Assessing the impact of excluded risks on cost and time of construction projects in Samarra using the relative importance index (RII)

Ahmed D. Abdulateef [1*]**, Ahmed Hadi** [1]**, Abeer Ahmed Azzawi** [1]**, Maryam Hassan Ahmed** [1]**, Noor Salim Dawood**[1]**, Ghadah Hadher Hamad**[1]

1- Department of Civil Engineering, College of Engineering, University of Samarra, Samarra, Iraq

Abstract

This study examined the impact of excluded risks on the cost and schedule performance of construction projects in Samarra, a city affected by persistent security-related challenges. A quantitative research approach was adopted using a structured questionnaire distributed to 49 engineers and construction experts from different engineering disciplines. The collected data were analyzed using the Relative Importance Index (RII) to evaluate excluded risks in terms of likelihood of occurrence, impact on project cost, and impact on project duration. The results indicated that security-related risks, particularly those associated with war conditions and civil disturbances, were perceived as the most critical, with RII values exceeding 0.70 in several cases. In contrast, risks related to partial occupation of projects by the employer, contract-driven design constraints, and nuclear-related considerations were assessed as less significant, with RII values generally below 0.50. The findings also showed that contracts incorporating proactive risk mitigation measures were perceived as more effective in reducing cost overruns and schedule delays than traditional insurance-based risk allocation approaches. The study concluded that improving construction project performance in security-dominant environments requires preventive contractual strategies, locally adapted risk management frameworks, and continuous professional training for engineers and contractors.

1. Introduction

Globally, risk management has been recognized as a fundamental pillar for achieving success in engineering and construction projects, as almost every major project generates uncertainties that pose potential threats to cost, schedule, and quality performance. As a result, *Excluded Risks*, defined as risks that are not contractually allocated to any party, have received considerable attention in project management literature and remain among the most debated and complex issues. These risks are generally understood as those not included in project risk registers or deliberately omitted from contractual agreements. The uncertainty associated with excluded risks can significantly affect project execution, cost control, and schedule performance, thereby increasing the likelihood of disputes among stakeholders. This challenge is particularly evident in countries with weak institutional and regulatory frameworks, such as Iraq, where risk allocation practices are often unclear or inconsistent. The situation is even more critical in the city of Samarra, where construction projects are undertaken under additional security-related and governance constraints that intensify the potential impacts of excluded risks. [1].

From a practical standpoint, the concept of excluded risk represents a fundamental gap within structured risk management approaches. Although numerous standardized methodologies for identifying, assessing, and mitigating risks have been widely adopted in the construction industry, these methodologies rely on two implicit assumptions. The first assumption is that all potential risks have been fully identified and recorded in the project risk register, while the second assumes that responsibility for all identified risks has been clearly allocated through contractual agreements. However, risks that are excluded from either formal risk registers or contractual arrangements are not subject to systematic monitoring or control. As a result, such risks create critical blind spots within otherwise structured risk management frameworks, potentially undermining their effectiveness and increasing exposure to unforeseen project impacts.

The FIDIC conditions represent a set of standard international contracts widely used in the construction industry and are based on the principle that it is in the best interest of all parties to clearly define, in advance, how responsibility for risk is allocated. These conditions also include limited provisions for risks that cannot be allocated or that lie outside the control of either contractual party [2]. In addition, globally recognized project management methodologies, including AACE, PMBOK, and the USACE Manual, acknowledge that risks not incorporated into project plans are not merely theoretical and may lead to significant schedule delays and cost overruns if they are not properly managed within construction projects [3], [4]. Furthermore, guidelines issued by AACE have proposed several approaches for managing risks not explicitly specified in contracts, including the use of Monte Carlo simulations, regression models, and structured alignment between contractual exclusions and adaptive response strategies, as well as flexible contingency funds or reserve allocations [5].

Risk management has been extensively examined on a global scale, particularly in developed countries with stable political and institutional frameworks, in relation to large-scale capital projects such as highways, railways, ports, and other megaprojects. Findings from these international studies indicate that project failure and significant schedule overruns are often attributable to inadequate risk identification or the failure to address critical risks, including unpredictable natural disasters, security disruptions, and changes in governmental policy [6]. In addition, empirical research has shown that project cost overruns may exceed 30% of the

original budget when excluded risks are not incorporated into project planning, while schedule extensions may extend several years beyond the planned completion date [7], [8]. Furthermore, results from large-scale systematic reviews, encompassing more than 100 studies, have identified previously unrecognized risks across various risk categories as a primary cause of project failure and a major contributor to stakeholder dissatisfaction [9].

However, the risk environment in the Arab region, and particularly in Iraq, is characterized by a more complex combination of factors, many of which stem from ongoing political instability, irregular financing mechanisms, and limited institutional coordination. Consistent with the findings of this study, previous research conducted in Iraq has reported high levels of project delays and reduced performance resulting from security threats, inadequate funding, weak governance structures, and insufficient understanding or application of effective risk management and mitigation practices [10], [11]. Samarra is characterized by a limited number of large-scale projects and a shortage of qualified project management professionals. Local reports and media sources indicate a growing demand for skilled construction project managers, which has contributed to a gap between theoretical risk management models and the practical approaches applied in real project environments [12], [13].

In parallel with the significant regional challenges facing Iraq, international development and financial institutions, such as the World Bank, have emphasized the need for more effective and context-specific risk and environmental management strategies to support the rehabilitation of Iraq's infrastructure. These studies have also highlighted excluded risks as a major concern, as many risks remain unassigned in post-conflict environments due to uncertainty, the unpredictability of security conditions, or difficulties in identifying responsible or legally accountable parties under existing laws and regulations [14]. Furthermore, several reports have indicated that project success in such contexts largely depends on how effectively projects address the "known unknowns," namely risks that are recognized but fall outside contractual risk allocation. Consequently, these excluded risks play a critical role in determining both cost performance and schedule outcomes in construction projects [15], [16]. Past studies have employed quantitative measurement techniques to assess externally considered risks through the application of methods such as Monte Carlo simulation, multi-criteria decision-making (MCDM) approaches, and probabilistic models based on expert judgment [17], [18], [19]. Incorporating risks that have been excluded from conventional analyses into more holistic and comprehensive risk assessment frameworks has been shown to improve the accuracy of cost estimates by up to 20% and to reduce the frequency of schedule overruns by approximately 15% [9]. However, despite methodological advances that have enabled practitioners to apply such analytical models, their practical implementation in Iraq remains limited. This limitation is primarily attributed to the persistent lack of reliable and high-quality project data, as well as the shortage of trained professionals capable of effectively applying advanced analytical and risk modeling tools [20], [21].

Currently, artificial intelligence (AI) and machine learning techniques are increasingly used in construction-related risk analysis as emerging technologies that enable the processing of large volumes of data to predict cost overruns and schedule delays through algorithms such as neural networks and decision tree models [22]. Unlike conventional risk management approaches, which typically rely on the prior identification of risks and reactive mitigation measures, AI-based models do not depend solely on historical risk classification. Instead, these

models offer the capability to identify complex and interrelated risk patterns across multiple projects before their actual occurrence [23]. Nevertheless, despite their potential advantages, the application of AI-based risk analysis methods in Iraq remains limited due to constraints related to data availability, technical infrastructure, and institutional readiness.

The existing body of global literature predominantly focuses on stable environments or regions characterized by well-developed and mature institutional systems. In contrast, fragile or security-affected regions generally receive limited attention, despite encompassing many mid-sized cities such as Samarra, Iraq. Consequently, a significant gap exists in the literature due to the lack of empirical evidence examining how excluded risks influence cost and schedule performance in construction projects operating within local, resource-limited contexts where government, security, and trade-related factors intersect across social, economic, and technical dimensions. This absence of empirical evidence is not confined to academic literature alone but is also evident in professional practice. As a result, construction projects in such environments continue to experience delays in the delivery of critical infrastructure and the persistent underdevelopment of affected communities.

Accordingly, the original contribution of this study lies in clearly distinguishing "excluded risks" from other forms of project uncertainty, which have often been treated as a single category in previous research, by providing a focused and dedicated analysis of excluded risks. This study presents an empirical investigation to identify and quantify actual excluded risk items encountered in construction projects within the local Iraqi context. In doing so, the research expands the existing body of knowledge and enhances the practical tools and capabilities available to project managers for more effective risk identification, assessment, and management in resource-limited and security-affected environments.

This investigation addresses the existing lack of information regarding the effects of risk exclusion in construction projects in Samarra. A field survey was conducted involving 49 engineers, contractors, and consultants to identify key categories of excluded risks and to assess their relative importance within the local project environment. Based on these identified categories, appropriate response strategies suited to the local context were also examined. By synthesizing findings from international and regional literature with empirical field data collected in Samarra, this research provides practical insights to support decision-makers in developing a contextual risk management framework. Such a framework is intended to improve decision-making processes and enhance the overall success of construction projects operating in environments where security conditions remain uncertain.

2. Methodology

The methodological approach adopted in this study was the descriptive–analytical approach. This methodology was selected because it was suitable for addressing the research problem and objectives, which focused on examining the effects of excluded risks on the cost and duration of construction projects in Samarra. The descriptive–analytical approach involved the collection of field data from practitioners directly engaged in construction projects, followed by the application of appropriate analytical techniques to transform the collected data into meaningful indicators. This approach was particularly applicable to construction risk studies conducted in environments where consolidated performance databases and formal risk records were limited or unavailable. Furthermore, previous project management research has

indicated that the descriptive–analytical approach is effective for evaluating risks in project settings that lack reliable and comprehensive official information sources.

The study population consisted of construction practitioners operating in Samarra, including civil engineers, contractors, and consultants with direct experience in managing or implementing construction projects within the city. Owing to the absence of a comprehensive and reliable sampling frame for construction professionals in Samarra, probabilistic sampling methods were not feasible. Consequently, a purposive sampling strategy was employed to target respondents possessing relevant technical and managerial expertise aligned with the objectives of the study. In total, 49 valid questionnaire responses were collected, which was considered an adequate sample size for questionnaire-based studies utilizing ranking techniques such as the Relative Importance Index (RII), where the emphasis is placed on prioritizing factors rather than achieving broad statistical generalization.

This study provided a detailed overview of construction risks by drawing on standard contract documents and established risk management records commonly used within the Iraqi construction industry. The term "excluded risks" was used to classify risks that were not assigned through specific contractual provisions, were not allocated to any project party, or were commonly encountered in practice but not formally documented or systematically evaluated within project risk registers. The risk identification process focused specifically on risks associated with the overall project context that could not be independently controlled by individual stakeholders. As a result, these risks remained outside traditional contractual and managerial responsibility frameworks.

The questionnaire was designed to focus explicitly on three main analytical dimensions of excluded risks: (i) likelihood of occurrence, (ii) impact on project cost, and (iii) impact on project duration. It consisted of a series of closed-ended questions structured using a five-point Likert scale, where 1 represents very low impact and 5 represents very high impact.

The questionnaire was structured into three main sections. The first section collected demographic information for each respondent, including professional role, construction experience, and years of involvement in construction projects in Samarra. The second section required respondents to identify excluded risks encountered in local construction projects across four predefined categories: security risks, financial risks, legal and regulatory risks, and natural risks. These categories were developed based on findings from existing literature, which indicate that such risks are frequently unallocated and insufficiently addressed in project contracts within post-conflict and unstable environments. The third section asked respondents to rate the perceived severity of each identified excluded risk in terms of its impact on project cost and schedule, integrating these assessments into an overall evaluation of risk influence. In addition to these three sections, the questionnaire included a set of questions designed to assess practitioners' views on the effectiveness of selected risk response measures, specifically contractor insurance and proactive contractual risk inclusion strategies.

Technical risks were excluded from the scope of this study because they are typically addressed through established design codes, technical specifications, supervision procedures, and quality control mechanisms, and are often contractually assigned to specific parties. In contrast, this research deliberately focused on non-technical excluded risks that remain either unassigned or inadequately managed in practice. Such risks were considered to pose a higher level of uncertainty and a more significant potential impact on project cost and schedule performance.

To ensure the clarity and content validity of the questionnaire, it was reviewed for face validity by a panel of academic experts. In addition, a pilot test was conducted with a small group of construction professionals to identify ambiguous wording and to confirm the overall clarity and readability of the questionnaire. After data collection, all completed questionnaires were assigned coded identifiers and entered into statistical software for analysis. Descriptive statistical techniques, including frequencies, percentages, means, and standard deviations, were applied to examine respondent characteristics and to evaluate excluded risks. Furthermore, frequency analysis was performed to assess the distribution of responses prior to the ranking of risks.

To prioritize excluded risks based on their relative severity, the Relative Importance Index (RII) was employed. This method was selected due to its suitability for analyzing ordinal survey data and its widespread application in construction risk management research. The RII values were calculated using Equation (1), as presented below:

$$RII = \frac{\sum W}{(A \times N)} \tag{1}$$

In this formulation, W denoted the weight assigned by respondents, A represented the maximum rating on the five-point scale, and N indicated the total number of participants included in the survey. The RII values ranged between 0 and 1, with higher values indicating a greater relative importance of a particular risk compared to others. Accordingly, the adopted approach considered not only the identification of risks but also evaluated their combined impact on both project cost and schedule performance. In contrast, many previous methodologies focused primarily on the effects of risks on technical performance indicators. Excluded risks were often found to materialize at later stages of projects; therefore, their impacts were not limited to cost overruns and schedule delays but also extended to technical performance outcomes.

To obtain an overall prioritization of excluded risks, a composite Relative Importance Index (Composite RII) was developed by integrating the individual RII values for probability of occurrence, cost impact, and schedule impact. This composite index was used to capture the combined influence of excluded risks on overall project performance, with greater emphasis placed on cost and schedule dimensions in accordance with the primary objectives of the study. The Composite RII was calculated using both weighted and equal-weight schemes to evaluate the robustness and consistency of the resulting risk rankings.

In addition to descriptive statistical analysis, a network-based representation of the RII results was developed to enhance the interpretation of excluded risk relationships. This visual representation was used to illustrate both graphically and analytically the relationships between excluded risk categories and their potential effects on project cost and schedule performance. The network diagram transformed the calculated RII values into a series of weighted connections, where the weight of each connection reflected the degree of influence of each risk on project costs and schedules. This network representation did not constitute a machine learning or artificial neural network model; rather, it supported the descriptive–analytical framework by providing clearer insight into patterns of influence and priority among excluded risks. Similar visualization approaches have been employed in construction risk research to improve the communication and interpretation of complex risk interactions, particularly in data-limited environments such as Iraq. Integrating RII rankings with network visualization therefore provided a more intuitive and transparent means of understanding how excluded risks may propagate into cost and schedule impacts.

Using this approach, the study sought to ensure that its findings were representative of the experiences of engineers, contractors, and consultants working in Samarra, thereby reflecting real project conditions as accurately as possible. Accordingly, a methodological framework was adopted that enabled the clear identification and prioritization of excluded risks that had not been adequately addressed in previous research, as well as an assessment of their effects on construction project cost and schedule performance. This methodology therefore facilitated clearer interpretation of the results and supported more effective discussion of the practical implications presented in this study.

3. Statistical analysis

Once the questionnaires were collected, they will be verified to see if they are complete, sorted into alphabetical order, and placed in SPSS software for statistical analysis. With regard to the statistical analysis, the data analysis will be based on a descriptive rather than a methodological approach, which is covered in more detail in the Methodology Chapter. The first step in establishing the distribution of responses to each of the risk items excluded from the study was to compute descriptive statistics (i.e., frequencies and percentages). To summarise the central tendency and variance in responses, means and standard deviations were calculated.

To prioritize excluded risks based on their perceived severity, the Relative Importance Index (RII) was applied. RII values were calculated for each risk factor by converting Likert-scale responses into weighted scores and normalizing them using the maximum possible score and sample size, as defined in Equation (1). This procedure enabled consistent comparison and ranking of risks according to their relative influence on project cost and schedule.

Instead of reiterating the methodology of the Statistical Analysis section like many have, it describes using the computed RII values to identify prioritised categories of risk and interpret the effects of these risks on the performance of projects in Samarra. The findings presented were also informed by comparative discussions with other international and regional studies related to construction risk, which provided a framework for contextualizing local risk trends. Although the current study was conducted using traditional statistical methods, the findings give researchers the opportunity to use more sophisticated statistical methodologies when they have access to larger data sets.

4. Results and discussion

The results of the questionnaire survey are presented below, and the excluded risks are interpreted in terms of their implications for project cost and schedule performance in Samarra.

4.1 Sample characteristics

The results indicated that the majority of survey participants held a bachelor's degree (46.9%), followed closely by respondents with a master's degree (44.9%), while only a small proportion held a doctoral degree (8.2%). As presented in Table 1, this distribution reflects the current structure of the engineering labor market in Samarra, where construction projects are predominantly managed and implemented by relatively young engineers who have recently graduated from universities, while the involvement of senior academic professionals remains limited. This composition suggests that the collected responses were largely informed by practical, field-based experience rather than purely theoretical knowledge. Consequently, the

findings provide a realistic representation of on-site project conditions, which enhances the credibility and practical relevance of the study outcomes.

Table 1. Distribution of the Sample by Educational Qualification.

Educational Qualification	Frequency	Percentage
Bachelor's	23	46.9
Master's	22	44.9
PhD	4	8.2

4.2 Probability of excluded risks

The output from the Relative Importance Index (RII) is presented as an indicator of which excluded risks were ranked highest based on their likelihood of occurrence. The results of the analysis are presented in Table 2. Security risks were the most likely to occur (RII = 0.85). This finding was in line with the current security environment in Samarra and other places where security is a major factor in stabilizing the environment to support project development. The next category is financial risks (RII = 0.78), which indicates that restricted availability of cash and delayed disbursements can have a negative impact on projects. The legal risk category (RII = 0.70) includes risks related to complex contracts and disputes between parties involved in the project. The risks in this category are primarily related to the complexity of contracts and disputes. Administrative risks (RII = 0.65) included institutional weaknesses, an inordinate amount of bureaucracy, and inadequate organizational coordination. All of these factors may delay project completion. Natural risks were rated as the least important of all the categories (RII = 0.55) and this parallels the geographical and environmental stability of the project area.

The results presented in Table 2 show the majority of risks excluded from the Samarra construction project come from the local environment. Thus, effective contract management and a guaranteed funding source are essential for success. Previous research supports the conclusion that the most prevalent risk categories in volatile environments (like Iraq) are financial and security-related risks [5], [13], [19]. Conversely, studies conducted in more stable and/or developed countries (advanced and institutionally stable) often conclude that there are very few technical and/or natural risk categories in relation to the uncertainty of construction projects [8], [15]. These differences between the types of risks associated with construction projects in different contexts highlight that the political, institutional, and security conditions in Iraq and (specifically) in Samarra need to be taken into consideration in development of project time and cost estimates if the project managers are to develop reliable project plans.

Table 2. Ranking of Excluded Risks According to the Relative Importance Index (RII).

Type of Risk	RII
Security	0.85
Financial	0.78
Legal	0.70
Administrative	0.65
Natural	0.55

4.3 Impact of risks on cost

Table 3 shows that security risk is the largest contributor to a project's overall cost (40%) when evaluating the identified uncontrollable risks. This indicates how significantly the future viability of a construction project in the city of Samarra is dependent on the stability of its security situation. Disruption of security will create work stoppages, necessitate a suspension of work for an interim period, require additional safety measures for the site, increase liability through higher insurance rates, and create monetary liabilities through a loss of revenue due to delayed outcomes. Financial risk was the second highest contributing factor to the overall project's cost (30%), demonstrating the extent to which late payment, funding interruptions, and unstable cash flow are detrimental to the total cost of a project.

The costs associated with legal and administrative risk account for 15% and 10%, respectively, of all project cost impacts and therefore create a material impact on project costs, while natural risks are a relatively small (i.e., 5%) factor in project cost impacts. As such, Project Cost impacts due to Natural Risks will be very low because of the relative stability of both the geography of Samarra and the environmental conditions within Samarra, as reflected in Table 3, Distribution of Cost Impact by Project Type. Finally, as outlined in Table 3, security risk and financial risk continue to be the two primary factors influencing project cost impacts of construction projects in Samarra. Furthermore, it is worth noting that the results of the studies previously conducted in Iraqi cities, as measured by the above parameters, clearly established that Security and Financial Risks are the two main factors associated with project cost escalation in unstable climates [11], [17]. As noted in Table 3, the impact of costs associated with Security and Financial Risks in Samarra is high, suggesting that the context of the projects in which these events take place outweighs the technical means by the manner by which those Projects are implemented.

Table 3. Impact of Excluded Risks on Project Cost.

Type of Risk	Impact on Cost (%)
Security	40
Financial	30
Legal	15
Administrative	10
Natural	5

4.4 Impact of risks on project duration

Table 4 presents the average perceived delay associated with each category of excluded risks in construction projects in Samarra.

Table 4. Impact of Excluded Risks on Project Duration.

Type of Risk	Average Delay (days)
Security	120
Financial	90
Legal	60
Administrative	45
Natural	20

Note: The reported delay durations represent respondents perceived average estimates of project delays associated with each excluded risk category, rather than exact recorded delays from completed projects.

The results indicate that excluded risks have varying levels of impact on project duration. Security-related risks resulted in the highest average delay, estimated at approximately 120 days, followed by financial risks with an average delay of about 90 days. These delays were mainly attributed to security incidents and financial disruptions that frequently led to work suspensions, supply chain interruptions, and prolonged periods of site inactivity. Legal risks contributed an average delay of 60 days, primarily due to the time required to resolve contractual disputes. In contrast, administrative and natural risks had comparatively lower impacts on project schedules, with average delays ranging between 20 and 45 days.

Findings from this research support earlier international and regional studies which show that legal/administrative risk has a modest impact upon project time, whereas financial/security risks often produce greater impacts leading to longer delays when projects are implemented under instability [6], [14], [9]. Security-related delays dominate in Samarra due to contextual variables associated with post-conflict conditions; in these situations, external disruptions to construction project timelines exceed all other forms of disruptions (such as technical/environmental).

4.5 Analysis of the relative importance index (RII) for excluded risks

To rank the eliminated risks reported in this research effort, the Relative Importance Index (RII) method was used. Such that the respondents' assessment on occurrence, cost, and time impacts were analyzed as numbers between 0 and 1. In this study, the concept of "risk importance" is operationalized through three measurable dimensions: probability of occurrence, impact on project cost, and impact on project duration. Accordingly, probability is treated as an integral component contributing to overall risk importance, rather than as an independent indicator. Using the RII formula on all the categories of risks, the resulting chronological order of severity fills out the image of the risks better than descriptive statistics, which were explained in earlier chapters, along with being more scientific in identifying the risks needing urgent managerial attention.

As shown in the tables that follow, along with the network diagram, the computed RII values demonstrate the relative ranking of excluded risks, as well as the inter-relationships of their probability, cost, and time delays.

4.6 Relative importance index (RII) for each dimension separately

Table 5 shows the computed RII values of the excluded risks for the three dimensions - probability of occurrence, cost impact, and schedule impact. This allows one to gauge the severity of each risk in a specific dimension before computing the composite index and deriving the final overall ranking. The risk categories presented in Table 5 were selected from the excluded risks identified through the questionnaire survey, focusing on risks that are not explicitly allocated contractually and are frequently encountered in practice within the local context of Samarra.

As shown in Table 5, risks related to war produced the highest values in most dimensions and particularly with respect to schedule impact (RII = 0.8122), given their potential to delay projects. In contrast, risks pertaining to nuclear energy/radiation and design conditions obtained lower scores in all dimensions, evidencing that this variation influences project performance in different ways.

To provide a consistent and comparable basis for analysis of risk categories and dimensions, the RII listed in Table 5 were computed by summing the Likert scale responses provided by respondents for Each risk under Each probability, cost, and duration dimension (probability/cost/duration) according to the following formula: (1). As an example, the RII for war risks related to impacts on schedule would be assigned a weighted mean of 0.8122 based on the normalized ratings from the respondents on how much impact such risks have on delays in completing projects relative to the highest rating that could have been awarded.

Table 5. RII Values for Each Dimension Separately (Probability – Cost – Duration).

Risk Category	RII – Probability	RII - Cost	RII - Duration
War-related risks	0.6939	0.6122	0.8122
Riots / Civil disorder	0.4980	0.6000	0.5755
Nuclear energy / Radiation	0.4000	0.5184	0.4490
Employer's occupation of works	0.5347	0.5061	0.4327
Engineer's design as per conditions	0.4939	0.5184	0.4490

4.7 Composite relative importance index (composite RII) for risk ranking

A composite index of the exclusion risk has been established by combining the risk of occurrence, cost impact and scheduling impact for all three dimensions together with weighted occupational coefficients assigned for the three dimensions based on their relative importance to overall project performance; probability (0.2), Cost (0.4), and Duration (0.4). The Composite Relative Importance Index (Composite RII) was calculated by summing the individual RII for each of the three dimensions previously shown in Table 5. Since the cost and scheduling elements are closely tied to the project performance objectives, as well as the decision-making process involved in the construction project, the Composite RII gives greater emphasis to these factors when determining the overall importance of exclusion risks associated with project performance objectives.

The rationales for the disproportionate weighting system is due primarily to the objective of this investigation - that is, to determine the impact of risks that are excluded when estimating project performance; rather than just the probability of occurrence. As indicated by prior research, in most cases, the risks that are excluded from consideration during the estimation process for construction projects generally occur much later in the project, with the effects manifesting through cost overruns and schedule delays. It is therefore appropriate to assign higher weights to the cost and duration dimension to adequately measure the practical severity of excluded risks from a project management viewpoint.

The Composite Relative Importance Index (Composite RII) was calculated using Equation (2):

$$\text{Composite RII} = (0.2 \times \text{RII\_Probability}) + (0.4 \times \text{RII\_Cost}) + (0.4 \times \text{RII\_Duration}) \qquad (2)$$

As indicated in Table 6, war-related risks achieve the highest ranking (Composite RII = 0.7086), followed by riots and civil disorder (0.5698). The excluded risks related to the engineer's design as per contract conditions, the employer's occupation of works, and nuclear energy/radiation obtained rankings from third to fifth, with relatively close Composite RII values.

Table 6. Composite RII and Risk Ranking (Weights: 0.2 Probability, 0.4 Cost, 0.4 Duration).

Risk Category	Composite RII	Rank
War-related risks	0.7086	1
Riots / Civil disorder	0.5698	2
Engineer's design as per conditions	0.4857	3
Employer's occupation of works	0.4824	4
Nuclear energy / Radiation	0.4669	5

To confirm the results of the risk ranking analyses using equal weights (⅓ for each risk dimension), an additional analysis was performed to determine the degree to which the ranking is robust against the assigned weights. The sensitivity analysis indicated that the overall ranking remained relatively stable (Table 7), with the war-related risks ranked the highest (Composite RII = 0.7061) and riots/civil disorder ranked second (Survivors RII = 0.5578). The only noticeable shift occurred in ranks 3 through 5, which were: (1) Employer's Occupation, (2) Engineer's Design and (3) Nuclear Energy/Radiation.

Table 7. Composite RII and Risk Ranking (Equal Weights: ⅓ for Each Dimension).

Risk Category	Composite RII	Rank
War-related risks	0.7061	1
Riots / Civil disorder	0.5578	2
Employer's occupation of works	0.4912	3
Engineer's design as per conditions	0.4871	4
Nuclear energy / Radiation	0.4558	5

The two ranking systems demonstrated a strong correlation on the determination of the highest priority risk factors; this is a clear indication of how reliable the Composite RII results are. The results also support the assertion that both war-related activity and civil unrest are the major contributors towards delays or increased costs for construction projects within Samarra. The results of the sensitivity analysis also show that the order of precedence as determined for the most important excluded risks is not solely based on one weighting assumption, thereby enhancing the credibility of the Composite rankings. Furthermore, to enhance the understanding of how these results will affect construction schedules and budgets, the following section provides a Graphic Network representation of the excluded risks which act as nodes, and illustrates how the excluded risks link to cost and schedule impacts.

4.8 Network diagram *representation of the relative importance index (RII)*

To further clarify the results, and to show the relationships amongst excluded risks on the left and their influences on cost and schedule on the right, a network diagram was developed to illustrate the positioning of each risk and the magnitude of its influence, as indicated by the RII values assigned to the connecting links. Excluded risks are positioned on the left side of the network diagram, while 'cost' and 'schedule', the key project performance dimensions, are positioned on the right.

The network diagram function is solely a visual and interpretive representation of the data obtained from the RII scores calculated in Section 4.4 and not a computational/predictive model utilizing optimization methods, machine learning or artificial neural networks to produce new information. The connections between nodes in the diagram reflect the relative weightings of each excluded risk's impact on project cost and time (i.e., project schedule) as determined from the RII scores in Section 4.4. By providing a graphical representation of the relative weightings associated with each excluded risk's impact on project cost and time, this network diagram enhances the tabular format presented in the earlier sections, thereby enabling readers to quickly interpret the relationships between multiple risks in comparison with numerical results only (i.e., by interpreting the RII scores).

Each link weight in the diagram corresponds proportionally to the computed RII values for cost and schedule impacts, ensuring full consistency between the graphical representation and the quantitative results reported in Tables 5–7.
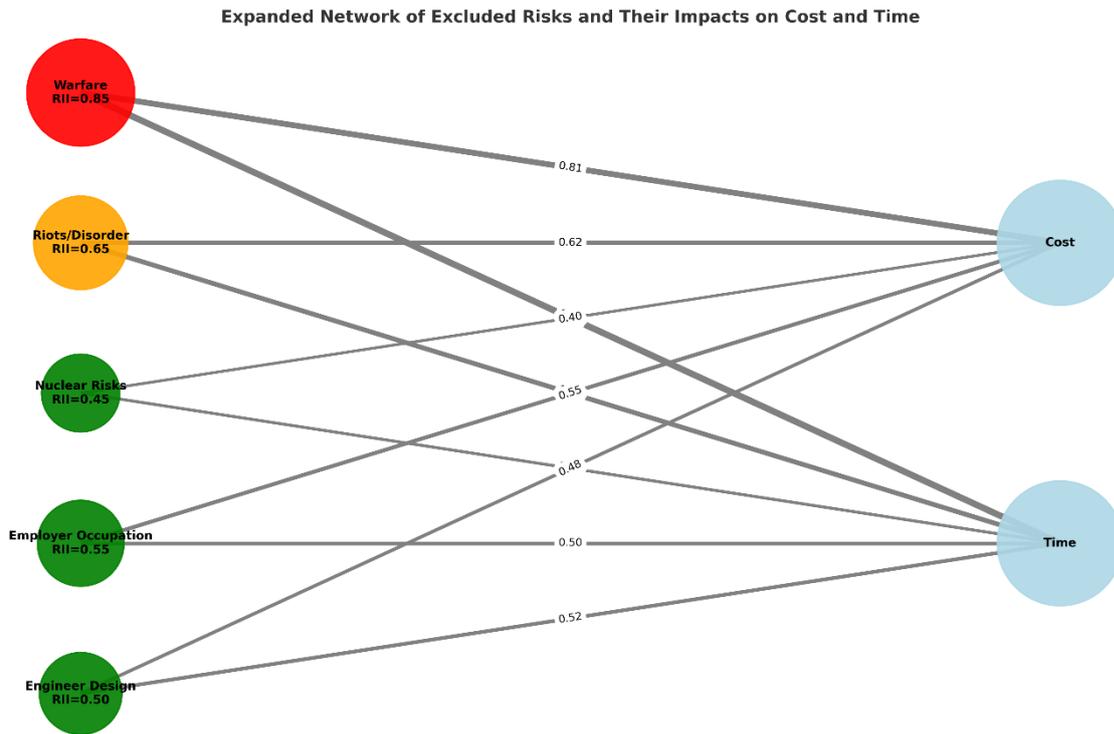
Fig.1. Network diagram of excluded risks and their impacts on project cost and schedule based on Relative Importance Index (RII) values.

The data displayed in Fig. 1 demonstrate that construction projects have significant exclusions with regard to risks associated with war and riots/civil disobedience and that these exclusions have a significant effect on the project schedule and cost due to the high risk indices. The other three excluded risk categories, including the employer's access to part of the works, the design by the engineer per contract requirements and: nuclear energy/radiation, have a lower connection to cost and schedule per the numbers and are ranked lower on the Risk Index Illustrations chart.

This visualization highlights that security-related excluded risks should receive priority attention when developing risk response strategies, while the remaining risks may be addressed through supporting measures aimed at mitigating their comparatively limited effects. By integrating RII-based tabular results with the network diagram representation, the analysis reinforces that war-related events and civil disorder constitute the most severe excluded risks affecting construction project cost and schedule in Samarra.

4.9 Risk response measures for excluded risks

Risk response measures represent the pragmatic step in which the product of quantitative analysis is transmuted into manifestly viable solutions. Having established hierarchy of risk importance with the aid of the Relative Importance Index, it became pertinent to turn our attention to some of the techniques that could ameliorate the damage that these priority risks may inflict on cost and schedule. In this regard, we investigated two types of responses: (i) insurance for the contractor and (ii) encouraging risk mitigation by the introduction of proactive provisions in the contract.

Table 8 summarizes responses and reveals that, by and large, participants (69.4%) did not view insurance against excluded risks as effective (or only to some extent effective). Just 30.6%

viewed insurance as an effective or very effective remedy, indicating that insurance is a blunt tool, particularly against security or exceptional risks. Besides, it floats in the sea of liabilities that contractors (and thus projects) must navigate.

Table 8. Contractor Insurance Against Excluded Risks.

Effectiveness Level	Frequency	Percentage (%)
Ineffective	21	42.9
Somewhat effective	13	26.5
Effective	10	20.4
Highly effective	5	10.2
Total	49	100

Table 9 shows that 81.7% of the respondents believe that the way contracts include proactive measures will be successful. Specifically, these proactive measures were rated by respondents on a range from "somewhat effective" to "very effective." This indicates the most significant movement towards the adoption of preventive techniques in the development of contracts as compared to an increased acceptance of fiduciary insurance.

Table 9. Inclusion of Proactive Measures in Contracts.

Effectiveness Level	Frequency	Percentage (%)
Ineffective	9	18.4
Somewhat effective	16	32.7
Effective	12	24.5
Highly effective	12	24.5
Total	49	100

The findings of this study indicate that, as an overall result of these two methodologies' evaluations, those who use the preventive approach of embedding clauses and procedures within a contract have a greater acceptance of this type of solution and believe that it is more effective than an insurance-based solution. This shows that an integrated approach that incorporates both of these methodologies will create a more comprehensive and effective method for addressing construction risks that are excluded from coverage. The findings of the quantitative analysis and some statistics will provide a framework for evaluating how excluded risks are managed; therefore, it is prudent to look at the findings of this study in conjunction with the findings from the other aspects of the study to gain an understanding of how the various methodologies have been applied. The next section, "Discussion," will examine the findings in greater detail and relate them to both theory and practice.

4.10 Discussion of findings.
The results obtained from this research illustrate that specific construction project exclusions of risk are based on the localised conditions present within the city of Samarra, Iraq. Most importantly, security-related risks such as conflict and civil disorder were always given

precedence over any other risk of cost and schedule. The predominance of these types of risks is indicative of the inherent instability of the country's environment following many years of civil war, resulting in an overall environment where outside sources of disruption have a more substantial impact on a construction project's ability to continue or perform than technical issues alone. The finding is consistent with a body of literature supporting the notion that violent events have played an integral role in leading construction projects in Iraq and in other parts of the world with similar security disturbances to suspend, terminate and experience major delays [6], [10], [11].

Financial risks ranked second, indicating the relevance of delayed capital flows and cash shortages in influencing project outcomes. This finding aligns with regional development reports and Iraqi case studies that highlight financing instability as a critical constraint on infrastructure delivery, corroborating evidence reported by the World Bank and other development agencies operating in Iraq [14], [16].

The data indicates that natural risks had little to no effect on cost and schedule overruns. This is likely due to the geographic stability of the region where the study was conducted, compared to studies taken from advanced, institutional stable countries indicating that the biggest contributor of cost and schedule overruns is primarily technical, environmental, or design-related. A comparison of the current research findings with the previously described stable construction environments suggests that the differences in the conceptualisation of risk and risk identification in Samarra are related to contextual variables associated with governance capacity, security conditions and financial resiliency that shape risk perceptions and priorities in Samarra.

Although the overall ranking of major risk categories is broadly consistent with findings reported in international literature, the present results reveal important local specificities related to the Iraqi context. In Samarra, excluded risks are amplified by weak institutional enforcement, fragmented decision-making structures, irregular funding release mechanisms, and limited availability of experienced project management personnel. These local conditions intensify the impacts of security and financial risks beyond levels typically observed in institutionally stable environments, transforming them from manageable uncertainties into dominant constraints on project cost and schedule performance.

The results of the risk ranking analyses offer support to confirm that the data used is valid and reliable across multiple risk analysis methodologies. The findings support the idea that security risks and financial risks continue to be at the forefront of risk rankings across all risk analysis methodologies, thereby enhancing confidence in the prioritization process [9], [19], [20].

The network representation further strengthens this interpretation by visually demonstrating how security-related risks exert strong and direct influence on both project cost and schedule, whereas other excluded risks occupy more peripheral positions. This suggests that conventional technically focused mitigation strategies alone are insufficient in highly volatile environments such as Samarra, and that effective risk management requires higher-level institutional coordination and policy-oriented interventions.

The findings of the evaluation of risk response strategies showed that conventional insurance coverage is thought to have a constraining effect, while an active contractually based approach was perceived as being more feasible and impactful. Thus, the researchers conclude that the current international recommendations support the development of a preventative-

based, and contract-based approach to risk management rather than relying solely on insurance [5] [15]. These results provide three primary observations: security and financial risk are the most important type of risk; the contextual basis of the differences from studies conducted in stable environments; and the advantages of adopting preventative measures in contractual arrangements, therefore forming a foundation for the subsequent recommendations presented in the next section.

5. Conclusions

The results of this research reveal that the greatest challenges to construction activity in Samarra arise from security-related risks, especially war-related occurrences and civil unrest, which greatly affect the duration and cost of construction projects. Second on the list of financial instability-related risks was the interruption of funding and the delay in receiving payment as being the primary contributors to under-performance of construction projects. In addition to these two types of risk, all other risks such as the occupation of the construction site by the owner's representatives, conditions specified in the designer's contract and nuclear-related issues are all placed in lower categories reflecting their limited effect within the regional project circumstances.

The evaluation of risk response strategies revealed that reliance on traditional insurance mechanisms is generally perceived as ineffective in addressing excluded risks, especially those driven by security and institutional instability. Conversely, the inclusion of proactive contractual provisions, such as flexible clauses, adaptive scheduling mechanisms, and predefined response procedures, emerged as a more practical and context-appropriate approach.

The practical implications of these results indicate that the need exists for all security and finance-related excluded risks to be specifically included in the Samarra project planning, estimation of costs, scheduling. It is also recommended that periods of time be scheduled for the re-examination of risk priorities using quantitative tools (for example, the Relative Importance Index [RII] framework developed in this study) to ensure that changes in security and institutional conditions are taken into account. Finally, improvements will be realized through greater collaboration between the various stakeholders in the Samarra project and the appropriate authorities who are responsible for delivering the project.

The research is limited to a quantitative analysis of risk factors excluded from the analysis of Samarra, Iraq, through the use of a questionnaire and two calculation methods: Relative Importance Index (RII) and a composite Relative Importance Index (Com-RII). Future studies should expand upon the findings of this study's RII-based ranking of excluded risks. Future research could apply advanced quantitative methods to explore higher-priority risks dynamically and their combined impacts on project outcomes through the use of Monte Carlo Simulation, machine learning algorithms, or multi-criteria decision-making (MCDM) methodologies. Future studies may also be useful to support or validate the transferability of the proposed risk ranking system by comparing the ranking systems developed in this study to those developed for other cities in Iraq and/or other post-conflict nations. Such studies are encouraged to enhance weighting used in Com-RII composite risk indices.

References

[1]   J. W. Won, W. Jung, S. Baek, and S. H. Han, "Probability and Impact Perspectives on Cost and Schedule Risks in International Construction Projects: An Empirical Investigation," *KSCE Journal of Civil Engineering*, vol. 28, no. 7, pp. 2600–2612, Jul. 2024, doi: 10.1007/s12205-024-2598-7.

[2]   S. Zhang, L. Zhang, and Y. Gao, "Risk allocations in construction contracts: A comparison of China's Standard Form of Construction Contract and FIDIC Conditions of Contract for Construction," Surveyor Times, vol. 15, no. 5, pp. 35–41, 2006.

[3]   Y. Hameed and G. R. Abduljabbar, "Risk assessment process for construction projects in Iraq using an MCDM framework applying the combined TOPSIS–SWARA method," OSF Preprints, 2022, doi: 10.17605/OSF.IO/TNAWV.

[4]   N. G. Bunni, FIDIC's International Conditions of Contract: Managing Risk, seminar paper, IBC/FIDIC, London, Oct. 2005.

[5]   J. P. Fitzsimmons, R. Lu, Y. Hong, and I. Brilakis, "CONSTRUCTION SCHEDULE RISK ANALYSIS - A HYBRID MACHINE LEARNING APPROACH," *Journal of Information Technology in Construction*, vol. 27, pp. 70–93, 2022, doi: 10.36680/j.itcon.2022.004.

[6]   I. L. Abramov and Z. A. K. Al-Zaidi, "Assessing of the Performance of Construction Companies in Iraq in Terms of Managing Risk Factors," in *AIP Conference Proceedings*, American Institute of Physics Inc., Nov. 2023. doi: 10.1063/5.0177948.

[7]   A. Lapidus, D. Topchiy, T. Kuzmina, and O. Chapidze, "Influence of the Construction Risks on the Cost and Duration of a Project," *Buildings*, vol. 12, no. 4, Apr. 2022, doi: 10.3390/buildings12040484.

[8]   E. Hindaryanto, M. Ardans, D. Kurnia, and H. H. Purba, "A systematic review of project risk in construction projects," Advance Researches in Civil Engineering, vol. 6, no. 1, pp. 57–70, 2024, doi: 10.30469/arce.2025.496131.1081.

[9]   V. Aarthipriya, G. Chitra, and J. S. Poomozhi, "Risk and its impacts on time and cost in construction projects," *Journal of Project Management (Canada)*, vol. 5, no. 4, pp. 245–254, 2020, doi: 10.5267/j.jpm.2020.6.002.

[10]   C. Engineering Center of Expertise, "USACE Recommended Best Practices, Cost & Schedule Risk Analysis (CSRA)," 2024.

[11]   I. Mahdi *et al.*, "Developing risk assessment model for FIDIC, NEC and local contracts in construction projects," *Online*, 2021. Available: https://www.researchgate.net/publication/351083148

[12]   Hassoon, A. (2025). Growing demand for housing and productivity challenges in the construction industry: workforce and management factors. Publication Source. https://doi.org/10.1186/s43065-025-00116-4

[13]   A. H. Nassar and A. M. Elbisy, "A Machine Learning Approach to Predict Time Delays in Marine Construction Projects," *Engineering, Technology and Applied Science Research*, vol. 14, no. 5, pp. 16125–16134, Oct. 2024, doi: 10.48084/etasr.8173.

[14]   Bunni, N. G. (2001). FIDIC's new suite of contracts: Clauses 17 to 19—Risk, responsibility, liability, indemnity, insurance, and force majeure. *International Construction Law Review*, 18(3).

[15]   S. Mohammed and A. Hasan, "In-depth analysis of critical factors affecting Iraqi construction projects performance," *Open Engineering*, vol. 14, no. 1, Jan. 2024, doi: 10.1515/eng-2024-0006.

[16]   H. Z. Faeq and T. A. Khaleel, "Determine the Most Important Construction Risks and Know the Degree of Their Impact on Construction Projects in Iraq," *International Journal of Safety and Security Engineering*, vol. 13, no. 5, pp. 933–943, 2023, doi: 10.18280/ijsse.130517.

[17]   A. Had, F. E. M. Ghazali, B. Jrew, and A. Hassoon, "Sustainable development strategies for improving the efficiency and safety of a highway in Iraq," *Edelweiss Applied Science and Technology*, vol. 9, no. 5, pp. 43–52, Jun. 2025, doi: 10.55214/25768484.v9i5.6775.

[18]   Ariza-Flores, V. A., & Zavala Ascaño, G. (2025). Quantitative risk analysis framework for cost and time estimation in road infrastructure projects. Infrastructures, 10(6), 139. https://doi.org/10.3390/infrastructures10060139

[19]   Ichsan, Muhammad. (2025). Monte Carlo simulation for enhancing schedule and cost risk analysis in construction projects. Applied Sciences, 15(13), Article 7464. https://doi.org/10.3390/app15137464

[20]   H. S. M. A. Alshehhi, R. S. @ M. Sidek, and E. A. Rozali, "The impact of risk management on the performance of construction projects," in Proc. Singapore International Conference on Management & Business Practices (MBP), Singapore, Mar. 13–14, 2024, pp. 207–208, doi: 10.20319/icbellp.207208.

[21]   AACE International. (2008, October). Risk analysis and contingency determination using range estimating (TCM framework: 7.6 – Risk management) (Recommended Practice No. 41R-08). AACE International.

[22]   Restrepo Ramirez, A. F., & Rua Machado, C. A. (2025). Predicting delays and cost overruns in construction projects: A machine learning approach. Revista EIA, 22(44), 1–30. https://doi.org/10.24050/reia.v22i43.1861

[23]   AACE International, Recommended Practice No. 44R-08: Risk Analysis and Contingency Determination Using Expected Value, TCM Framework: 7.6 – Risk Management, AACE International, Morgantown, WV, USA, 2012.