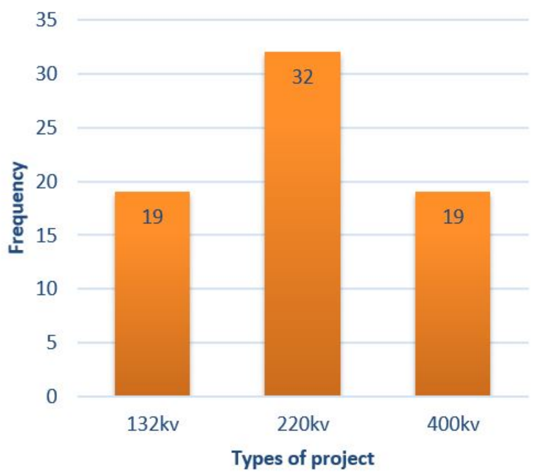

Figure 3: Voltage level of selected project

3.5 Data Analysis

For the analysis of data collected from the questionnaire survey software like SPSS and Excel were used. Reliability of data relates to the identification of the position held by the person who completes the questionnaire and the data source. Internal consistency reliability of the identified factors was checked by using Cronbach's alpha ($C\alpha$). It is used to check the appropriateness of the identified factors. The value of $C\alpha$ ranges from 0 to 1, with a higher value indicating greater internal reliability. If the value of alpha is higher than 0.7, then the data would be in the acceptable range[7].

Table 3 shows that reliabilities for the groups used in this study are within an acceptable range.

Table 3: Reliability Analysis Results

SN	Group	Sample size	Number of items	Cronbach's Alpha
1	G1	70	7	0.732
2	G2	70	7	0.813
3	G3	70	9	0.885
4	G4	70	6	0.857
5	G5	70	5	0.841
6	G6	70	5	0.791
7	G7	70	5	0.849
8	G8	70	7	0.863
9	G9	70	4	0.826
10	G10	70	5	0.870
11	G11	70	6	0.846
12	G12	70	8	0.839

The K-S and Shapiro-Wilk tests are the most commonly used tests to measure the normality of a data set [8]. That test shows that the P-value obtained was less than 0.05, which shows the non-normal distribution of the sample. Thus this research use non-parametric statistical measure. Spearman's rank order correlation method was used to calculate the agreement between project parties. The agreement between all parties is significant at level 0.01.

Table 4: Agreement between Project Parties

	Client	Consultant	Contractor
Client	1		
Consultant	0.811**	1	
Contractor	0.488**	0.438**	1

** Correlation is significant at the 0.01 level (2-tailed).

Spearman's rank order correlation method was also used to find the linear relation between the delay factors of all 12 groups. Table 5 and Table 6 show the correlation matrix for the delay factors of group 2 and group 4 respectively.

Table 5: Correlation Matrix for G2 Factors

	G2F1	G2F2	G2F3	G2F4	G2F5	G2F6	G2F7
G2F1	1						
G2F2	.589**	1					
G2F3	.440**	.376**	1				
G2F4	.300*	.309**	0.207	1			
G2F5	.335**	.576**	.454**	.252*	1		
G2F6	0.199	.289*	0.164	.284*	0.197	1	
G2F7	.421**	.579**	.455**	.423**	.557**	.439**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlation Matrix for G4 Factors

	G4F1	G4F2	G4F3	G4F4	G4F5	G4F6
G4F1	1					
G4F2	.648**	1				
G4F3	.457**	.499**	1			
G4F4	.573**	.650**	.463**	1		
G4F5	.497**	.499**	.333**	.475**	1	
G4F6	.549**	.500**	0.187	.483**	.622**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

4. Results and Discussion

The research assessed how each delay factor contributed to overall delays and ranked the attributes based on their perceived criticality by the respondents, utilizing the Relative Importance Index (RII). By analyzing the rankings assigned to each cause of delays, the researcher was able to pinpoint the most significant delay factors in the construction of the TL project by NEA. The top 10 overall delay factors are summarized in Table 7

Table 7: Overall Top 10 Delay factors

Overall Rank	Factor	RII	Client Rank	Cons. Rank	Cont. Rank
1	Delay approval for forest clearance	0.874	3	1	1
2	Right of way Problem	0.866	1	4	3
3	Land acquisition problem	0.854	2	2	3
4	Public obstruction	0.823	4	4	2
5	Lowest bid award system	0.743	4	9	27
6	Cash flow problem of contractor	0.729	6	6	29
7	Delays in work by sub-contractor	0.72	7	10	15
8	Ineffective planning and scheduling	0.706	10	7	33
9	Price escalation/ Inflation	0.706	22	12	5
10	Poor site management and supervision	0.7	8	3	49

Overall RII, RII by clients, consultants, and contractors for the top 10 factors are shown in Figure 4.

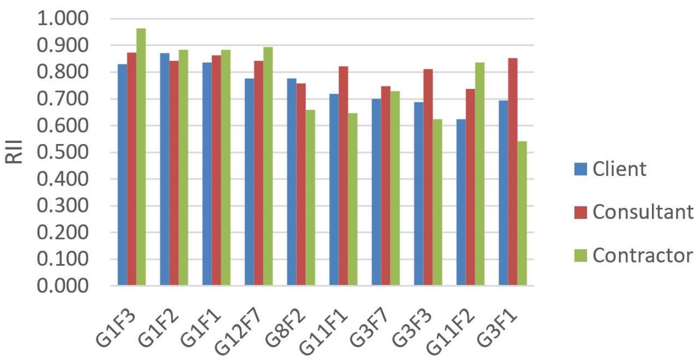

Figure 4: RII of top 10 delay factors

After analyzing the data, it has been found that the "Project Specific" group has the most critical impact on the construction of TL. This same group has been ranked as first by both the client and contractor; however, it has been ranked second by the consultant. The consultant ranks the "Contractor Related" group as the most critical for delays in TL construction. The overall rankings and rankings by the project parties for delay groups are shown in Table 8. Contribution to project delay by each group according to their RII is presented in Figure 5.

Table 8: Ranking of Delay Groups

Code	Group	Overall Rank	Client Rank	Cons. Rank	Cont. Rank
G1	Project Specific	1	1	2	1
G12	External	2	2	3	2
G3	Contractor Related	3	2	1	4
G2	Client Related	4	4	10	2
G8	Bid/Contract Related	5	5	4	7
G5	Material Related	6	5	5	7
G10	Design and Drawing Related	6	7	5	4
G4	Consultant Related	8	9	5	4
G11	Financial Related	8	7	5	7
G6	Labor Related	10	9	5	7
G7	Construction Equipment Related	11	9	10	7
G9	Contractual Relationship	11	9	10	7

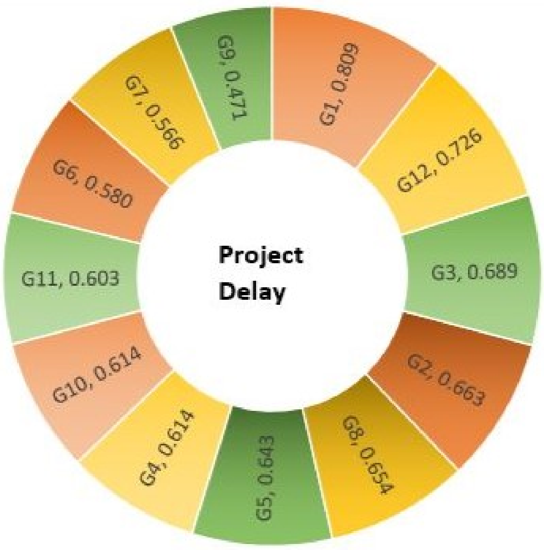

Figure 5: RII of Groups

The studies show that the delay in the approval of forest clearance is the most critical factor for delay in the construction of TL. The use of national forest land, the granting of possessory rights, or the transfer of rights within national forests cannot occur without the approval of the Government of Nepal's Council of Ministers[9]. The approval process for the cutting of trees is very lengthy.

The second major problem is the issue of right of way (ROW). The right of way is defined as the strip of land containing the transmission line's center and is crucial for the safety and proper functioning of the transmission line. The required ROW width varies based on the voltage level: 18 meters (9 meters on each side) for 132kV TL, 30 meters (15 meters on each side) for 220kV TL, and 46 meters (23 meters on each side) for 400kV TL [10]. Typically, landowners are compensated with a payment equivalent to 10-20 percent of the land's value for the portion covered by the Right of Way. They are also prohibited from constructing any permanent structures on this land, and banks do not accept it as collateral for loans. These factors contribute to public reluctance to allow transmission lines on their land.

The third major problem is land acquisition, particularly for constructing tower pads. Landowners are typically compensated with a payment equal to 100 percent of the land's value for the portion occupied by the tower foundation. While offering 100 percent compensation makes this problem less critical than the ROW issue, it becomes a concern because the compensation value is set lower than the market value, and the proximity of the ROW to neighboring lands exacerbates the issue, making it the third major problem.

The fourth significant challenge involves public obstruction during the construction of the TL. This obstruction primarily stems from issues related to Right of Way (ROW) and land acquisition problems. The construction progress of the Hetauda-Dhalkebar-Inaruwa 400 KV double circuit transmission line has experienced delays due to local residents demanding improved contractor performance and route changes [11]. Obstruction from the public is a recurring issue in nearly every transmission line (TL) project in Nepal.

To minimize the impact of these major factors, recommendations were gathered from experts in the related field. The following are the recommendations provided by these experts.

a) Modern technology, such as Light Detection and Ranging (LiDAR) surveys, can be employed to accurately assess the environmental impact. This data can provide information on the maximum tree height, allowing for the possibility of increasing the height of TL towers to maintain the necessary minimum clearance, thereby avoiding the need for tree cutting within the ROW area. However, it's important to note that this method may not always be feasible or cost-effective.

b) If the government strongly implements Land Use Regulation 2079, which defines land in ten different categories, including agricultural land, and ensures that the majority of transmission line alignments pass through agricultural land, the Right of Way (ROW) problem may be minimized because the impact of transmission lines on the cultivation of agricultural products is minimal.

c) Use of narrow base TL tower, monopole, and multi-circuit towers will minimize the area required for the tower foundation leading to less acquisition of land.

d) Explore the possibility of sharing ROWs with other utility infrastructure, such as roads, to minimize the overall land footprint.

5. Conclusion

The purpose of this study was to identify the major causes of delay in the construction of transmission line (TL) projects by the NEA, rank these causes, explore correlations between factors, and propose procedures to mitigate the impact of these major causes.

After an extensive review of 42 pieces of literature and consultation with experts in the related field, a total of 12 groups and 74 delay factors were identified. To assess the significance of these factors, a questionnaire survey was conducted involving project stakeholders, including clients, consultants, and contractors. The Relative Importance Index (RII) was calculated, and the top 10 overall delay factors were presented.

The findings revealed that the most critical factor contributing to project delays was the "Delay in approval of forest clearance," with an overall RII of 0.874. Similarly, the "Right of Way (ROW) problem" and "Land acquisition problem" were identified as the second and third most critical factors for project delays, with RIIs of 0.866 and 0.854, respectively.

To mitigate the impact of the identified major factors, recommendations were provided after consulting with experts in related fields. These findings will assist in reducing the effects of the delay caused in the construction of TL projects by NEA.

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