Risk Assessment in Construction of Highway Project

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Abstract **- Risk assessment is necessary for the planning and management of risks to minimize the adverse impacts of risks involved in highway construction. Risk factors are involved at every stage from designing and planning stages to completion of project. To enhance successful performance on highway construction projects, risk factors of the projects have to be identified, assessed, and minimized for scheduled, safe and cost-effective completion of the projects. This study involves identification, classification, and assessment of various risks in construction of highway projects using Relative Importance Index (RII). Further, risk factors are ranked according to their impacts.**

Index Terms **- Risk Assessment; Planning; Management; Risk; Identification of Risk, Impact.**

I.INTRODUCTION

Risk is involved in every aspect, and the construction of highway projects are no exception. Risk is defined as the possibility of loss, injury, disadvantage, or destruction also as a combination of the probability of frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence. Risk assessment is a stepwise procedure consisting of risk identification, risk classification and risk analysis or evaluation. Risk assessment is determination of quantitative or qualitative estimate of risk.

Highway projects consist of many risks, and this is due to involvement of many contracting parties including designers, contractors, sub-contractor, and suppliers. Risks are the major cause of poor performance.

on highway construction projects. Construction of highways involves various risk factors from designing and planning stages to completion of project. Due to these factors, there are delays in completion of project which involve large funds. So, risk assessment consisting of risk identification, risk classification and risk analysis or evaluation is necessary for maintaining cost and quality of the project and for scheduled completion of the project.

The solution to a decision-making problem of budget allocation problem, to allocate funds to deserving and competing organizations can be done by using regression analysis and Fuzzy techniques. The major risk factors affecting highway construction project cause delay in making decision and land acquisition. Hence it needs to deploy the use of proper risk management. The most significant risks include inefficient planning, unexpected ground utilities, quality and integrity of design, and delays in approvals.

Risk assessment for highway construction project is done to prevent adverse impact at the design or planning stage, prioritize hazards and control measures, to maintain cost and quality of the project and for scheduled completion of the project. This study involves risk identification, risk classification, risk analysis or evaluation and ranking of risks using Relative Importance Index (RII).

Risks are tangled in each case and highway constructions are no exclusion. Risks are often said to be the causes of loss of life, field disadvantages and could ultimately also lead to carnage. Risk Assessment consists of identification of the particular risk, classification of the risk along with risk analysis and appraisal. In this both the Qualitative assessment of risk and Quantitative assessment of risk are obtained. Highway construction activities involve a lot of hazardous risks. These risks are caused due to the association of several people like the design department team, construction contractors, subcontractors, workers. These risks impose great

threat to the construction pace and performance standards.

Several risks occur mainly during initiation periods, managing periods and also in the end phases of the highway construction. These risks that occur can cause huge expenditure in case of occurrence of errors and time loss. Hence Risk Assessment consisting of identification of the particular

There are certain major risks that cause delay to the highway construction project like acquiring land, deploying correct personnel for the job along with necessary machinery. These risks can be avoided by efficient planning, using proper utilities, following quality procedures, and avoiding delayed validation.

The most huge process in risk management is the risk assessment as it involves evaluation of probability of risk occurrence. The risk assessment is done to avoid design, planning disparities and to have a control over the project related threats. By risk assessment the tasks can be prioritized for the smooth completion of the respective highway construction project. This paper is done by proper identification of several risks, classifying them, evaluating, and ranking based on the Relative Importance Index further with regression model and fuzzy logic model.

II. LITERATURE REVIEW

Alok.S Manoj.S and A.Trivedi (2016) discussed that the currently used methods for risk assessment are Brainstorming, checklist, Flowchart Delphi method, Risk significant index method. Each method of risk assessment has their limitation therefore this paper attempt to formulate integrated risk assessment tools. It was observed that currently used risk assessment methods can be integrated into new approach that can aid the decision makers applying the risk assessment effectively.

Aitwar.V, S.Kaustubh, Patel.K and Ashwini.S (2016) concluded that an effective risk assessment is determination of quantitative estimate of risks as risks are involved at every stage of highway construction project. This study provides a good understanding of the risk assessment procedure to assist in assessing the risks involved during construction.

B.A.K.S. Perera, I.Dhanasinghe and Raufdeen.R (2009) aims to research initially with twenty six risk sources , during the analysis it was found that there were a few risks that were not relevant to the two cases under study. The observance of real cases, as the literature on the subject demonstrates reveals the extent to which the environment determines construction work and the many risks to which they are exposed throughout the entire process.

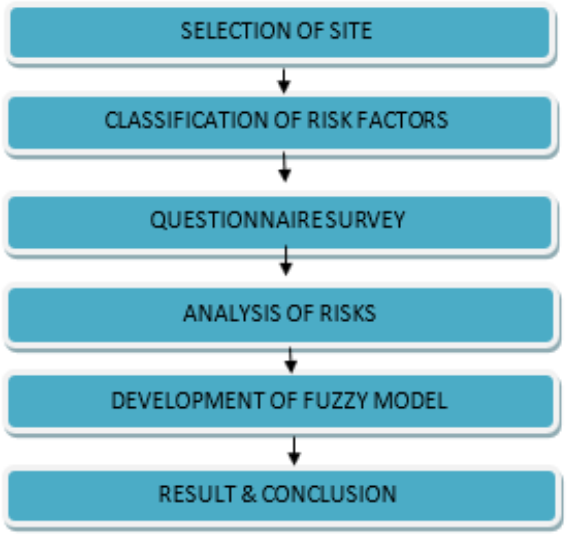
Nagalla.V, D.Satish And S.Asadi (2018) concluded the Risk ranks and importance are attained from the analysis done by using Relative Importance Index (RII). This is based on the obtained responses via the Questionnaire survey. The ranks of the risks are based on how much harm they can cause to the project. The importance of the risks is based on the obtained ranks.

Terje Aven (2016) studies on Risk assessment and risk management are established as a scientific field and provide important contributions in supporting decision-making in practice. Basic principles, theories and methods exist and are developing.

III. METHODOLOGY

Risk is defined as the potential for complications and problems with respect to the completion of a project and the achievement of a project goal. The aim of the risk assessment is to identify hazards, after which it may be possible to treat risk, thereby preventing them. Regression analysis using SPSS and fuzzy analysis using MATLAB were used in this study for developing the models.

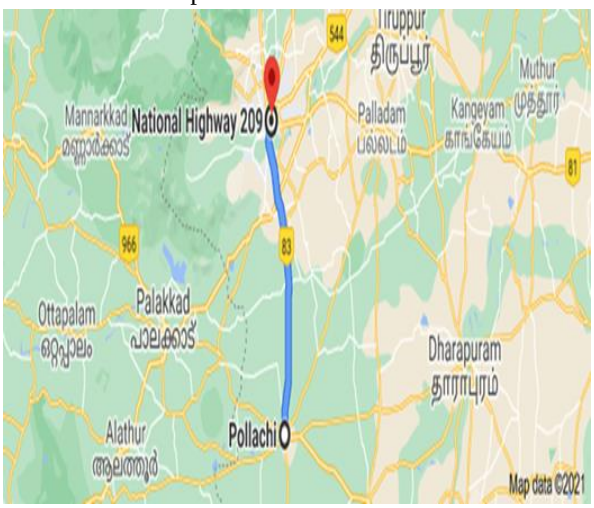
The methodology of this study is explained through the flow diagram of work:



The site location were decided for risk analysis are as follows:

SITE:

1. Name: Upgradation of Pollachi to Coimbatore section of NH-209
2. Location: POLLACHI - COIMBATORE
3. Project Value: ₹ 414 crores
4. Length of the Road: 26.850 Km
5. Number of Lanes: 4 Lane
6. Width of the road: 9 M
7. Year of Completion: MAY 2021



CLASSIFICATION OF RISKS:

Various risk affecting factor are identified and classified as follow:

a. CONSTRUCTION RISK:

Most risks associated with the construction are more likely to root in contractors and subcontractors. To keep the construction work on track, experienced contractors need to be involved in the project as early as possible to make sound preparations for developing valid construction programs. Machineries, delay due to rain and other causes, uncertain market conditions, contractor productivity issues, time etc. are the risks which construction phase constitutes.

b. DESIGN RISK:

This may result from issues such as variations in design and defective designs. The design risks arise due to uncertainty in horizontal alignment, 23 uncertain indirect costs and consideration of improper basic parameters while designing. To avoid defective design, the design team needs not only to fully understand what the clients want as defined in the project brief, but also to establish an efficient communication scheme among the designers. solution. The magnitude of the EMF is also depended on the temperature of the solution.

c. ACCIDENTAL RISKS:

Unanticipated damage during construction is a accidental risk. Any type of accidents on construction sites like machineries accidents, overexertion, accidental falls etc. can be disastrous for the project.

d. ORGANIZATIONAL RISKS:

Lack of skilled labour, lack in knowledge level of lead group, etc. are the example of organizational risks. Lack of skilled labour can lead to project delays, poor workmanship, safety and liability issues.

e. TIME/FUNDS:

As time and cost are always closely correlated, a lengthy schedule will undoubtedly wreck the project cost benefit. Correlation between time and cost is a quantitative risk. In extreme cases the risk of time and cost overruns can compromise the economic viability of the project, making a potentially profitable investment untenable.

f. UNCERTAIN MARKET CONDITIONS:

Uncertain market conditions usually called as ―price inflation of construction materials‖ is identified to be related to external environment. The 24 price of construction materials is always changing in response to the inflation and the relation between supply and demand in the construction material market. As this risk is usually unavoidable, clients should choose an appropriate type of contract, while contractor should always avoid using fixed price contracts to bear the risk.

g. UTILITIES:

Utilities include: electricity, gas, water, fuel, etc. which plays a huge role in construction projects completion; shortage of these utilities would create problems on site. For example, use of ground water is prohibited by government agencies for highway construction projects in India.

PREPARATION AND ANALYSIS OF QUESTIONNAIRE SURVEY:

Various literatures were studied and based on the preliminary investigation conducted at the outset of this study. A questionnaire was then drawn up and was divided into two sections. Section A sought to know the general particulars of the respondents while section B includes various risk factors. A five-point scale is adopted to facilitate ranking exercise and to facilitate the analysis of the responses, the following numerical values were assigned to the respondents' ratings. They were very low-1, low-2, medium-3, high-4, very high-5. The questionnaire survey was carried out among three groups of construction practitioners which are clients, consultants and contractors related to road construction.

Templates of sample questionnaire survey is given below:

QUESTIONNAIRE SURVEY

Researcher - based Questionnaire on risk factors affecting the construction site Four-Laning Of Thalessery - Mahe National Highway (NH) Bypass, Kerala.

Section A

RESPONDANT PROFILE

Name Of The Responder : PIUS ANTONY

Phone : 9486720196 Email : piusa_04@gmail.com

Years Of Experience : 14

Position And Company :

GENERAL MANAGER,

EKK INFRASTRUCTURE LTD

Section B

Risk- Related Factors

Direction :please check and rate yourself honestly based on what you actually feel given in the statements using the following scales.

1.very low risk 2. Low risk 3. Medium risk 4 - High risk 5 -very high risk

S.NO	TYPE OF RISK	1	2	3	4	5
	TECHNICAL RISK (design risk)					
1.	Inadequate design					✓
2.	Inadequate specification					✓
3.	Inadequate site Investigation				✓	
4.	Lack of risk management			✓		
5.	Complexity of project		✓			
6.	Improper estimation of time and cost			✓		
7.	Poor safety procedures			✓		
8.	Misinterpretation of traffic data			✓		
	ORGANISATIONAL RISK					
9.	Intense competition at tender stage			✓		
10.	Efficiency of managers or supervisors	✓				
11.	Lack of specified arbitrators	✓				
12.	Change of supervisors	✓				
13.	Poor performance of contractors			✓		
14.	Improper distribution of roles and responsibility			✓		
15.	Conflict between executives			✓		
16.	Stakeholders disputes over changes	✓				
17.	Contractor problem and inadequate experience			✓		
	CONSTRUCTION RISK					
18.	Change in scope	✓				
19.	Change in construction procedure	✓				
20.	Delay in material procurement				✓	
21.	Poor quality of material				✓	
22	Change in laws and regulation			✓		
23.	Excessive labour and material movement				✓	
24.	Lower work quality				✓	
25.	Dewatering due to change in water table			✓		
26.	Insufficient resource availability				✓	
27.	Rework due to error in execution					✓
28.	Unskilled labours and poor labour productivity				✓	
29.	Diversion of existing traffic					✓
	FINANCIAL RISK					
30.	High compensation demands				✓	
31.	Unsettled and lack of project funding			✓		
32.	Change in material prices and price escalation				✓	
33.	Delay in running bill payments to the contractors			✓		
34.	Price inflation of construction materials			✓		
	ACCIDENTAL RISKS					
35.	Damage to equipment's			✓		
36.	Labour injuries	✓				
37.	Equipment and material fire and theft	✓				
38.	Removal of structures			✓		
39.	Shifting of utilities		✓			
	POLITICAL RISKS					
40.	Local citizens issue		✓			
41.	Interference of local politicians		✓			
42.	Delay in environmental and forest clearance			✓		
43.	Law and order problems		✓			
44.	Land acquisition					✓
	ENVIRONMENTAL ISSUE					
45.	Weather implications		✓			
46.	Natural disasters			✓		
47.	Management of large construction waste			✓		
48.	Pollution and safety rules			✓		
49.	Forest clearance				✓	
50.	Any natural obstructions			✓		
	UTILITIES ISSUE					
51.	Insufficient fuel			✓		
52.	Does cost of minerals high				✓	

ANALYSIS OF RISKS:

The data collected through questionnaire survey was analyzed by using quantitative method of relative importance index (RII) on a excel sheet. The RII is computed using the equation given below:

$RII = \sum W / (A*N) \quad (0 \leq RII \leq 1)$

Where:

W – is the weight given to each risk by the respondents and ranges from 1 to 5, (where 1‖ is very low risk, 2 ‖ is low, 3 is moderate, 4 is high and 5‖ is very high risk)
A – is the highest weight (i.e. 5 in this case) and;
N – is the total number of respondents. The various risks categorized under different categories were calculated and ranked. The higher value of RII represent significant risks affecting construction of highway project.
After the calculation by using RII, the risks are ranked accordingly listed below:

Risk Category	Risk No.	Risks	RII	Risk Rank
Technical (Design)	R1	Inadequate design	0.937142857	3
	R2	Inadequate specification	0.948571429	2
	R2	Inadequate site investigation	0.84	6
	R4	Lack of risk management	0.765714286	8
	R5	Complexity of project	0.297142857	47
	R6	Improper estimation of time and cost	0.445714286	30
	R7	Poor safety procedures	0.371428571	35
	R8	Misinterpretation of traffic data	0.622857143	13
Organizational	R9	Intense competition at tender stage	0.314285714	44
	R10	Efficiency of managers or supervisors	0.342857143	41
	R11	Lack of specified arbitrators	0.337142857	43
	R12	Change of supervisors	0.354285714	38
	R13	Poor performance of contractors	0.514285714	19
	R14	Improper distribution of roles and	0.485714286	24
	R15	Conflict between executives	0.348571429	40
	R16	Stakeholders disputes over changes	0.365714286	37
	R17	Contractor problem and inadequate experience	0.457142857	28
Construction	R18	Change in scope	0.228571429	52
	R19	Change in construction procedure	0.302857143	46
	R20	Delay in material procurement	0.485714286	24
	R21	Poor quality of material	0.548571429	17
	R22	Change in laws and regulation	0.377142857	34
	R23	Excessive labour and material movement	0.502857143	20
	R24	Lower work quality	0.742857143	10
	R25	Dewatering due to change in water table	0.4	33
	R26	Insufficient resource availability	0.52	18
	R27	Rework due to error in execution	0.96	1
	R28	Unskilled labours and poor labour productivity	0.76	9
	R29	Diversion of existing traffic	0.937142857	3
Financial	R30	High compensation demands	0.782857143	7
	R31	Unsettled and lack of project funding	0.605714286	14
	R32	Change in material prices and price escalation	0.645714286	12
	R33	Delay in running bill payments to the	0.502857143	20
	R34	Price inflation of construction materials	0.571428571	15
Accidental	R35	Damage to equipment's	0.371428571	35
	R36	Labour injuries	0.245714286	50
	R37	Equipment and material fire and theft	0.245714286	50
	R38	Removal of structures	0.342857143	41
	R39	Shifting of utilities	0.308571429	45

Risk Category	Risk No.	Risks	RII	Risk Rank
Political	R40	Local citizens issue	0.257142857	49
	R41	Interference of local politicians	0.262857143	48
	R42	Delay in environmental and forest clearance	0.48	26
	R43	Law and order problems	0.354285714	38
	R44	Land acquisition	0.897142857	5
Environmental	R45	Weather implications	0.428571429	31
	R46	Natural disasters	0.411428571	32
	R47	Management of large construction waste	0.502857143	20
	R48	Pollution and safety rules	0.451428571	29
	R49	Forest clearance	0.68	11
	R50	Any natural obstructions	0.497142857	23
Utilities	R51	Insufficient fuel	0.474285714	27
	R52	Does cost of minerals high	0.554285714	16

DEVELOPMENT OF FUZZY MODEL:
For developing fuzzy model firstly define input and output variables, here the input variables are critical factors, and the output is considered as risk. Then define linguistic variables like very low, low, medium, high and very high and the shape of the membership function is considered as triangular because of its simplicity. The operator used in the study is AND operator. Set up different mamdani style fuzzy inference rules and assigning weights to the rules. In this study, the defuzzification method was selected as Center of Gravity (COG) Method and aggregation method was selected as ―max‖ (maximum). Fuzzy Logic Toolbox software is a collection of certain functions built on the MATLAB. It provides tools to create and edit fuzzy inference systems within MATLAB software.

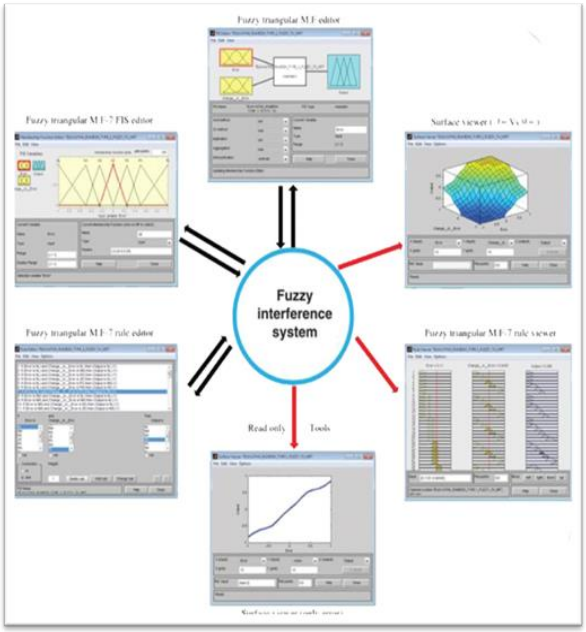


Fig 1: Graphical User Interface tool (GUI) for fuzzy model

ANALYSIS USING FUZZY:
In this paper fuzzy logic model is used for the analysis of the risks. There are basically two steps for analyzing data in Fuzzy logic toolbox

- Fuzzification
- Defuzzification

FUZZIFICZTION:

- The severity is calculated using mere multiplication of probability of occurrence and impact.
- The input membership functions are defined using triangular membership function.
- The range 1 to 5 is opted for the input variables.
- The conversion of input into fuzzy is termed as fuzzification's input terms are shown in table 1 and 2.
- The output severity is also defined as triangular function ranging from 1 to 100.it is shown in table 3.

Table 1: Fuzzy set representation for each linguistic term of Probability (P).

Probability	Triangular number
Very low	(1,1,2)
Low	(1,2,3)
Medium	(2,3,4)
High	(3,4,5)
Very high	(4,5,5)

Table 2: Fuzzy set representation for each linguistic term of Impact (I).

Impact	Triangular number
Low	(1,1,2)
Medium	(2,3,4)
High	(4,4,5)

Table 3: Fuzzy set representation for each linguistic term of output.

Severity	Triangular number
Minimum	(0,0,35)
Moderate	(35,50,60)
Critical	(60,100,100)

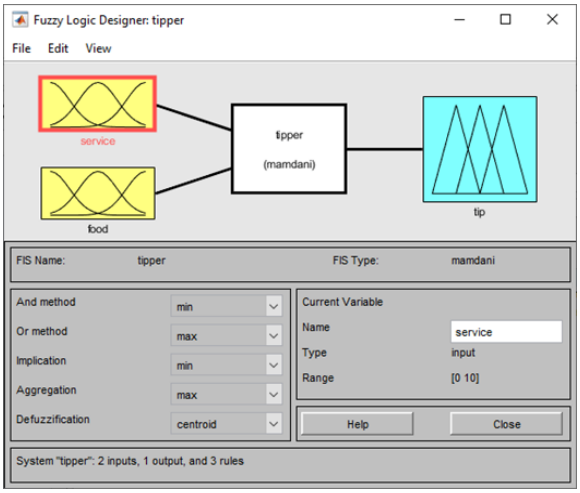


Fig 2: Sample fuzzy triangular M F editor

DEFUZZIFICATION (OUT PUT):

- Thus the defuzzification gives output i.e., the risk severity was given here as output. The severity of each and every risk factor was tabulated.
- The severity ranges from 0 to 100. The severity below 35 is said to be less severe, severity 35 to 60 represents moderately severe risks and severity above 60 represent highly severe risks which need mitigation to avoid project failure.

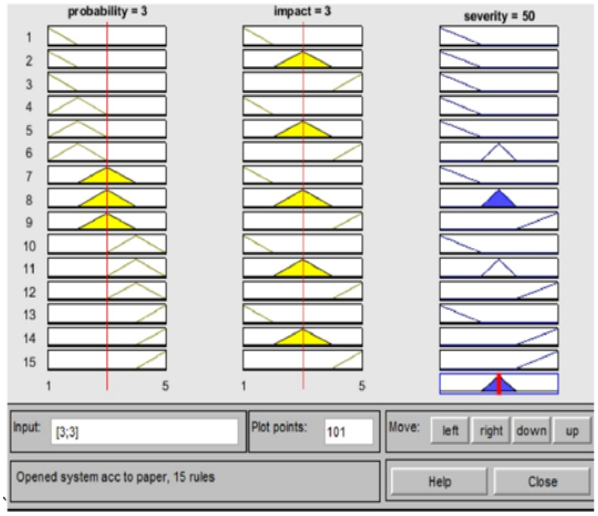


Fig 3: Rule viewer.

V. RESULT AND DISCUSSION

From the above study we find out that inadequate specification, Rework due to error in execution and the above-mentioned risks are some major unavoidable risks which need proper mitigation before actual commencement of the work.

These risks may cause project failures if not planned and mitigated in advance. The mitigation strategies to be adopted in order to mitigate the mentioned risks.

Table 4: Severity values found by fuzzy logic

Sl no.	Risk	Severity
1.	Rework due to error in execution	0.95
2.	Inadequate specification.	0.932
3.	Inadequate design.	0.921
4.	Diversion of existing traffic.	0.918
5.	Land acquisition.	0.88
6.	Inadequate site investigation.	0.85
7.	High compensation demands.	0.772
8.	Lack of risk management.	0.754

9.	Unskilled labours and poor labour productivity.	0.73
10.	Lower work quality.	0.711

The above table values are determined as the severity by using fuzzy logic in matlab , and these risks are mitigated by the several mitigation strategies i.e, risk transfer, risk reduction, risk avoidance, risk retention by the correct selection.

Table 5: Comparison between RII values and matlab values

Manual values (RII)	Matlab fuzzy values (severity)
0.96	0.95
0.948	0.932
0.936	0.921
0.931	0.918
0.897	0.88
0.84	0.85
0.782	0.791
0.765	0.754
0.75	0.73
0.742	0.711

From the above table we found out the difference between relative importance index (RII) values and matlab values that is obtained by fuzzy logic for finding the error for our calculation.

V. CONCLUSION

- The Systematic risk management helps in managing the risks occurring during any project on time so as to avoid the impact on any of the project objectives.
- If risks are not managed on time it may lead to adverse effect on the project objectives which may even lead to project failure sometimes.
- Fuzzy logic models were developed in order to evaluate project risk. Results of the fuzzy model indicated that the most significant risk factors are mentioned above, and these risks are found for the Pollachi-Coimbatore high way.
- These risks will vary based on the highways on the different states and we found outed risks mentioned above in table 4.
- The relative importance index is being used for finding such risks but if we use this fuzzy logic in matlab will give more accurate and time saving.
- We can use direct fuzzy logic in matlab after questionnaire survey for time saving.
- In this paper we showed both RII and matlab values for the comparison.
- The proposed model in this study helps to analyze the risks and manage them beforehand thus helping the manager to plan the risks and try to mitigate them even before the commencement of the project.

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