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Article

Potential risk factors affecting cost and schedule performance in the case of construction projects in Dire Dawa city administration and Harari region, Ethiopia

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Abstract: Construction projects are inherently fragmented and complex, influenced by various risk factors that can significantly affect both costs and schedules. Identifying and prioritizing these risk factors is crucial for enhancing project management and achieving successful outcomes. This research aimed to identify the most significant risk factors affecting construction projects in terms of cost and schedule performance within the Dire Dawa City Administration and Harari Region, considering the perspectives of contractors, clients, and consultants to provide actionable insights for risk mitigation. A comprehensive literature review and pilot survey initially identified 41 risk factors, which were refined through an iterative process to select 42 factors for a detailed questionnaire survey. Additionally, semi-structured interviews were conducted to gather qualitative insights. Data analysis employed mean ratings to identify the top ten risk factors, utilizing Probability Impact (P-I) Matrix and regression techniques to assess each factor's significance. The results highlighted six critical risk factors among the ten identified as most impactful: inflation, increases in material prices, exchange rate fluctuations, payment delays, poorly coordinated design, and material delays. The findings indicated strong positive correlation values (R = 0.800 and R = 0.840) in both models, suggesting that as one variable increases, the other tends to increase as well. These insights provide valuable guidance for project managers, emphasizing the need to focus on these critical risk factors to improve cost and schedule management, ultimately enhancing project outcomes and minimizing cost overruns in the region.

Keywords: construction projects; cost and schedule impact; potential risk factors; probability impact matrix; risk management; risk response

1. Introduction

The construction industry's complexity, financial intensity, and diverse collaboration expose it to risks that can affect project goals such as completion time, budget, quality, sustainability, and safety [1]. Previous research has acknowledged that project risk stems from uncertainties affecting the entire project, encompassing both individual risks where stakeholders face the consequences of varied project outcomes, whether positive and negative [2–4]. According to the International Organization for Standardization (ISO 31000:2009), risk is described as the effect of uncertainty on objectives, while risk analysis is the process of understanding the nature of risk and determining its level [5].

One of the issues facing the construction industry in developing nations is cost and schedule overruns [6,7]. Given that risk assessment and the use of appropriate management practices are at a highly critical stage, Ethiopian construction companies face a number of significant risks that require careful attention to address [8]. In addition, there is a lack of effective implementation of the risk management model that involves risk management planning, identification, assessment, response, and monitoring in the Ethiopian construction projects [9]. Risk analysis includes evaluating the likelihood of identified risks and their severity on a project [10]. Effective risk management is crucial for understanding how the advantages and disadvantages of risks affect the success or failure of project objectives [11]. By implementing robust risk management practices, organizations can navigate uncertainties more effectively and enhance their ability to achieve project goals [12].

Identifying the potential risk factors is the most important stage to manage the occurrence and probability of the factors in a construction project. To identify the most relevant factors, this research commenced different stages of screening from the perspective of project stakeholders, including contractors, clients, and consultants. A mean rating was applied to rank the selected factors based on the experts' judgments. Moreover, the top-ranked risk factors were also categorized using a probability-impact matrix according to their level of impact on projects for applying risk response techniques based on the severity of the factors on the projects. To further validate the impact of the factors over time and costs, the study also conducted a linear correlation analysis between the probability of occurrence of identified risk factors (i.e., the independent variable) and their impact on project cost and project completion time (i.e., the two dependent variables). This paper applied mean values to rank and categorize the impact levels of the critical risk factors (CRFs) using the Probability Impact (P-I) Matrix method, despite the research conducted that relied solely on the Relative Importance Index to rank critical risk factors [13–15]. This approach classifies the impact levels as high, moderate, or low in relation to project cost and completion time, providing a more comprehensive assessment of how these factors affect project outcomes.

The findings indicate that the variables have strong positive correlation in both models, meaning that as one variable increases, the other tends to increase as well. Moreover, prediction models also developed, and the high percentages of prediction in both models underscore the significant impact that risk factors have on construction projects in Dire Dawa city administration and the Harari region. Finally, the risk response techniques were also proposed for the top-ranked risk factors affecting the construction costs and times in the study area.

2. Literature review

The impact of risk in construction projects in developing countries, including the sub-Saharan region, specifically in Ethiopia, is severe, challenged by many more problems than developed countries [16]. Such problems lead the sector to be highly prone to various types of risks, which lags the effort in raising the industry and is very difficult and complex [9]. The level of practice in terms of safety, quality, budget, and completion time management in Ethiopian construction projects was found to be very low, and the amount of schedule slippage ranges between 61%–80% and that of planned costs deviates 21%–40% from predetermined requirements or anticipated at the beginning of the project [17].

The study area encompasses the Dire Dawa City Administration and the Harari Region in the eastern part of Ethiopia, which have been shaped by both economic and geographic challenges that reflect broader global construction risks while also being uniquely intensified by local conditions [15,18]. Economic factors such as inflation, rising material prices, and exchange rate fluctuations significantly affect the cost of construction projects in these regions [19]. Due to reliance on imported materials and the volatility of the Ethiopian birr, projects are vulnerable to sharp cost increases, leading to budget overruns [20]. It is crucial to identify the potential risk factors responsible for these issues to mitigate their effects on the construction industry. The target areas are geographically close and may face similar challenges. Dire Dawa and the Harari Region present difficulties for construction projects, particularly due to challenging site conditions and inadequate infrastructure [19,21]. This causes similar problems to impact the target locations, which hinders construction progress and delays the project's completion [22]. The goal of this study is to identify potential risk factors that could be responsible for schedule and cost overruns in construction projects.

2.1. Selections of potential risk factors in the construction industry

Through an extensive review of various literatures, 41 major risk factors affecting construction projects were identified and are illustrated in **Table 1** from the perspective of project stakeholders, including contractors, clients, and consultants. These elements were determined and grouped according to how frequently they cited as prevalent dangers impeding the successful completion of construction projects [10]. This categorization reflects a synthesis of multiple studies, highlighting the most prevalent risks that affect project performance. Experts in the field participated in a pilot survey aimed at further validating these factors. This survey assessed the relevance of the identified risk factors to the specific study area and allowed for the inclusion of additional factors that were not listed initially but were deemed significant by the industry's professionals.

Table 1. List of major risk factors identified from literatures.

Risk Category	**Risk Factors**	**Authors**
Financial Risk	Financial failure of the contractor Payment delays Exchange rate fluctuation Inflation, Increase of Material price Increase of Labor costs	[23], [24], [25], [26], [27]
Construction Risk	Construction procedures Actual quantity differs from the contract Rush bidding Gaps b/n implementation and specification Construction cost overruns Site condition Equipment failures, Lower work quality due to workman ship Lower work quality due to time constraint Labor productivity Technology changes	[28], [29], [30], [31], [32]

Table 1. (*Continued*).

Risk Category	Risk Factors	Authors
Design Risk	Design changes Design errors and omissions Design process takes longer than anticipated Lack of consistency between BOQ and drawings Not coordinated design	[7], [24], [33], [34], [35]
Socio-political Risk	Legal disputes among parties in contract Language/Cultural barrier Security problems Public objections	[7], [36], [37], [38], [39]
Physical Risk	Supplies of defective material Damage to equipment Damage to structure Pollution and safety rules Labor injuries	[13], [35], [40], [41], [42]
Organizational and Managerial Risk	Resource management Project team conflicts Scheduling errors Contractor's experience Failure to comply contractual requirements Poor communication between parties Inexperience work force Attitudes of participants	[39], [43], [44], [45], [46]
Logistics Risk	Unavailable labor/material/equipment Transportation problem to site	[13], [42], [47], [48], [49]

A pilot study serves as a crucial component in the execution of larger projects, aimed at gathering data to mitigate risks associated with new products and their production processes [50]. By initiating the implementation phase with a pilot study, organizations can refine their plans before fully committing, ultimately saving time and resources. Beyond merely enhancing research instruments like questionnaires, pilot studies play a vital role in ethnographic approaches, where they help identify potential research problems, highlight gaps in data collection, and address significant issues such as validity, ethics, representation, and researcher safety [12]. Testing research questions on a small group of participants can also provide valuable insights into whether the questions effectively meet the study's objectives [50].

2.2. Risk response

After completing a qualitative and/or quantitative risk analysis, the next stage is risk response, which is the process of formulating plans of action to mitigate risks and increase opportunities for the project's goals [51]. It includes the identification and assignment of individuals or parties to take responsibilities for each agreed risk response, and the chosen response corresponding to the identified risk should be financially cost-effective, timely to be successful, realistic within the project scope and context, expected quality, acceptable by involved parties, and owned by a responsible person [52]. In general, the responses should focus on risks with a high likelihood of occurrence and/or severe repercussions relative to the stated project objectives [53]. Risk avoidance, risk transfer, risk mitigation, and risk acceptance are the four most frequently used strategies (for threats) in responding to risks identified in projects, according to the majority of risk management guidelines [54].

3. Research methodology

The choice of research design in this study was a mixed-methods approach, in which data collection techniques and analysis procedures were implemented using both quantitative and qualitative methods sequentially [55]. The research uses both primary as well as secondary data sources. First, the secondary data obtained from different literatures were used to determine sort of risk factors that could have a high probability of occurrence and affect construction projects in terms of cost and completion time [56]. Accordingly, 41 risk factors were determined from the reviewed literature. Then a pilot survey was conducted with a selected group of construction experts to test whether the collected risk factors were relevant to the study area and to include additional factors that were not comprised during the literature review [57]. Conduction of preliminary analysis using a pilot survey supports obtaining some assessment of the reliability and validity of the collected data [58].

To meet the research objectives and maintain a coherent flow, the study commenced with a qualitative risk analysis to categorize identified risk factors based on their impact levels (high, moderate, and low) on project objectives such as cost and time, utilizing a probability impact matrix (P-I matrix) derived from questionnaires completed by respondents [59]. Following this, a quantitative analysis method was employed to rank these categorized risk factors quantitatively, focusing on key metrics such as probability of Risk (POR), Impact Rating of Cost (IRC), and Impact Rating of Time (IRT), which facilitated the identification of the top ten critical risk factors (CRFs) affecting project objectives [1]. This quantitative approach emphasized objective measurement through a questionnaire survey, employing statistical and graphical techniques to generate numerical results that elucidate the relationship between the likelihood of identified risks and their effects on project costs and timelines [17]. In addition, a descriptive approach summarized data from the sample, while inferential statistics allowed for broader population inferences [58,60].

The research also utilized non-standardized, semi-structured interviews to delve deeply into respondents' attitudes and opinions regarding management practices, providing a rich source of qualitative data [58,60]. This interview format facilitated flexibility and encouraged open-ended responses, allowing for a comprehensive understanding of perceptions without researcher bias [61]. By correlating variables and employing regression analysis to explore their relationships, the study systematically identified critical risk factors with the highest likelihood of occurrence and their anticipated impacts on project costs and completion times [62]. Subsequently, reaction strategies for each risk factor were analyzed, pinpointing effective response strategies for those with high impact scores [63].

This research employs expert validation to assess the relevance of risk factors determined from various literature sources prior to the pilot survey questionnaire [50]. This approach ensures that the gathered risk factors are both valid and applicable to the study area. The number of participants in a pilot survey should be adequate to capture significant variations from the population that may influence responses [12].

Accordingly, ten experts were invited to evaluate the collected risk factors and to identify any additional factors not previously considered. Eligible participants were selected based on a minimum of 11 years of work experience in various construction roles and a Bachelor of Science degree in a construction-related field [57]. Based on the experts' feedback, nine risk factors were eliminated, including factors such as lower work quality due to workmanship, technology changes, changes in laws and regulations, pollution and safety rule violations, labor injuries, damage to structures, contractor experience, participant attitudes, and transportation problems. Conversely, ten new risk factors were added: undocumented change orders, excessive approval procedures in government departments, tight project schedules, security issues at construction sites, local community support, pandemic-related risks, material theft, changes in top management, delays in material arrivals, and equipment shortages. As a result, 42 major risk variables were ultimately determined to be specific to the Harari region and the city administration of Dire Dawa, as shown in **Table 2**.

Table 2. Selection of risk factors from pilot survey.

Description	No. of Risk Factors
Determined risk factor from literatures	41
Eliminated factors from pilot survey	9
Recommended risk factors from pilot survey	10
Total selected risk factors for the research	42

The questionnaire was designed based on the findings of the pilot study and given to 95 participants, comprising important experts, contractors, consultants, and client companies that are involved in construction projects. This survey utilized both closed and open-ended questions to ensure comprehensive data collection.

Three sections made up the design of the questionnaire. General participant information was included in the first section, and five points of Likert scaled questions were also contained in the second. The study utilized Likert-scaled questions to ascertain the likelihood of selected risk variables occurring and their impact on project cost and completion time. On the other hand, each risk factor's response strategies were covered in the third section. Out of the questionnaires that were distributed, 73 respondents completed them in accordance with the instructions. The data of the other 22 respondents was not analyzed because 10 of them provided incorrect information, and 12 of them failed to submit the survey on time. The responses can be regarded as satisfactory for this kind of survey [55]. **Table 3** provided an illustration of the experts' backgrounds for participation.

Table 3. Experience level, educational background and project type of respondents.

Years of experience	Number	Educational level	Number	Project type	Number
0 to 5	0	Diploma holders	3	Building	38
6 to 10	43	BSc. holders	46	Road	21
10 to 15	24	MSc. Holders	24	Water	14
Above 16	6	PhD holders	0	Others	0
Total	73		73		73

To ensure a complete and meaningful set of responses, a semi-structured interview was also conducted in addition to the questionnaire survey [60]. To determine the number of sample units, a sample of 5 to 25 participants for semi-structured interviews, thus a sample size of 20 respondents, was determined in this research [64]. The purposive sampling method was chosen to conduct the interview with the selected participants who were eligible to fulfill a minimum of five years of work experience in the construction sector [65].

In this study, the risk mapping matrix was developed to help to classify each of the causing factors under specific risk zones [59]. Both the probability and impacts of each risk factor were assessed from very low (VL) to very high (VH) by their rates and combined through the probability-impact matrix (P-I matrix) as shown in **Figure 1** to order risks as low (L), moderate (M), or high (H) priorities [66]. Such classification was made based on the mean values of probability of occurrence of identified risks, impact of identified risks on project cost, and impact of identified risk on project completion time (Catyanadika and Isfianadewi, 2021) Equation (1).

$$\text{Mean Rating} = [\textstyle\sum \text{W}_{(i = 1 - 5)} \times F_{\text{i}}]/n \quad (1)$$

where, 'W' is weight scaled value of response for the specified project risk; 'F_{i}' is Frequency of the ith response; 'n' is total Number of respondents to the specified project risk; and 'i' is response scale value = 1, 2, 3, 4 and 5 for very low risk, low risk, moderate risk, high risk, and very high risk respectively.

Impact of Risk on Project Cost/Completion Time

Probability of Occurrence of Risk		VL	L	M	H	VH
	VH	M (VH,VL)	M (VH,L)	H (VH,M)	H (VH,H)	H (VH,VH)
	H	L (H,VL)	M (H,L)	M (H,M)	H (H,H)	H (H,VH)
	M	L (M,VL)	L (M,L)	M (M,M)	M (M,H)	H (M,VH)
	L	L (L,VL)	L (L,L)	L (L,M)	M (L,H)	M (L,VH)
	VL	L (VL,VL)	L (VL,L)	L (VL,M)	L (VL,H)	M (VL,VH)

Figure 1. The scale used to map a risk factor's occurrence and impact.

1) Green: Low risks and minimum oversight needed to ensure risk remains low.
2) Yellow: Moderate importance and different approaches can be required. Additional management attention may be needed.
3) Red: Unacceptable and different approaches are required. Priority management attention is required.

4. Data analysis and discussion of results

4.1. Measure of reliability

In this study, the measures of internal consistency of a given scale, i.e., the extents to which the items included in the scale were correlated and evaluated, were measured using Cronbach's alpha techniques [67]. A cut-off value of 0.7 was taken to designate an acceptable level of internal consistency [68]. According to the result of the analysis, it can be inferred that the questionnaire used in this research was reliable, as the alpha values for the reliability analysis under the mentioned factor categories were determined to be above 0.7 (see **Table 4**).

Table 4. Reliability test using Cronbach's Alpha.

No.	Group Risk Factors (RFs)	No. of Risk Factors	Cronbach's Alpha Result		
			Probability of Occurrence	Impact on Cost	Impact on Time
1	Financial Risk	6	0.738	0.719	0.713
2	Construction Risk	10	0.839	0.773	0.758
3	Design Risk	7	0.858	0.794	0.774
4	Socio-political and Legal Risk	5	0.798	0.800	0.817
5	Physical Risk	4	0.756	0.708	0.746
6	Organizational and Managerial Risk	7	0.838	0.766	0.753
7	Logistics Risk	3	0.721	0.716	0.709

4.2. Ranking of identified risk factors using mean rating value and probability impact (P-I Matrix)

The selected major risk factors were prioritized based on the mean values obtained from the questionnaire result. The factors with the highest rankings are those most likely to have an impact on construction projects in terms of probability of occurrence (i.e., POR) as well as their impact on project cost and time (i.e., IRC and IRT, respectively). The top ten factors were then taken into account as critical risk factors (i.e., CRFs) in the study area's construction projects. The ranking of each factor was intended to assist project engineers in providing a clear vision for construction implementation activities, discovering associated risk factors, and assessing how those factors would ultimately affect the project's goal in terms of cost and completion date [3].

The potential risk factors were ranked according to their mean values using Equation (1), as shown in **Table 5**.

Table 5. Ranking of major project risks factors based on mean rating values.

S/N	Potential Risk Factors		Prob. of Occur. (POR)		Impact on Cost (IRC)		Impact on Time (IRT)	
			Mean	Rank	Mean	Rank	Mean	Rank
RF1.1	1. Financial	Financial failure of the contractor	2.59	42	3.32	9	2.67	42
RF1.2		Payment delays	3.35	5	3.58	4	3.37	7
RF1.3		Exchange rate fluctuation	3.46	3	3.64	3	3.38	6
RF1.4		Inflation	3.63	2	3.92	1	3.42	2
RF1.5		Increase of Material price	3.88	1	3.69	2	3.51	1
RF1.6		Increase of Labor costs	3.01	23	3.18	15	3.03	26
RF2.1	2. Construction	Construction procedures	2.78	40	2.87	41	2.82	40
RF2.2		Actual quantity differs from the contract	2.9	33	2.97	35	2.88	37
RF2.3		Rush bidding	2.87	38	2.88	40	2.81	41
RF2.4		Gabs b/n implementation and Specification	2.87	37	3.08	26	2.94	35
RF2.5		Construction cost overruns	2.91	32	2.82	42	3.00	28
RF2.6		Difficult site condition	3.29	7	3.18	15	3.24	13
RF2.7		Equipment failures	3.44	4	3.21	14	3.41	3
RF2.8		Lower work quality due to workman ship	3.25	9	3.53	5	3.04	25

Table 5. (*Continued*).

S/N	Potential Risk Factors		Prob. of Occur. (POR)		Impact on Cost (IRC)		Impact on Time (IRT)	
			Mean	Rank	Mean	Rank	Mean	Rank
RF2.9	2. Construction	Labor productivity	2.88	35	2.90	39	3.05	24
RF2.10		Undocumented change orders	3.27	8	3.22	12	3.23	14
RF3.1	3. Design	Design changes	3.21	12	3.08	27	3.39	5
RF3.2		Design errors and omissions	3.1	18	3.15	20	3.19	16
RF3.3		Design process takes longer than anticipated	3	24	3.27	11	3.31	9
RF3.4		Lack of consistency b/n BOQ and drawing	3.15	15	3.22	13	3.29	10
RF3.5		Not coordinated design	3.1	18	3.36	7	3.36	8
RF3.6		Excessive approval procedures	2.99	26	3.17	19	3.26	12
RF3.7		Tight Project Schedule	3.04	20	3.04	30	3.18	17
RF4.1	4. Socio-political and Legal	Legal disputes among parties in contract	2.67	41	2.97	35	2.99	30
RF4.2		Language/Cultural barrier	3.01	22	3.10	23	2.96	33
RF4.3		Security problems in construction site	2.9	33	3.10	24	3.13	20
RF4.4		Public objections	2.78	39	3.09	25	3.08	23
RF4.5		Local People support for project	3.1	17	3.03	33	2.86	38
RF5.1	5. Physical	Supplies of defective material	3.04	21	3.04	31	3.09	22
RF5.2		Damage to equipment	2.99	28	3.05	29	3.00	27
RF5.3		Pandemic (COVID19)	3.21	12	3.18	15	3.19	15
RF5.4		Theft of materials at site	3.13	16	3.12	22	2.97	34
RF6.1	6. Project Management	Resource management	3.22	10	3.50	6	3.10	21
RF6.2		Project team conflicts	2.97	30	2.99	34	2.83	39
RF6.3		Scheduling errors, contractor delays	2.94	31	2.96	37	3.17	19
RF6.4		Poor communication between parties	2.97	29	2.96	38	3.00	28
RF6.5		Failure to comply contractual requirement	2.99	26	3.12	21	2.90	36
RF6.6		Inexperience work force	2.88	36	3.06	28	2.99	31
RF6.7		Change of top management	3	25	3.03	32	2.97	32
RF7.1	7. Logistics	Unavailable labor, material and equipment	3.18	14	3.18	18	3.18	18
RF7.2		Some materials do not arrive to site	3.33	6	3.28	10	3.40	4
RF7.3		Shortage of equipment	3.21	11	3.35	8	3.27	11

Analysis Results for Ranking Major Project Risk Factors Based on Mean Rating Values

From the analysis, it was found that the top three ranked critical risk factors (CRFs) based on the probability of occurrence in the study area are increase in material price, inflation, and exchange rate fluctuation. These financial risks were considered to have a high likelihood of occurring, as seen in **Table 5**. The findings are consistent with other studies, such as [69], which identified material price escalation and inflation as significant economic risks in both developing and developed countries. Proper inflation forecasting is essential, and lenders often have more expertise than project developers in anticipating these risks [70]. Furthermore, exchange rate fluctuations are a major risk in large construction projects, particularly in countries where foreign capital is used, as this can devalue local currency [69].

Other significant risks identified include equipment failures, payment delays, some materials not arriving on site, difficult site conditions, undocumented change orders, lower work quality due to workmanship, and resource management challenges, which were among the top 10 CRFs in terms of probability of occurrence.

Regarding the impact of risks on project cost, the top CRFs include financial risks (such as inflation, material price increases, exchange rate fluctuation, and payment delays), construction risks (such as equipment failures), project management risks (such as resource management), design risks (like uncoordinated design), and logistics risks (such as material shortages and equipment unavailability). Whereas, financial failure of the contractor was identified as among the top 10 critical risk factors in terms of probability of occurrence. As for the impact on project completion time, the top three factors found to have the most significant influence include an increase in material price, inflation, and difficult site conditions.

Discussion of Results for Ranking Major Project Risk Factors Based on Mean Rating Values

The analysis highlights the financial risks as the most critical in construction projects, particularly material price increases, inflation, and exchange rate fluctuations. The occurrence of these risks not only affects cost but also disrupts project timelines. These findings are supported by noting that inflation and material price escalation pose significant challenges in both developing and developed countries [69]. Moreover, foreign currency fluctuations impact large projects, especially when foreign capital is involved, leading to local currency devaluation.

Inflation, a common economic challenge, demands accurate forecasting to mitigate its impact. The lender's role in inflation forecasting is emphasized, highlighting that lenders generally have more experience than project promoters in this aspect [70]. The inability to predict inflation accurately can cause delays, increase costs, and lower productivity.

The other factor, which was identified as the top critical risk factor in terms of probability of occurrence and its impact on project cost and schedule, was payment delays. In construction projects, delayed payments can significantly disrupt cash flow, leading to a cascade of financial challenges [71]. When contractors and subcontractors experience payment delays, they may struggle to meet their financial obligations, resulting in stalled work, increased borrowing costs, and even project abandonment [72]. This financial strain not only affects the contractors but can also delay project timelines and increase overall costs as resources become scarce and the workforce is affected [71].

Equipment failure was also identified as the top critical risk factor, which has a high probability of occurrence and potential impact on the schedule of a project. Moreover, equipment failures are a critical risk that can exacerbate the issues caused by delayed payments. When funds are insufficient, maintenance and timely replacement of equipment may be neglected, leading to breakdowns that halt work and extend project durations [73]. This not only affects the immediate project schedule but can also result in penalties and a damaged reputation for all parties involved [73]. Ultimately, addressing payment timeliness and ensuring proper maintenance of equipment are essential for mitigating risks and ensuring the successful completion of construction projects [72].

Other identified risks, such as difficult site conditions and equipment failures, can lead to schedule disruptions. Inflation, driven by rising material prices, labor wages, and machinery hire rates, disturbs construction project schedules [27]. Difficult site conditions often have a greater impact on project schedules than on costs, further emphasizing the importance of managing these risks [73].

In conclusion, the interplay between financial and operational risks, especially in terms of material cost, inflation, and site conditions, significantly affects the overall success of construction projects. These risks must be proactively managed to ensure timely project completion and cost control.

4.3. Ranking of identified risk factors using probability impact (P-I Matrix)

The risk matrix is one of the most helpful techniques for project risk analysis, identification, and preliminary risk assessment [74]. The matrix was created to provide risk categories based on combining impact and probability [75]. High probability and high impact risks should be subject to additional study, which should include proactive risk management and project team certification. The outcomes of the qualitative risk analysis include a ranking of the project's overall risk, a list of risks that are prioritized, a list of risks that require further research and management, and a trend analysis of the results [76].

In order to identify critical risks and their relative importance, a study was conducted and a process for prioritizing risks in construction projects that captures the uncertainty associated with risks and decision-makers' risk appetite in relation to the risk exposure zones across a risk matrix is also crucial [49]. In this study, the severity level of identified critical risk factors (CRFs) was rated and graded using a P-I matrix by categorizing them qualitatively as high, medium, or low in order to differentiate outstanding hazards towards construction projects in the study area [77]. To find the impact levels of each factor against project objectives, a P-I matrix for probability of occurrence versus cost and completion time (i.e., POR vs. IRC and POR vs. IRT) was developed based on the mean values and analyzed, respectively.

$$(N - 1)/N = (5 - 1)/5 = 0.8 \quad (2)$$

Table 6 illustrates the mean rating distances by grouping the values into five categories by employing Equation (2) as Very Low (VL), Low (L), Medium (M), High (H), and Very High (VH) [78]. This facilitates the integration of the results into a risk matrix and ascertains the extent to which the likelihood of the identified risk variables occurring influenced the project's cost and schedule.

Table 6. Scale used to rate factor for occurrence and affect risk matrix.

Scale	X-axis (Impact of Risk Factors) IRC and IRT	Y-axis (Probability of Occurrence) POR
1.00–1.80	Very Low (VL)	Very Low (VL)
1.81–2.60	Low (L)	Low (L)
2.61–3.40	Moderate (M)	Moderate (M)
3.41–4.20	High (H)	High (H)
4.21–5.00	Very High (VH)	Very High (VH)

Analysis Result for Ranking of Identified Risk Factors Using Probability Impact (P-I Matrix)

The analysis revealed that inflation and an increase in material prices were two of the most critical factors, having a high level of impact (represented by the red color in **Tables 7** and **8**) on both project cost and completion time. Additionally, difficult site conditions and exchange rate fluctuations were found to have a high level of impact on project cost and completion time, respectively. These risks fall under the red zone, indicating a significant threat to project objectives. Despite being among the top 10 critical risk factors (CRFs) in terms of probability of occurrence, the experts agreed that the financial failure of the contractor was found to have a low impact on project cost (indicated by the green color), suggesting that minimal oversight is needed to maintain this risk at a low level.

Table 7. Result of P-I Matrix for CRFs in terms of occurrence (POR) and impact on cost (IRC).

Risk ID	Risk Factors	Rank Overall	Mean Score		Risk Matrix	Impact Level
			POR	IRC		
RF1.4	Inflation	1	3.63	3.92	H X H	High
RF1.5	Increase of Material price	2	3.88	3.69	H X H	High
RF1.3	Exchange rate fluctuation	3	3.46	3.64	H X H	High
RF1.2	Payment delays	4	3.35	3.58	M X H	Moderate
RF2.7	Equipment failures	5	3.22	3.53	M X H	Moderate
RF6.1	Resource management	6	3.22	3.50	M X H	Moderate
RF3.5	Not coordinated design	7	3.10	3.36	M X M	Moderate
RF7.3	Shortage of equipment	8	3.22	3.35	M X M	Moderate
RF1.1	Financial failure of the contractor	9	2.59	3.32	L X M	Low
RF7.2	Some materials don't arrive at the assigned site	10	3.29	3.28	M X M	Moderate

The remaining CRFs exhibited a moderate impact (indicated by the yellow color) on both project cost and completion time. These findings indicate that although these risks pose some disruption, they can be managed with additional attention and mitigation efforts.

Discussion of Results for Ranking of Identified Risk Factors Using Probability Impact (P-I Matrix)

The findings highlight that financial risks such as inflation and material price increases are the most significant factors affecting both project cost and completion time, and this is in line with previous research by [79]. However, both [23,79] identified contractor financial failure as a serious threat to stakeholders, while in this study its effect on project cost was found to be minimal. This means that even though contractor financial failure is one of the top 10 risk factors affecting the construction projects in the study area, the project managers can give minor attention to risk responses compared to the other top 10 identified risk factors, and this risk factor can be categorized under tolerable risk.

Table 8. Result of P-I matrix for CRFs in terms of occurrence (POR) & impact on time (IRT).

Risk ID	Risk Factors	Rank Overall	Mean Score		Risk Matrix	Impact Level
			POR	IRT		
RF1.5	Increase of material price	1	3.88	3.51	H X H	High
RF1.4	Inflation	2	3.63	3.42	H X H	High
RF2.6	Difficult site condition	3	3.44	3.41	H X H	High
RF7.2	Some materials do not arrive at the assigned site	4	3.29	3.40	M X M	Moderate
RF3.1	Design changes	5	3.21	3.39	M X M	Moderate
RF1.3	Exchange rate fluctuation	6	3.46	3.38	H X M	Moderate
RF1.2	Payment delays	7	3.35	3.37	M X M	Moderate
RF3.5	Not coordinated design	8	3.10	3.36	M X M	Moderate
RF3.3	Design process takes longer than anticipated	9	3.00	3.31	M X M	Moderate
RF3.4	Lack of consistency b/n BOQs & drawings	10	3.15	3.29	M X M	Moderate

The moderate risks (yellow zone) require further management attention to prevent disruption to the project by cost consideration. Risks in the yellow zone still pose enough of a threat that proactive management is required to minimize their impact [80]. Other studies have similarly identified material price fluctuation as a leading cause of cost overruns in construction projects [24,53]. In light of this, it is suggested that implementing mitigation strategies can curb the adverse effects of fluctuating material rates [53]. Additionally, price fluctuations, categorized under financial risks, are consistently ranked among the most critical risk factors [81]. These research findings support the need for cost contingency planning as an essential part of budgeting in construction projects.

In conclusion, financial risks such as inflation, material price increases, and exchange rate fluctuations dominate both project cost and completion time impacts. However, contractor financial failure, though identified as a risk factor with a high probability of occurrence, showed a low direct impact on cost in this study. The financial failure of contractors has been identified as one of the top ten significant risk factors, categorized with a high to medium level of importance [79]. This finding is further reinforced by noting that a contractor's financial failure during a construction project can present a serious risk to project owners and stakeholders, including investors, banks, and fellow contractors [23].

4.4. Pearson's correlation test

The relationship between the success of the construction project and the risk factors can be determined by verifying their effect on the main components of the project, which are the cost and schedule [82]. Accordingly, in this study, a simple linear correlation analysis was implemented in order to interpret the relationship between the probability of occurrence of identified risk factors (i.e., the independent variable) and its impact on project cost and project completion time (i.e., the two dependent variables), respectively, with the help of IBM SPSS V26 software [83,84]. In order to determine the coefficients and degrees of correlation, Pearson's correlation coefficient (*R*) was applied. *R* is a parametric test used when the variables are normally distributed and the relationship between them is linear [85]. In **Table 9**, a suggestion guide was used to interpret the size (strength) for the absolute value of Pearson's correlation coefficient that was obtained from the analysis result [86].

Table 9. Interpretation of strength of Pearson's correlation coefficient.

Strength of Association	Pearson's Correlation Coefficient, *R*	
	Positive	Negative
Very Weak	0.00 to 0.19	0.00 to −0.19
Weak	0.20 to 0.39	−0.20 to −0.39
Moderate	0.40 to 0.59	−0.40 to −0.59
Strong	0.60 to 0.79	−0.60 to −0.79
Very Strong	0.80 to 1.00	−0.80 to −1.00

Analysis Result for Pearson's Correlation Coefficient (Model 01 and Model 02)

From the analysis presented in **Table 10**, it was observed that both models (Model-01 and Model-02) exhibited a very strong positive linear correlation among the variables. The correlation coefficients (*R*-values) were 0.80 for Model-01 and 0.84 for Model-02. These *R*-values indicate that both models have a high degree of positive linear correlation between the variables. Furthermore, the significance values listed under the Sig. (2-tailed) column were both less than 0.05 for each model, confirming the statistical significance of the relationships [62]. This finding suggests that there is strong evidence to reject the null hypothesis, which posits that there is no correlation between the variables. Thus, the relationships identified in both models are statistically significant and substantial [62].

Table 10. Pearson's correlation coefficients result.

Model	Pairs of variables	Sig. (2-tailed)	Pearson Correlation Coefficient, *R*	Degree of Correlation
Model 01	POR x IRC	0	0.800**	Very Strong
Model 02	POR x IRT	0	0.840**	Very Strong

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

Discussion of Results and Interpretation of Correlation Strength (Model 01 and Model 02)

The strong positive correlation values (*R* = 0.800 and *R* = 0.840) indicate that the variables in both models are closely linked, meaning that as one variable increases, the other tends to increase as well. In Model-01, the *R*-value of 0.800 reflects a robust relationship between the critical risk factors and their impact on the outcome being analyzed (likely project cost or performance). Similarly, Model-02, with an *R*-value of 0.840, demonstrates an even stronger correlation, suggesting a slightly closer relationship between the variables in this model.

The significance values ($p < 0.05$) provide solid evidence that the correlations observed in both models are not due to random chance [62]. This is crucial for hypothesis testing, as it enables the rejection of the null hypothesis that the correlation between the variables is zero. According to [62], a significance value below 0.05 is a threshold for establishing the presence of a meaningful correlation. Therefore, the analysis confirms that both models have statistically significant relationships.

The strong positive correlations in both models highlight the importance of understanding the interconnectedness of variables in project risk analysis. For practitioners, these findings suggest that the variables considered in both models have a significant influence on project outcomes and should be carefully monitored. The high *R*-values also imply that changes in one variable (such as inflation or payment delays) can lead to notable changes in project performance, reinforcing the need for effective risk management strategies [62]. In conclusion, both models provide strong statistical evidence of significant positive correlations among the variables, allowing for the rejection of the null hypothesis and reinforcing the importance of these relationships in project risk management [62]. The analysis results for the Pearson's correlation matrix, risk ranking, and impact levels of the CRFs on project cost were summarized and tabulated in **Table 11**.

Table 11. Pearson's correlation matrix, rank and impact level of CRFs on project cost (Model 01).

Risk ID	Top CRFs on Cost	Pearson's Correlation Matrix POR x IRC For CRFs			Rank	Impact Level
		Pearson Coefficient	Significance (2-tailed)	Degree of Correlation		
1.4	Inflation	0.734**	0.000	Strong	1	High
1.5	Increase of Material price	0.533**	0.000	Moderate	2	High
1.3	Exchange rate fluctuation	0.556**	0.000	Moderate	3	High
1.2	Payment delays	0.554**	0.000	Moderate	4	Moderate
2.7	Equipment failures	0.711**	0.000	Strong	5	Moderate
6.1	Resource management	0.498**	0.000	Moderate	6	Moderate
3.5	Not coordinated design	0.581**	0.000	Moderate	7	Moderate
7.3	Shortage of equipment	0.576**	0.000	Moderate	8	Moderate
1.1	Financial failure of the contractor	0.419**	0.001	Moderate	9	Low
7.2	Some materials do not arrive at the assigned site	0.479**	0.000	Moderate	10	Moderate

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

Analysis Results for Pearson's correlation matrix, rank, and impact level of CRFs on project cost-Model 01

In the first model (Model-01), Pearson's correlation analysis was conducted to understand the relationship between various critical risk factors (CRFs) and their impact on project costs. The top 10 CRFs showed significant correlation, as indicated by *p*-values of less than 0.05. This suggests that all the relationships in the analysis were statistically significant [62].

1) Strong Positive Correlation: Inflation and equipment failure demonstrated a strong positive correlation with project cost, meaning that as inflation and equipment failure increased, there was a substantial corresponding increase in project cost.
2) Moderate Positive Correlation: The remaining CRFs showed moderate positive degrees of correlation with their respective impacts on project cost. These factors did not have as dramatic an impact as inflation and equipment failure but still contributed positively to increases in project cost.

Discussion of Results for Pearson's Correlation Matrix, rank, and impact level of CRFs on project cost-Model 01

The findings from both models align with prior research, particularly a study conducted in Ethiopia [4]. Their study evaluated risk variables for building projects and examined the relationships between risk factors and project performance. Like the present analysis, they found that certain key CRFs—such as inflation, price raises, payment delays, and poor design—had a significant impact on project performance, particularly in terms of cost and time overruns [4].

In Model-01, inflation was a particularly critical risk factor, as its strong positive correlation with project costs echoes the findings of [87]. This suggests that inflation is a key driver of cost increases in projects, which is consistent with the broader economic context, where rising prices affect materials, labor, and other resources. The finding that equipment failure also has a strong positive correlation with cost indicates that technical and operational issues are significant contributors to cost overruns [62]. Similarly, the findings of the paper regarding the Pearson's correlation matrix, ranking, and impact level of CRFs on project completion time were presented in **Table 12**.

Table 12. Pearson's correlation matrix, rank and impact level of CRFs on completion time (Model 02).

Risk ID	Top CRFs on Time	Pearson's Correlation Matrix POR x IRT For CRFs			Rank	Impact Level
		Pearson Coefficient	Significance (2-tailed)	Degree of Correlation		
1.5	Increase of Material price	0.458**	0.000	Moderate	1	High
1.4	Inflation	0.510**	0.000	Moderate	2	High
2.6	Difficult Site condition	0.481**	0.000	Moderate	3	High
7.2	Some materials do not arrive at the assigned site	0.553**	0.000	Moderate	4	Moderate
3.1	Design changes	0.453**	0.001	Moderate	5	Moderate
1.3	Exchange rate fluctuation	0.781**	0.000	Strong	6	Moderate
1.2	Payment delays	0.708**	0.000	Strong	7	Moderate
3.5	Not coordinated design	0.642**	0.000	Moderate	7	Moderate
3.3	Design process takes longer than anticipated	0.431**	0.001	Moderate	9	Moderate
3.4	Lack of consistency between BOQ, drawings and specifications	0.412**	0.000	Moderate	10	Moderate

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

Analysis Results for Pearson's correlation matrix, rank, and impact level of CRFs on completion time-Model 02

The Pearson's correlation analysis for the second model (Model-02) was focused on the relationship between the top 10 CRFs and their impact on project completion time. Similar to Model-01, all relationships had statistically significant correlation coefficients (p-values < 0.05) [62].

1) Strong Positive Correlation: Exchange rate fluctuation and payment delay demonstrated strong positive correlations with project completion time, implying that as these factors increased, project delays became more pronounced.
2) Moderate Positive Correlation: The remaining CRFs showed moderate degrees of positive correlation with project completion time, indicating that while their impact on completion time was significant, it was less pronounced than the impact of exchange rate fluctuation and payment delay.

Discussion of Results for Pearson's Correlation Matrix, rank, and impact level of CRFs on completion time-Model 02

In Model-02, the strong positive correlation between exchange rate fluctuation and payment delay with project completion time also aligns with the previous study. Exchange rate fluctuations can severely affect the cost and availability of materials, while payment delays often result in work stoppages, leading to project delays [4]. Both factors highlight the importance of financial stability and efficient cash flow management for timely project completion.

A research model similarly highlighted the significant impact of inflation, price rises, delays in site access, and late contractor payments on overall project risk [4]. This finding is reinforced by another study that presents similar conclusions [87]. This further supports the conclusion that economic and financial risk factors are among the most critical in determining project performance [72]. The consistent correlation between these factors and project outcomes in different contexts suggests that managing inflation, exchange rate fluctuations, and payment delays should be a top priority for project managers.

4.5. Regression analysis

A regression analysis establishes the nature of the relationship between two or more variables and then estimates the unknown variable (dependent variable) with the help of known variables (independent variables), i.e., how well a set of variables is able to predict a particular outcome [85]. In this case, determining the type of regression analysis method for the data collected was the first step [88]. In this case, the relationship for both models (i.e., POR vs. IRC and POR vs. IRT) was assumed linear. There is only one independent (POR) variable that explains the dependent variables (i.e., cost and time) in both models; the regression technique applied in this paper was assumed to be simple linear regression [82]. The results of the analysis using the normal P-P plot of the standardized residual for Model-01 and Model-02 were presented in **Figure 2**.

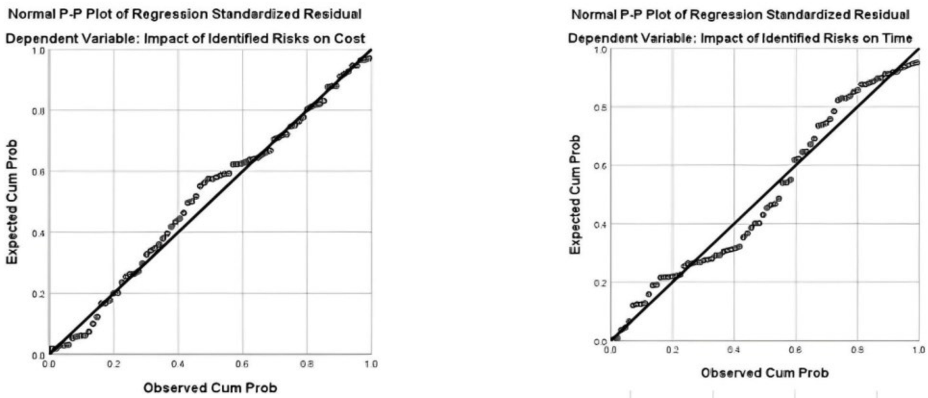


Figure 2. Normal P-P plot of standardized residual for Model-01 and Model-02.

The first thing checked after running the analysis was observing whether the regression equation fits the data (i.e., predicts the dependent variable) by examining the ANOVA table [85]. If the value of significance in this table becomes less than 0.05, then one can conclude that the model works better (i.e., the model is significant at 95%) than simply using the mean to explain the relation [82].

1) Predictors: (Constant), Probability of Occurrence of Identified Risks
2) Dependent Variable: Impact of Identified Risks on Cost
3) Dependent Variable: Impact of Identified Risks on Time

Illustration of ANOVA Results and Model Significance (Model 01 and Model 02)

The ANOVA analysis presented in **Table 13** reveals that both Model-01 and Model-02 have significant values less than 0.05, indicating statistical significance. Furthermore, the models were found to be significant at the 99.0% confidence level (i.e., p-value < 0.01), confirming that the R^2 values in both models are statistically different from zero. This means that the independent variables in each model explain a substantial portion of the variance in the dependent variable, making the models highly effective [82]. The statistical significance at this level allows for the rejection of the null hypothesis, which assumes that the models do not explain any variance. Thus, both models can be confidently considered reliable predictors, providing meaningful insights into the relationships between the variables, and are valuable tools for applications such as project risk management and forecasting [62]. This high significance level supports the use of these models in practical applications related to project risk management, cost estimation, or timeline forecasting [87].

Table 13. ANOVA for Model 01 and Model 02.

Model		Sum of Squares	df	Mean Square	*F*	Sig.
01	Regression	16,671.314	1	16,671.314	125.219	0.000
	Residual	9452.713	71	133.137		
	Total	26,124.027	72			
02	Regression	18,930.132	1	18,930.132	169.56	0.000
	Residual	7926.608	71	111.642		
	Total	26,856.74	72			

Illustration of Model Summary for Model 01 and Model 02

According to the model summary in **Table 14**, Model-01 showed that 63.3% of the effect of risk on project cost could be predicted by the probability of occurrence of identified risks, while Model-02 indicated that 70.1% of the effect of risk on project completion time was similarly predicted. These findings demonstrate that the probability of occurrence of the identified critical risk factors plays a substantial role in influencing project performance, particularly by increasing costs and extending project timelines [87]. The high percentages of prediction in both models underscore the significant impact that risk factors have on construction projects in Dire Dawa city administration and the Harari region. This result highlights the critical importance of effective risk management to mitigate potential cost overruns and delays in construction projects within these areas [89].

Table 14. Model Summary for model 01 and Model 02.

Model	*R*	*R* Square	Adjusted R Square	Std. Error of the Estimate
01	0.800[a]	0.638	0.633	11.538
02	0.840[a]	0.705	0.701	10.566

A model coefficient table was also created to examine the effects of major factors by calculating the values of the gradient and intercept terms for the regression line for both models and summarized in **Table 15**.

Table 15. Coefficients for Model-01 and Model 02.

Model		Unstandardized Coefficients		Standardized Coefficients Beta	*t*	Sig.
		B	Std. Error			
01	(Constant)	49.715	7.990		6.222	0.000
	Probability of Occurrence of Identified Risks	0.658	0.059	0.800	11.190	0.000
02	(Constant)	40.743	7.316		5.569	0.000
	Probability of Occurrence of Identified Risks	0.701	0.054	0.84	13.022	0.000

The equations (i.e., Equations (3) and (4)) for both models were summarized and given below using the coefficient table's output respectively.

For Model-01: ………………. $IRC = 49.715 + 0.658 \times POR$ (3)

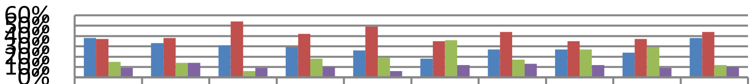
For Model-02: ………………. $IRT = 40.743 + 0.701 \times POR$ (4)

Illustration of Model Coefficient Table

The regression analysis for Model-01 and Model-02 revealed that a unit increase in the probability of occurrence of identified risk factors leads to a 50.37 unit increase in the impact on project cost and a 41.44 unit increase in the impact on project schedule [82]. These results clearly show that as the likelihood of risks materializing increases, both the cost and duration of construction projects in the Dire Dawa city administration and Harari region are significantly affected. The magnitude of these increases highlights the critical influence of risk factors on project success, emphasizing that managing the probability of these risks is essential for controlling both cost overruns and schedule delays [89]. This reinforces the importance of proactive risk mitigation strategies to enhance the efficiency and timely delivery of construction projects in these regions [4].

4.6. Method of risk response and monitoring

After identification of CRFs that affect the project objectives more severely, we developed a strategy that helps to minimize the negative impact using a systematic risk response technique [10]. Among the several types of risk response approaches discussed in the literature, risk avoidance, risk transfer, risk mitigation, and risk acceptance are the four used strategies for addressing acknowledged risks in this study. The result of the analysis for the top-ranked CRFs was presented in **Figure 3.** The objective of this section is to bring into line the identified CRFs to the chosen risk response appetite to reduce the exposure of influential threats in the study area.



	RF6.1	RF2.7	RF2.9	RF2.5	RF7.2	RF1.2	RF2.6	RF1.3	RF1.4	RF1.5
Acceptance	38%	33%	31%	29%	26%	18%	27%	27%	24%	38%
Mitigation	37%	38%	54%	42%	49%	35%	44%	35%	37%	44%
Transfer	15%	14%	6%	18%	19%	36%	17%	27%	29%	12%
Avoidance	9%	14%	9%	10%	6%	12%	13%	12%	9%	10%

Figure 3. Risk response methods for the top ranked CRFs.

Illustration of figure regarding risk response method for the top-ranked CRFs

The study's results indicate that respondents predominantly selected mitigation techniques as the preferred risk response for eight critical risk factors (CRFs) deemed likely to occur in the study area. These CRFs include significant issues such as an increase in material prices, inflation, exchange rate fluctuations, difficult site conditions, material delivery issues, construction cost overruns, labor productivity, and equipment failures. By prioritizing mitigation strategies, respondents demonstrate a proactive stance aimed at minimizing the impact of these risks on construction projects, which can ultimately enhance the likelihood of successful outcomes.

Interestingly, while mitigation was favored for most CRFs, risk transfer emerged as the most heavily weighted response technique specifically for payment delays. This suggests that respondents prefer to shift the responsibility for this particular risk to other stakeholders, such as subcontractors or insurers, reflecting a strategic decision to protect their interests and manage financial exposure. The choice of risk transfer for payment delays underscores the significant impact that cash flow issues can have on project timelines and overall success, prompting respondents to seek ways to alleviate this burden.

Conversely, for risks related to resource management, a majority of respondents opted for risk acceptance as their best strategy. This indicates a willingness to acknowledge certain risks without active intervention, which may stem from the belief that these risks are either unavoidable or manageable within the project's scope. The varied approaches to risk response illustrate the complexity of risk management in construction, where different strategies can be employed based on the specific nature and potential impact of each risk. Ultimately, the findings highlight the importance of tailoring risk management strategies to address the unique challenges faced in construction projects.

Discussion of Results for Risk Response Methods for the Top-Ranked CRFs

The questionnaire survey conducted on risk factors affecting the cost and schedule performance of construction projects in Dire Dawa city administration and the Harari region revealed key insights into preferred risk response and monitoring techniques. The majority of respondents indicated that mitigation was the most effective response method for addressing eight critical risk factors (CRFs) with high probabilities of occurrence. These CRFs included increases in material prices, inflation, exchange rate fluctuations, difficult site conditions, payment delays, material delivery issues, construction cost overruns, labor productivity issues, and equipment failures. Mitigation, as a proactive approach, aims to reduce the likelihood or severity of these risks by implementing strategies such as better planning, resource allocation, and contingency measures [90].

Additionally, risk transfer was recognized as the most suitable response for managing payment delays, with the risk being transferred to other parties, such as contractors or insurance companies, to minimize the project owner's exposure [90]. Meanwhile, for resource management risks, the respondents predominantly selected risk acceptance as the preferred response technique. This approach reflects a willingness to acknowledge and tolerate the inherent risks in managing resources without significant intervention, indicating that these risks are considered manageable within the scope of the project [89]. Overall, the study underscores the importance of selecting appropriate risk response strategies tailored to specific risks to enhance project cost and schedule performance in the region's construction sector.

4.7. Interview result and discussion

In addition to the questionnaire survey, a semi-structured interview was conducted with respondents based on the theoretical framework, with the objective of obtaining more depth of data regarding the risk management implementation in the study area. Using a purposive-heterogynous sampling technique, the interview was performed based on the respondents' background knowledge and practical implementation of construction risk management practices executed in the study area [65].

In the interview, respondents were first asked to give a brief overview of the term "construction project risk" in their own opinion. Thus, some respondents defined a construction project risk as an event that can occur or exert a negative impact during different construction points because of technical or financial reasons. Other interviewees defined it as a sort of hazard that could affect the construction phase by reducing the intended quality, expending additional unnecessary budget, stretching the intended completion time of the project out of its estimated schedule, and causing physical and health problems.

According to the findings of the interview, all respondents replied that the success of a construction project is in order to achieve its planned objectives based on proper risk management practices. Most respondents also added that on-time risk management helps to reduce the probability of occurrence of project risks to hit the project's targeted goals. Nevertheless, the interviewees pinpointed that although most of the staff are aware of the concept of risk management mainly from university education, its practice is in its infant stage. They rationalize this due to corruption, peace and security of the working area, negligence, weak supervisory structure, and incapability due to the financial power of the contractor.

Regarding risk identification, most of the respondents revealed that the common denominator in terms of identification of construction projects was based on brainstorming, where every individual could contribute with their own experience and/or experience from past history of similar projects. Other interviewees mentioned the checklist, group meeting, physical inspection, and experts' opinion as a broadly implemented risk identification mechanism constructively applied in Dire Dawa city administration and the Harari region construction sector. Furthermore, most of the interviewees agreed that risk identification should be carried out from the early stage through the project lifecycle using individual experience and/or experience from the history of similar projects as well as using a checklist. They discussed that a checklist expands continuously with experience of past project work, specifically for past identified risks that require special measures in times of inventory of work. This response is in line with the PMBOK Guide, which states that the most effective way of a construction project's risk management is when it is first performed early in the life of the project.

The most widely implemented method amongst the respondents when it comes to the assessment of critical risks was brainstorming. Gathering of relevant data from previous similar projects as well as documentation such as site books were also amongst the meetings for risk assessment techniques given by respondents. However, it was found from the conduct of the interview that most of the respondents had a profound lack of knowledge about the scientific risk assessment methods as discussed in the literature review, i.e., a simplistic approach rather than a detailed structural manner.

As noticed from the interview, respondents apply various methods of risk response and monitoring techniques depending on the type of work and type of organization. Although respondents didn't mention the technical terms as discussed in the literature, the most shared replay regarding risk response was mitigation and transfer. The majority of interviewees stated that the method of mitigation used in their construction companies was a discussion about the work plan with qualified technical workers who have in-depth knowledge of the problem and would perform the job better to minimize practical risks. Moreover, respondents emphasized that brainstorming and discussing the plan of the work in the assessment process should be documented well in order to learn from past incidents and minimize similar risks in the future. In addition to this, other respondents from supervisory organs reviled that implementation of risk monitoring was through scheduled checkups or regulation, performing documentation on a checklist, and continuously arranged meetings with contracting parties throughout the project life. Furthermore, according to almost all respondents who participated in the interview, they agreed that all project stakeholders should participate in all phases of risk management methods throughout the lifecycle of the project.

5. Recommendation

To effectively address the critical risk factors affecting cost and schedule performance in construction projects within the Dire Dawa City Administration and the Harari region, it is essential to implement a robust risk management framework. This framework should include conducting thorough and regular risk assessments focused on local economic conditions, such as inflation and fluctuations in material prices, which identified as the top two potential factors affecting the cost and schedule performance of construction projects in the study area. By utilizing local construction cost indices and comprehensive market analyses, stakeholders can develop adaptive budgets that respond effectively to changing circumstances. To mitigate the issue of cost overruns, it is crucial to establish budgeting methodology at the project's inception that accounts for inflation before finalizing budget estimates. Engaging economists or financial analysts with expertise in construction economics is advisable for tailored insights. Additionally, stakeholders should consider the duration of the project, as longer timelines might increase susceptibility to inflation and price fluctuations. Furthermore, establishing strong relationships with local suppliers can also enhance procurement practices, enabling bulk purchasing and favorable long-term contracts that help mitigate price volatility.

To mitigate uncoordinated design risks in construction projects, it is essential to facilitate intensive design sessions where all parties can collaboratively brainstorm solutions and address conflicts in a structured environment. Scheduling frequent meetings will help track design progress, address concerns, and keep all stakeholders updated on changes. Developing comprehensive checklists for design reviews ensures that critical aspects—such as regulatory compliance, constructability, and interdiscipline coordination—are thoroughly considered. Adopting an iterative approach to design allows for continuous feedback and timely adjustments, rather than waiting for final approvals. Additionally, applying augmented reality technology to overlay design elements onto the physical site enables real-time conflict detection, further enhancing coordination and reducing the likelihood of delays and rework.

To minimize payment delays and ensure consistent cash flow, it is vital to establish clear contractual agreements regarding payment terms. Implementing escrow accounts can ensure funds are designated for timely payments, thereby maintaining project momentum. Regular communication among all stakeholders—clients, contractors, and suppliers—is essential for addressing financial concerns and preventing misunderstandings. Adopting just-in-time delivery strategies for materials can further reduce the risk of delays and storage costs, ensuring that materials arrive precisely when needed.

Finally, providing training for project managers in financial oversight and risk mitigation techniques will empower them to proactively identify and address potential issues. By implementing these comprehensive strategies and recommendations, construction projects can enhance their efficiency and resilience, leading to successful outcomes.

6. Conclusion

The primary objective of this study was to identify the most significant risk factors affecting the cost and schedule performance of construction projects in the research area and to offer suggestions to minimize such risks. To achieve this, the study began with a comprehensive literature review and pilot survey, initially gathering 41 potential risk factors. An iterative process of refining the list by adding new factors and eliminating less relevant ones culminated in the selection of 42 risk factors for the detailed investigation. Identifying these potential risk factors was a crucial step in managing their probability of occurrence and potential impact on construction projects in the study area. Various stages of screening techniques were also conducted, with mean ratings applied to rank the selected factors based on expert judgments. Additionally, semi-structured interviews were utilized to gather qualitative insights, further enhancing the analysis. As a result, the study identified ten top critical risk factors through data analysis using mean ratings, which were considered essential for addressing construction challenges effectively.

To assess the likelihood of occurrence and the corresponding impact of the identified top ten risk factors on project cost and schedule, the research employed both probability-impact (P-I) matrix and regression techniques. These analytical methods allowed for a deeper understanding of how each risk factor could influence project outcomes. Furthermore, a linear correlation analysis was conducted to validate the relationship between the two models, which are the probability of occurrence of the identified risks and their impact on both project costs as well as project completion time. The findings revealed six particularly impactful risk factors: inflation, increases in material prices, exchange rate fluctuations, payment delays, poorly coordinated design, and material delays. The strong positive correlations between these two models indicated that as the probability of a risk factor occurring increases, so does its negative impact on both project cost and schedule. Moreover, the development of prediction models with high percentages of accuracy further underscored the significant role these risk factors play in affecting the performance of construction projects in Dire Dawa city administration and the Harari region, offering a reliable means for project managers to anticipate and mitigate these risks.

Finally, the research proposed practical risk response techniques tailored to the top-ranked risk factors affecting construction projects' costs and timelines. The questionnaire results indicated that mitigation was the most effective response method for addressing eight of the top critical risk factors with high probabilities of occurrence, including increases in material prices, inflation, exchange rate fluctuations, difficult site conditions, material delivery issues, construction cost overruns, labor productivity issues, and equipment failures. Migration strategies, which involve proactive planning, resource allocation, and contingency measures, aim to minimize the likelihood and severity of these risks. For managing payment delays, risk transfer was identified as the most suitable response, where the responsibility be shifted to third parties, such as contractors or insurers, to minimize the project owner's exposure. Additionally, risk acceptance was recommended for resource management-related risks, acknowledging that some risks are inherent and can be tolerated without significant intervention. Overall, the findings of this research provide valuable insights for project stakeholders, emphasizing the need to focus on these critical risk factors to better manage costs and schedules, ultimately improving project outcomes. The study offers practical guidance for enhancing risk management practices in the study area, contributing to more successful project execution and minimizing the impact of potential risks to ensure that construction projects are completed within the planned cost and timeframe.

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