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Risk Management in Infrastructure Projects

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Abstract: Risk is that one factor which every human will face in every facet of life, whether in life or in a work situation. In today's world, development is constant and where there is progress there are various risks involved in it. Be it any field, the involvement of hazards has been consistent. In early life, there was a huge conundrum in this simple human mind about how to tolerate risk but as the time passed and we moved towards the modernization, the problem of risks has been decreased. In the world, the construction industry has been valued hugely. In Indian economy some amount of percentage is contributed by the infrastructure projects. In this study, we will discuss about the identification and analyzing those various hazards which affect the infrastructure projects. It is a very necessary step because millions of rupees are spent on these types of projects. In this research work, we have selected canal infrastructure as my field of research. The logic behind studying the risk management of canal work is that in India there are very fewer literatures based on canals. Moreover, canals in India are one of the most important as it supplies water to farmer's land in which crops are cultivated. The identification and analysis of hazards is very important in the infrastructure projects. So that was the main problem which was detected. The methodology used in my study for data collection was questionnaire survey. 10 major risks were identified and then it was sub-divided further. Following the collection of data, analysis was done based on probabilistic analysis, severity analysis and risk matrix. In the end, all the results which we gathered, were all compared through a scale and they were categorized accordingly. The factors which were dominant are (1) Electricity risk (2) Having black cotton soil and (3) Change in design.

Index Terms **– Risk management, Canal work, Infrastructure projects, Construction management.**

I. INTRODUCTION

The Construction enterprise sounds to be challenging to the stakeholder connected to any project on every occasion. Various types of risks are involved within the construction project specifically in Infrastructure projects. If these risks aren't known then the contractor goes to face lots of troubles. So, there is a must study about risk management by the scholars so as to realize the expertise and to implement on site, due to the varied forms of dangers involved within the infrastructure project there'll be loss of life, cost overruns and delay of the project. The study of risk management analysis includes a bigger scope not only within the industry but also in human life and business sectors too. within the infrastructure project, there are numerous kinds of risks involved. Political risk, financial risk, labour risk, client risk, contractual risk, stakeholder risk etc.

Risk management is an important and fundamental little bit of undertaking the board in significant advancement adventures. A risk management system optimizes success, minimizes threats, maximizes opportunities, and allows you to actively understand and control individual hazardous events, still as general hazards. It is the method of finding that what not goes consistent with the plan. the appropriate level of uncertainty. Risks is viewed as positive (potential growth opportunities) or negative (negative factors). A hazard has the flexibility of a situation or event to interfere with the achievement of certain goals**.** In large construction projects, hazard management is a crucial a part of project management. Infrastructure projects can effectively manage risks by inspecting and identifying the sources of risk related to each project activity. These risks may be evaluated or measured in line with their probability of occurrence and impact.

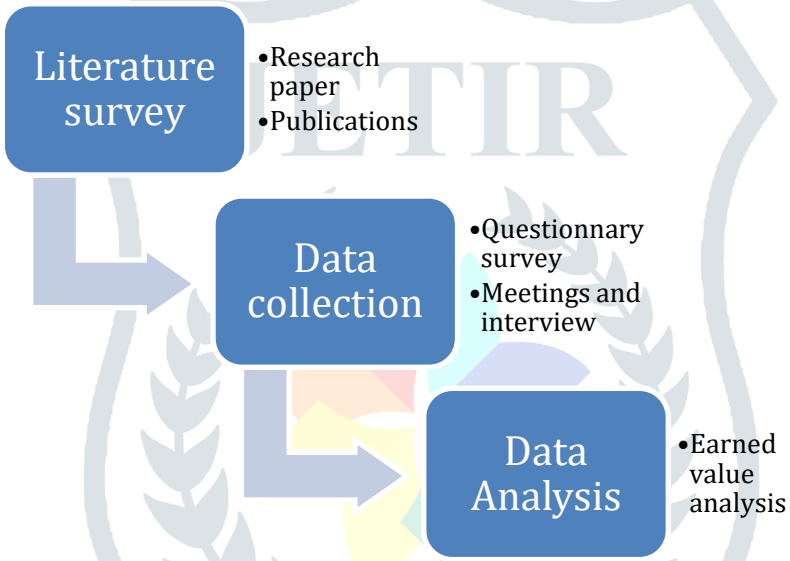
II. NEED FOR STUDY

In the construction industry, risk management is essential, as it allows a company or an enterprise to control and frequently prevent political, financial, social, and operational risks. Any enterprise must be aware of the potential effects a hazard could have on its project, whatever its level of danger. Risk management is performed to identify potential problems that may arise during the project. Thus, the executive plan evolved as per the requirement to achieve the target within a given time and cost constraint.

III. OBJECTIVES

The primary objective of this research is to identify and analyse the risks after examining the consequences and to overcome that hazard. The secondary objective of this study is to evaluate and compare the risk aspect of each canal activity. Further, this study determines the severity of various activities in the canal project.

IV. RESEARCH METHODOLOGY



V. LITERATURE SUMMARY

Table 1 Literature Publications

Sr. No.	Title of Paper	Year of Publication	Authors Name	Journal/Publication
1.	Risk and risk management in construction: a review and future direction for research.	1998	P J Edwards and P a Bowen	Engineering, Construction and Architectural Management
2.	A Framework of Project Risk Management for the Underground Corridor Construction of Metro Rail.	Feb 2011	Debasis Sarkar, Goutam Dutta	IIMA (Indian Institute of Management Ahmedabad)
3.	Risk management in projects: peculiarities of Lithuanian construction companies.	2011	Nerija Banaitiene, Audrius Banaitis and Arturas Norkus	International Journal of Strategic Property Management
4.	A new type of risk in	2011	Mihnea Craciun	Modern economy

	infrastructure projects.			
5.	A review of quantitative analysis techniques for construction project risk management.	2012	Muhammad Jamaluddin Thaheem, Alberto De Marco and Kristen Barlish	Creative construction conference
6.	Establishing risk management factors for construction projects in Iraq.	March 2015	Dr. Firas Khairy Jaber	International Journal of Advanced Research in Engineering and Technology (IJARET)
7.	Risk Management in Infrastructure Projects in India.	2015	Chaitali S. Pawar, Jalinder R. Patil and Suman S. Jain	International Journal of Innovative Research in Advanced Engineering
8.	Risk identification and assessment for EPCM projects using fuzzy set and fuzzy theory.	2016	A. Salah, O. Moselhi and Ahmad Salah	Canadian Journal of Civil Engineering
9.	Identification of risk investment using the risk matrix on railway facilities.	2018	Jan Kowalski and Mieczyslaw Polonski	Open Engineering
10.	Subsidy risk related to construction project: seeking causes.	2018	Tomas Hanak and Jana Korytarova	Open Engineering.

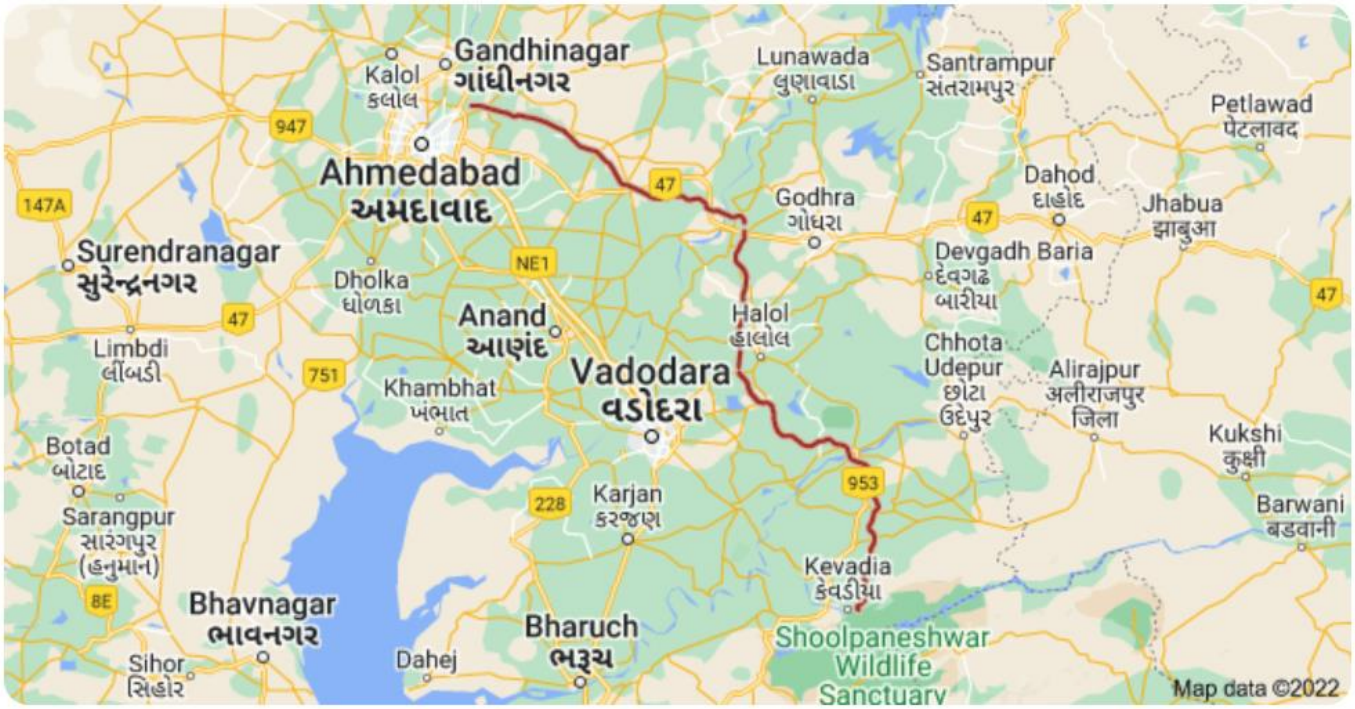
VI. DATA COLLECTION

a) Introduction:

The canal which passes through all the rural region starting from Kevadiya to Gandhinagar is known as Narmada canal. This canal is constructed and now maintained by Sardar Sarovar Nigam Limited (SSNL) of Gujarat. The canal also delivers water to all the rural region of the largest city in Gujarat which is Ahmedabad.

Construction phase of the canal started in the year 1992, with the total length of 458 kilometres covering the regions of Gujarat and Rajasthan. As per the reports, the work of the canal was completed on 24th April 2008. The department of water resources approved the project and the estimated cost of the total project was around 12.900 crore. The starting of Narmada canal is from Kevadiya district of Gujarat which also passes through the capital city, Gandhinagar and ends in the state of Rajasthan.

The Narmada canal is contour canal in western India that brings water from the Sardar Sarovar dam to the state of Gujarat and then into Rajasthan. It is the largest lined irrigation canal in the world. The below Fig 1 represents the route map of Narmada canal. The figure shows canal from Kevadiya to Gandhinagar because the research work which is to be carried out is in that region.



Narmada Canal

Gujarat

Figure 1 Route map of canal in Gujarat

b) Project Details:

1. **Patch 1**

- ✓ Length of distributary channel – 4 km (2.48 miles)
- ✓ Name - -Vidaj distributary
- ✓ Raised – 0.5 m (50 cm) above ground
- ✓ Fully operational

2. **Patch 2**

- ✓ Length of distributary channel – 6 km (3.72 miles)
- ✓ Name – Sedrana distributary
- ✓ Raised – 0.5 m (50 cm) above ground
- ✓ Fully operational

Figure 2 Construction of canal

c) Construction Methodology

Canal is an infrastructure made by the humans to carry the water from point A to point B and is also used for reservoir and irrigation purpose. The most commonly used method in the construction of canal is "Concrete lining method".

d) Details of Segment:

Table 2 Segment details

1	Project name	Constructing earthwork lining structure and road approaches of branch canal.
2	Estimated cost	40 lakh per kilometres
3	Contractor	Valji Puna Surathiya (Kutch)
4	Consultant	Murti associates, Puna.

e) Location of Segment:

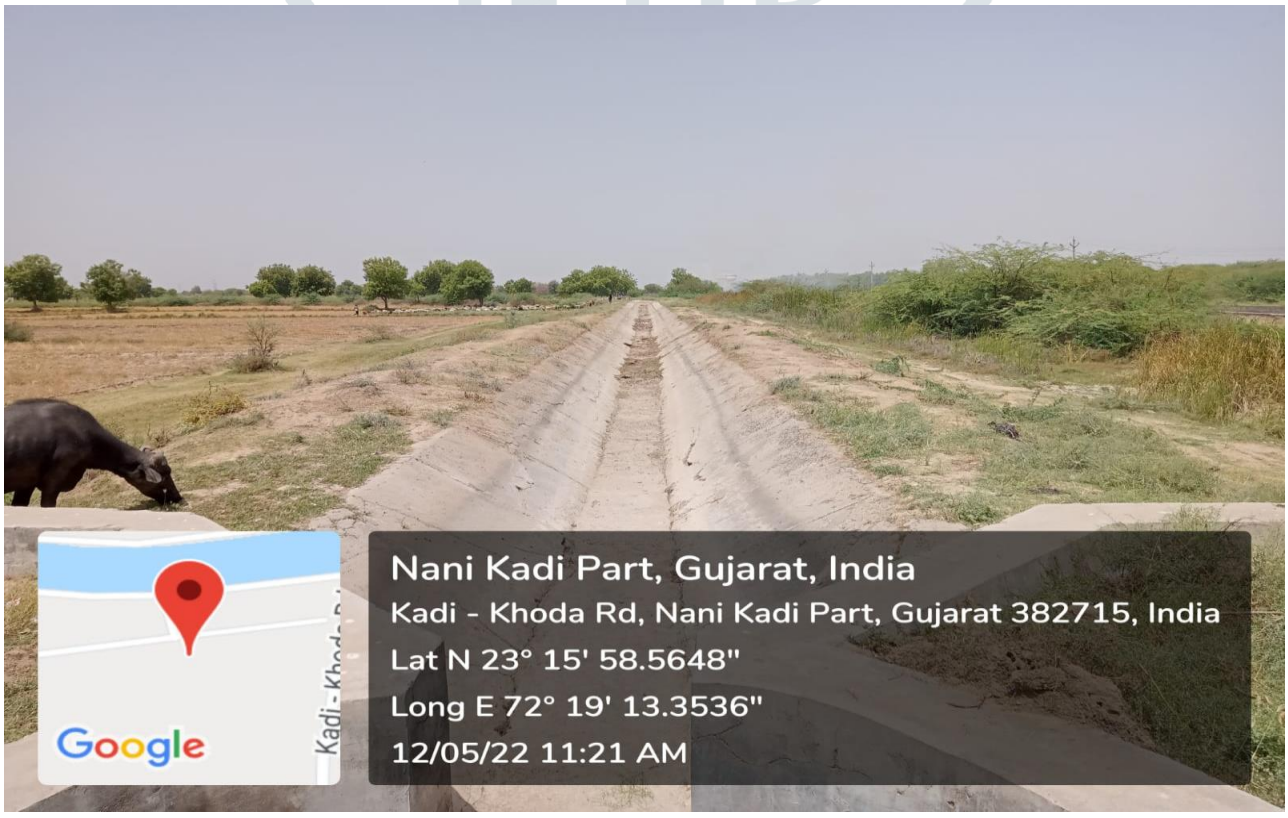


Figure 3 Location of segment

f) Questionnaire Design:

Further, all the major risks are now categorized into different various dangers which are all related and they all must be checked and completed to analyze and identify the risks involved.

The questions are then asked to the particulars in a proper manner. The questions which are written have two answerable options which weigh from scale one to five. First option depict likelihood which is the probability of the event to

occur and the second option says about the impact that's going to have if the event occurs. Then from both probability and impact we can find the severity of a particular hazard.

There are total number of 10 major risk factors which can affect the canal projects being constructed. These questions are distributed in means of questionnaire survey and the weightage of each and every danger can be calculated based on the reply of the people.

g) Sampling Size:

The sample size or sampling is done before the questions are handed to the people. The size shows us that to how many people we have to distribute the questionnaires.

$$\eta_0 = \frac{pq\, z^2}{e^2}$$

$$= (1.96)^2 (0.5)\ (1\text{-}0.5) / (0.12)^2$$

$$\eta_0 = 66$$

z = Confidence level (95 %)
p = 0.5 (As population is unknown, I have taken 50% of it)
e = Correction error (12%)

VII. DATA ANALYSIS

a) Introduction:

In construction of canal, there are few major activities which involve and are directly related to risks. In this paper, I have listed out 10 major risks which are going to be analysed. The risks are (1) Risk in management (2) Technical risks (3) Market related risks (4) Social risks (5) Environmental risk (6) Risk of facilities (7) Risk in road widening (8) Risk in setting up lab (9) Safety related risk (10) Financial related risk.

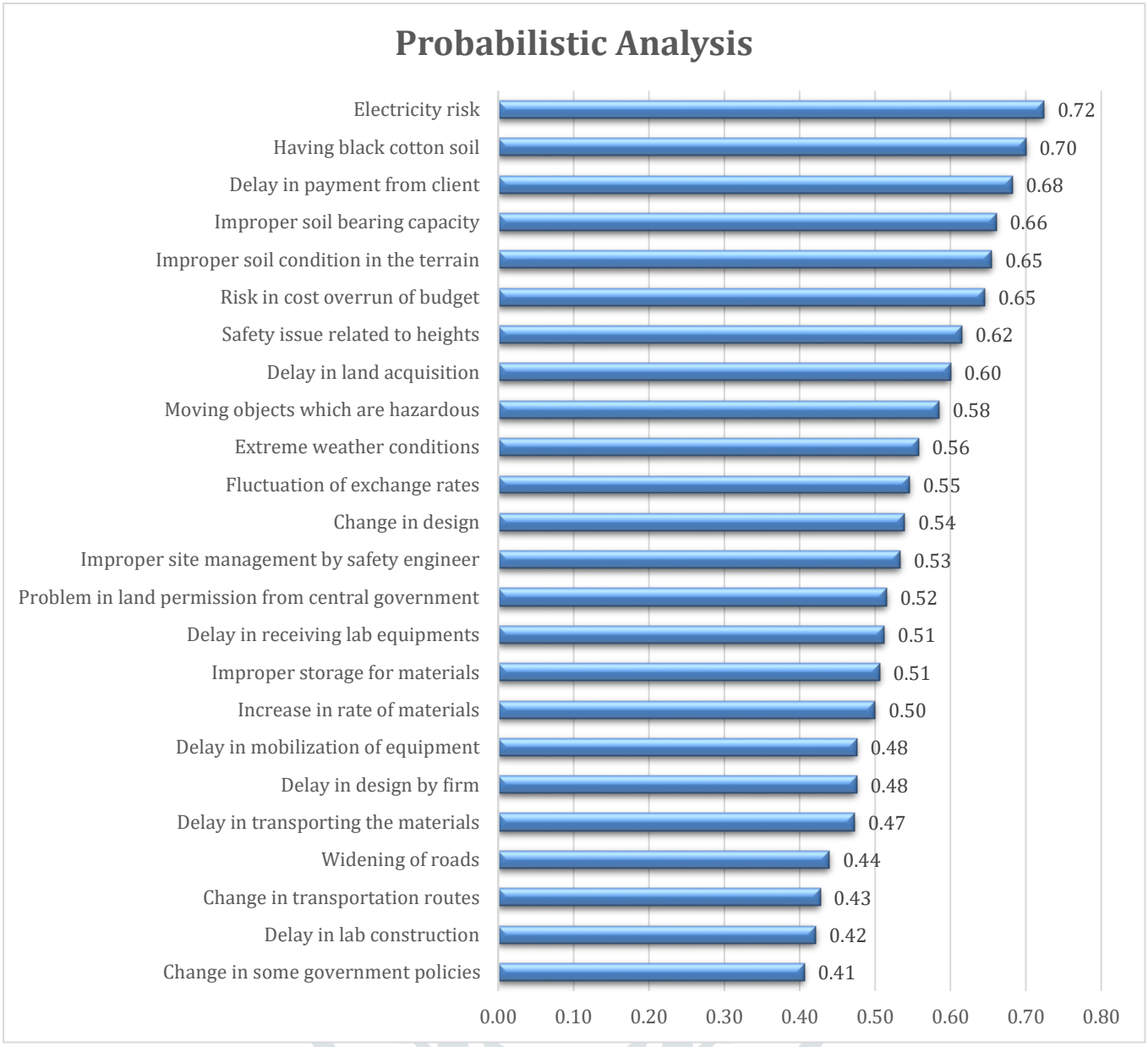
After the identification of risks, all the 10 hazards are then analysed by two main methods. They are quantitative analysis and qualitative analysis. In quantitative analysis, first is probabilistic method and then second is risk severity method. In qualitative analysis the method of risk matrix will be used. All the data will then be presented in a graphical form and then it will be compared.

b) Probabilistic Analysis:

Probability is a chance that the given event will occur or the possibility of something to happen and the impact is how the project is affected by the happening of any events.

Probabilistic analysis is a technique used by risk managers for forecasting future events. This process involves a review of data to calculate probability distribution that can be used to predict the future. Now, this method is going to be used in this research study where all the data will be analysed with reference to probability.
It starts from an assumption about a probabilistic distribution of the set of all possible input.

In this probabilistic method, the graphical representation will be shown. Each and every factor involved in canal project risks will be mentioned and with the help of questionnaire surveys it will be set in an arranging order. The hazard which is most likely to occur will be the first one and the least one will be at the last. In this manner all the factors will be arranged. Further, in this study, a single event is determined with a single outcome. Then one has to identify the total number of outcomes which in our case is 5 starting from very low to very high. After that the numbers are multiplied with the outcomes and then they are divided with total outcomes and number of responses.



Graph 1 Probabilistic Analysis

In this graph 4.1, the hazard factors are arranged in an ascending order. One can see the highest likelihood factor comes at 0.72 and the least factor is at 0.41. So, from that a scale is decided and then factors are sorted accordingly. The major observation done in this graph is that most of the factors are very high in numbers ranging from 0.50 to 0.80.

c) Risk Severity:

What is risk severity?

The risk severity of anything is to how much extent the thing has been damaged by the risk factors. That extent deicides the severeness and so it is called risk severity.

L - L stands for the likelihood of any event.

I - I stands for the Impact which has occurred due to any event.

W – W stands for weightage of any event that has occur.

Likelihood (L): The likelihood of any activity is a probability of that thing to occur. The project which fails due to some factors of risks are calculated here through questionnaire survey.

Impact (I): The impact is a damage or the effect which is caused due to risk factor on a large-scale project. The impact for the different factors were also collected using questionnaire survey.

Weightage (W): The weightage represents the weight of the risks factor. The weightage with highest number tends to be more dangerous and should be careful about it.

Composite likelihood factor (CLF): Composite likelihood factor are the values which we can find after collecting the data. The CLF basically can be found by the multiplication of the weightages with their respective answer of probability.

Formula to calculate CLF = Likelihood*Respective weightage

Composite impact factor (CIF): Composite impact factor again can be obtained with the same method as done in CLF. The impact of various hazards is multiplied by their respective answers in the google form.

Formula to calculate CIF = Impact*Respective weightage

After applying all the formulas, graphs are made of (CLF) composite likelihood factor and (CIF) composite impact factor. The graphs are made individually and not all in one.

The severity of risk is calculated once we have the data of likelihood and impact. The likelihood and impact factor are multiplied with each other and the value of severity is obtained. Further, in the study, the researcher has classified the scale into on the basis of severity.

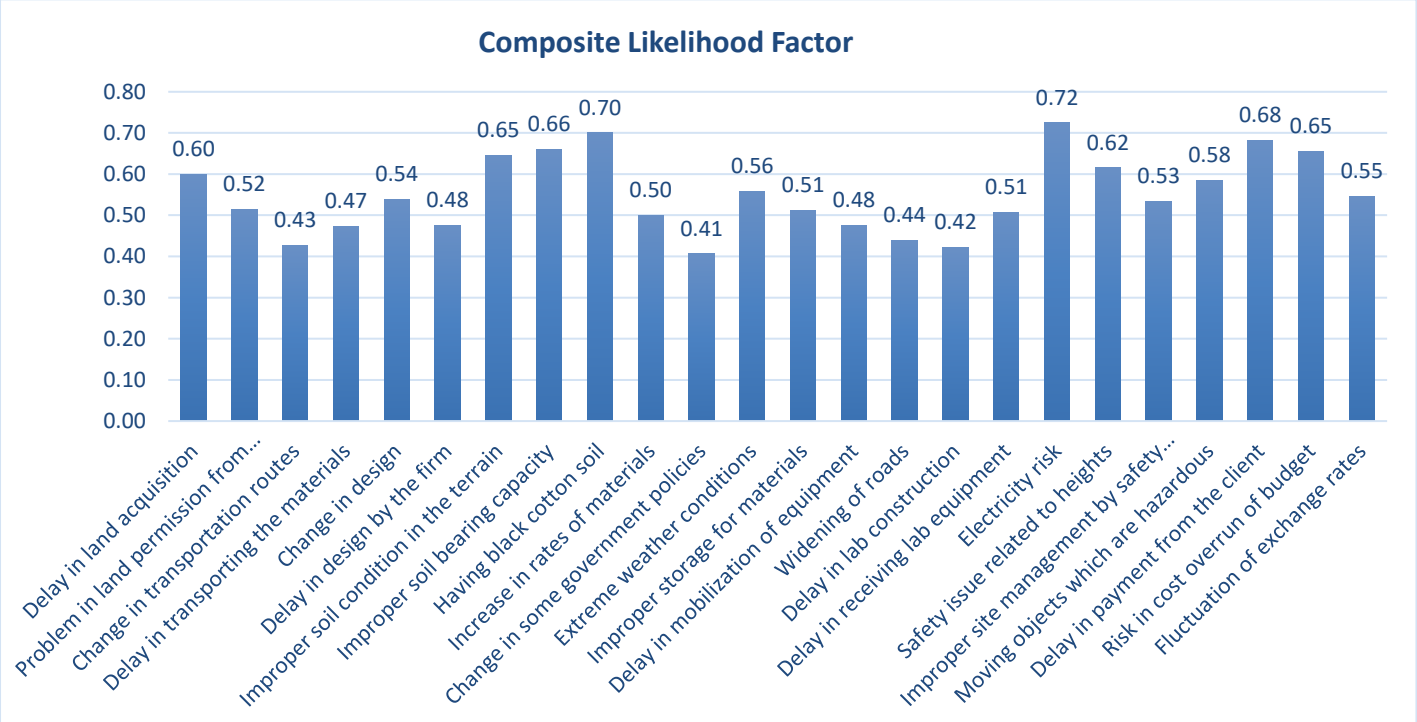
Severity	Classification
0.00 – 0.02	Very Low
0.03 – 0.04	Low
0.05 – 0.25	Medium
0.26 – 0.50	High
0.51 – 1.00	Very High

Table 3 Scale of Severity

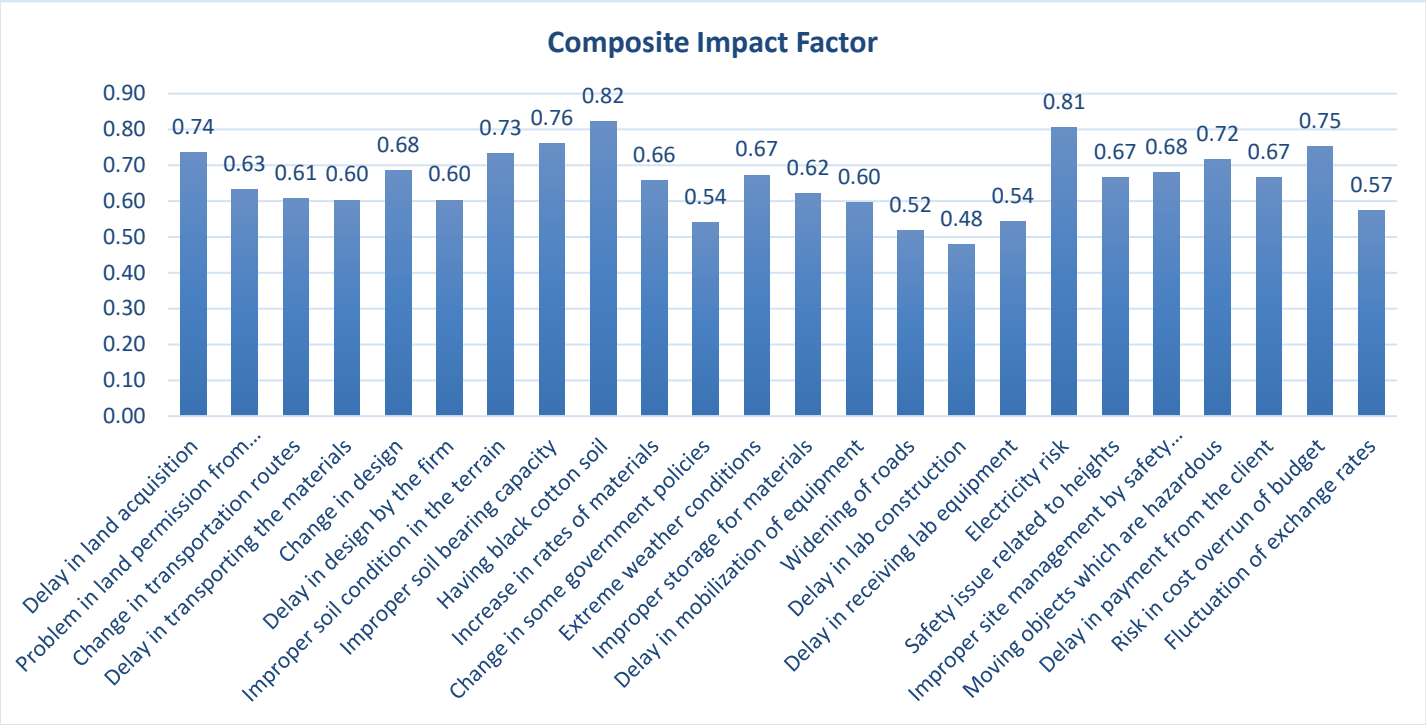
Description	Composite Likelihood Factor (CLF)	Composite Impact Factor (CIF)	Severity (CLF x CIF)
Delay in land acquisition	0.60	0.74	0.44
Problem in land permission from central government	0.52	0.63	0.33
Change in transportation routes	0.43	0.61	0.26
Delay in transporting the materials	0.47	0.60	0.29
Change in design	0.54	0.68	0.37
Delay in design by the firm	0.48	0.60	0.29
Improper soil condition in the terrain	0.65	0.73	0.47

Improper soil bearing capacity	0.66	0.76	0.50
Having black cotton soil	0.70	0.82	0.57
Increase in rates of materials	0.50	0.66	0.33
Change in some government policies	0.41	0.54	0.22
Extreme weather conditions	0.56	0.67	0.38
Improper storage for materials	0.51	0.62	0.32
Delay in mobilization of equipment	0.48	0.60	0.28
Widening of roads	0.44	0.52	0.23
Delay in lab construction	0.42	0.48	0.20
Delay in receiving lab equipment	0.51	0.54	0.27
Electricity risk	0.72	0.81	0.58
Safety issue related to heights	0.62	0.67	0.41
Improper site management by safety engineer	0.53	0.68	0.36
Moving objects which are hazardous	0.58	0.72	0.42
Delay in payment from the client	0.68	0.67	0.45
Risk in cost overrun of budget	0.65	0.75	0.49
Fluctuation of exchange rates	0.55	0.57	0.31

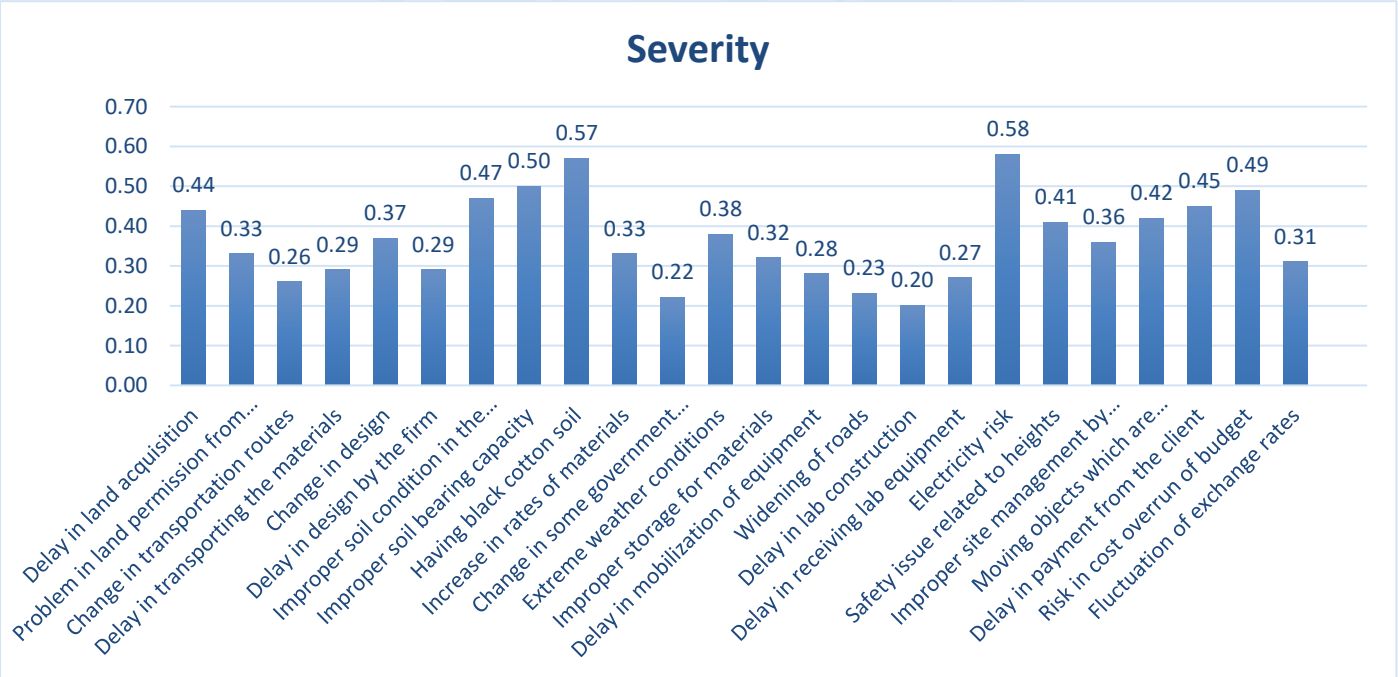
Table 4 Questionnaire response



Graph 2 CLF



Graph 3 CIF



Graph 4 Severity

d) Risk Matrix:

The risk matrix is used to assess risk and determine the level of risk based on the likelihood or possibility category and the impact of the activity on the severity category. This is a simple mechanism to increase risk transparency and support management in Decision making.

	Negligible	Inconsequential	Bearable	Consequential	Disastrous
Very high					Change in design Improper soil condition in the terrain Improper soil capacity Having black cotton soil Electricity risk Delay in payment from client Risk in cost overrun of budget
High			Problem in land permission from central government Improper storage for materials	Delay in land acquisition Delay in mobilization of equipment Delay in receiving lab equipment	Increase in rate of materials Extreme weather conditions Safety issue related to height Improper site management by safety engineer Moving objects which are hazardous
Medium			Delay in lab construction	Change in transportation routes Delay in transporting the materials	

				Delay in design by the firm Change in some government policies Delay in mobilization of equipment Widening of roads	
Low					
Very Low					

VIII. CONCLUSION

This paper concludes that, identification and analysis of various hazards related to infrastructure projects like canal is a very important step to carry before starting of the project. Starting from sub-structure to super-structure there are ample types for dangers present in every type of construction project. If one can get a proper insight of the project by identifying and analyzing of multiple risk factors then we save time, energy and cost of various things and also the project is carried out safely without any person hurting themselves.

In this study, observation was done across various types of minor and major risks which were related to canal work by doing a feasibility study. The hazards which we found should be very carefully handled or else it will have a direct impact on the infrastructure project which will affect cost and efficiency of the project. Firstly 10 major hazard factors were chosen and then each and every factor was bifurcated and further studied.

For the data collection, the researcher have used quantitative method. In this method google forms were distributed to engineers and contractors. The google sheet got several responses of probability and impact of various risk factors. From that the researcher sorted out the top five factors which are likely to affect the project majorly are (1) Electricity risk (2) Having black cotton soil (3) Delay in payment from client (4) Improper soil bearing capacity and (5) Improper soil condition in the terrain. Whereas the impact of these five factors is high as well.
The data analysis is done by both quantitative and qualitative methods. Quantitative methods include probabilistic analysis and risk severity analysis, while risk matrix method is included in qualitative.

Risk severity methods gave us two highest affecting factors which were (1) Having black cotton and (2) Electricity risk. Other risks which were as major but lower than the first two ones were (1) Improper soil bearing capacity (2) Change in design and (3) Change in transportation routes. So, we can say that these were the top five factors from risk severity analysis. Furthermore, when conducted risk matrix method, seven factor emerged out as catastrophic and they were (1) Change in design (2) Improper soil condition in the terrain (3) Improper soil capacity (4) Having black cotton soil (5) Electricity risk (6) Delay in payment from client (7) Risk in cost overrun of budget. Apart from that, I have listed out the top three factors which were dangerous in both the methods and also common in their respective highest affecting factor were (1) Electricity risk (2) Having black cotton soil and (3) Change in design.

In this paper, the total factors which were taken was 24. Out of that the most dangerous and affecting ones are mentioned above. There are few hazards there which are negligible and inconsequential but that doesn't mean that it should be ignored. Everyone knows that risk is very highly involved in construction industry, so as a precaution factor all the risks should be considered from minor to major and it should be analysed at a proper time or else it will affect the project time and cost. Sometimes, some hazard factors may end up taking lives of some personal which is very huge loss for the family members be it a small labour or a chief engineer working on site.

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