A Novel Model for Risk Management Software in Construction Projects

Alireza Davoodi[1], Mohammad Ammarlou[2], Meysam Ebrahimi lakme sari[3]

1- Department of Mathematics, Ne.C.,Islamic Azad University, Neyshabur, Iran.
ALIRZD@IAU.AC.IR
2. Department of Civil Engineering, Ne.C., Islamic Azad University, Neyshabor, Iran.
MOHAMMAD.AMMARLOU@IAU.AC.IR
3. Department of Civil Engineering, Ne.C., Islamic Azad University, Neyshabor, Iran.
MEYSAM.EBRAHIMILAKMESARI@IAU.AC.IR

Abastract

A construction project involves a wide range of activities and transformations during its planning and execution stages, which can pose several risks. An essential function of risk management is to create awareness of uncertainty, qualify risks, manage controllable risks, and curtail uncontrollable risks. The evidence demonstrates that effective implementation of digital risk management software can achieve significant improvements in safety performance, regulatory compliance, project delivery times, and cost control. This study aimed to propose a new model for Risk Management software for Construction Projects based on a Review of the literature. We conducted a literature review according to the PRISMA guidelines. In our search, we focused on construction and civil engineering projects(P) and Risk Management Software (I). The comparison of interest (C) was Traditional/Manual Methods. In terms of outcomes (O), it was postulated that reported outcomes could be categorized as the "identification of specific outcomes". We set a timeframe (T) for research published since 2010, which encompassed the last 16 years. A literature search was conducted on 23 September 2025, and a final search was conducted on 22 October 2025 via Web of Science, Scopus, Wiley, and Science Direct databases. The search keywords were "Risk Management, software, Construction Projects" using AND/OR operators. We searched all combinations of terms from each category to find the target studies. We included six articles and two websites. The developed risk management software systems demonstrated a broad application scope, having been designed for use in various countries, including Iraq, China, Korea, and the United Kingdom. These systems were successfully deployed across diverse projects such as hospitals, railways, metro lines, bridge construction, coal chemical enterprises, and small and medium-sized enterprises (SMEs) in the construction sector. Crucially, the majority of the custom-designed software solutions were BIM-based, underscoring the trend towards integrating advanced information modeling into risk management practices across the global engineering sector. We presented the results section in three distinct stages: 1. A review of the literature, 2. the synthesis of the study findings, and 3. the proposal of a new model.

BIM is an intelligent 3D model-based tool that gives users a digital depiction of the functional and physical aspects of a facility. Increased understanding of the planning, design, construction, and management of the space is made possible by this type of representation. When properly applied, building information models can address communication issues in the construction industry and offer a shared knowledge base that can serve as a trustworthy foundation for decisions made throughout a building's lifecycle.

Keywords: *Risk Management, software, Construction Projects*

1. Introduction

During the planning and execution stages of a construction project, a variety of activities and transformations are involved, which can present risks. There are intricate planning procedures, expensive production processes, and time-consuming custom design processes. Additionally, building projects are growing in size, complexity, and cost. If this massive size is not properly managed, losses may result.(1).

The impact of uncertainty on an organization's goals in the construction sector can be defined as a construction risk. The coordinated efforts aimed at controlling construction risk inside an organization are known as construction risk management, or CRM. CRM includes all RM activities at the project, business, and industry levels in the construction sector.(2).

A key function of risk management is to create an awareness of uncertainty, to qualify risks, to manage controllable risks, and to reduce non-controllable risks. (3). There are many definitions of risk management, all portraying the fundamental goal of minimizing the impact of risk. As stated by Irimia-Diéguez et al. (2014) defines risk management is the methodical process of recognizing, evaluating, and reacting to project risk. (4). Tohidi (2011) states that risk management entails determining and evaluating risks as well as implementing strategies to lower them. Therefore, risk management entails assessing the probability that a risk will materialize, taking the appropriate actions to investigate its consequences, and devising strategies to prevent or mitigate those consequences should the risk materialize.(5).

Digitization of construction using BIM offers innovative ways to effectively manage construction risks(6).

The market for BIM technologies has expanded dramatically in recent years to support BIM workflow of processes. Even though BIM software has grown tremendously, end users have faced difficulties due to its enormous quantity and other technical problems. According to Fazli et al. (2014), one of the main challenges in developing a combined building information model is getting various file formats to work correctly. A particular value is obtained when data is extracted from the original BIM model, but a different value may be produced when the data is converted into a different file format.(7).

The evidence demonstrates that effective implementation of digital risk management software can achieve significant improvements in safety performance, regulatory compliance, project delivery times, and cost control. The aim of this study was to This study aimed to propose a new model for Risk Management software for Construction Projects based on a Review of the literature.

2. Methods

2.1. Protocol and registration

Our systematic literature review was performed in alignment with the PRISMA guidelines(8).

2.2. Eligibility criteria

The Population, Intervention, Comparison, Outcome, and Timeframe (PICOT) framework guided our literature search to guarantee a thorough search strategy(9). In our investigation, we concentrated on construction and civil engineering projects (P) as well as Risk Management Software (I). The comparison of interest (C) was Traditional/Manual Methods. Concerning outcomes (O), we proposed that reported outcomes could be classified as the "identification of specific outcomes." We established a timeframe (T) for research published since 2010, covering the past 16 years.

2.3. Information sources

Two engineering researchers (MA and MEl) independently searched three electronic databases, including Web of Science, Scopus, and Science Direct, to identify eligible publications. A literature search was conducted on 23 September 2025, and a final search was conducted on 22 October 2025.

2.4. Search

The search identified original articles. The search keywords were "Risk Management, software, Construction Projects" using AND/OR operators. We searched all combinations of terms from each category to find the target studies. An example of the search strategy was as follows:

(Risk Management) AND (software) AND (Construction Project).

2.5. Study selection

Two researchers (MA and MEl) independently reviewed the titles and abstracts of the retrieved articles to find studies that met the inclusion criteria. The inclusion criteria consisted of (a) Original research papers, systematic Review, case studies), (b) publications in English (c) articles examining one or more software, (d) the context of **civil, construction, or infrastructure projects** (e.g., buildings, roads, dams, public works), and (e) performing the e software in construction project. The exclusion criteria consisted of (a) Studies focusing exclusively on **general project management, scheduling, or cost control** that do not feature a dedicated risk management module or methodology, (b) Research conducted in other industries (e.g., IT/software development projects, finance, or manufacturing). (c) Grey literature, including dissertations, Master's theses, editorials, letters to the editor, white papers, or vendor software advertisements (unless explicitly published as peer-reviewed academic articles). (d) Books or book chapters. We then retrieved the full texts of these studies and evaluated their eligibility. A third reviewer (Dr.Davoudi) helped resolve disagreements regarding the eligibility of studies (Figure 1).

2.6. Data Collection Process

Our team developed a sheet for data extraction. The data were extracted by two reviewers (MA and MEl). There was a consensus reached between the reviewers if there were any disagreements, and data was included only on whether there was an agreement.

2.7. Data items

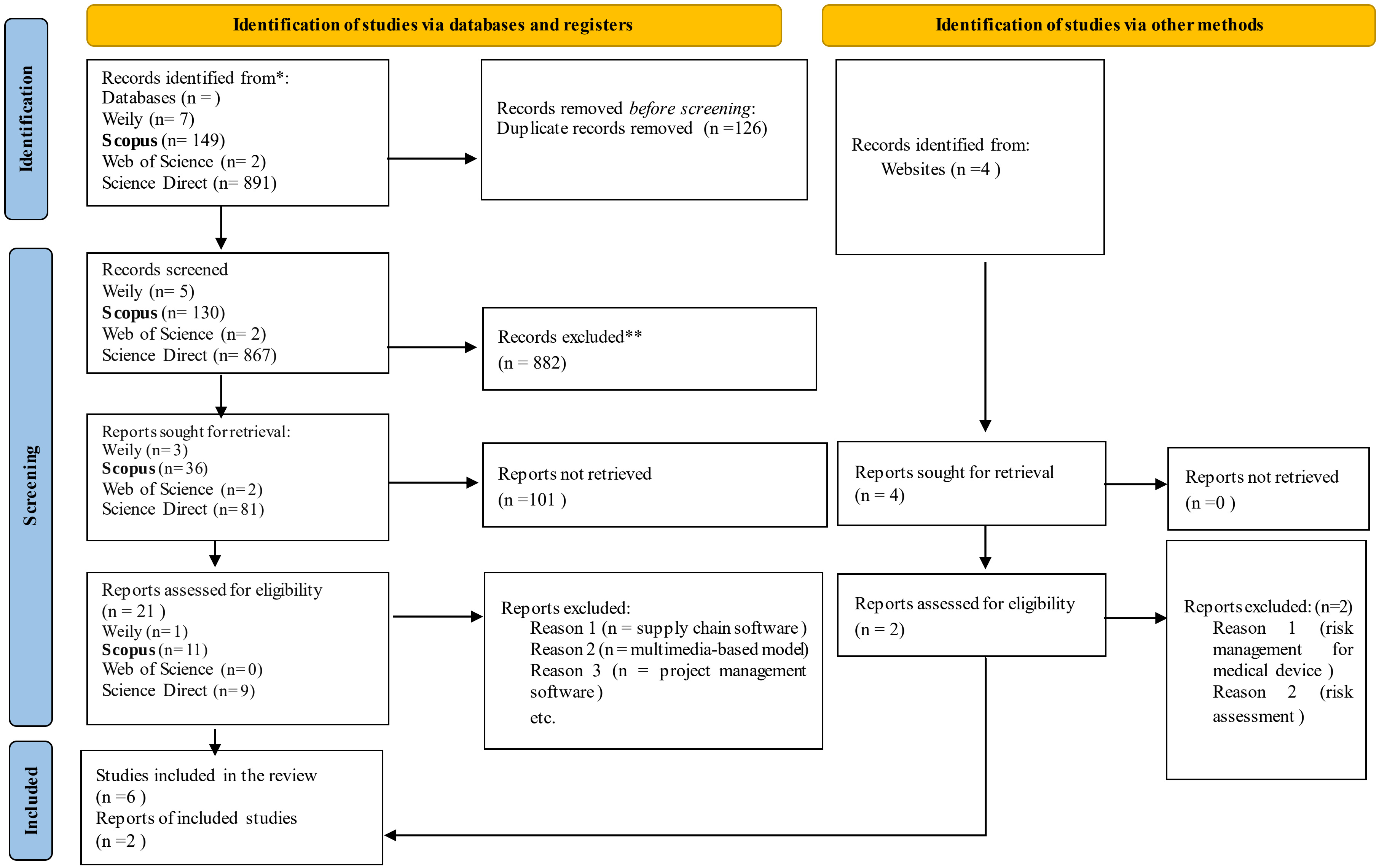
To extract and summarize information from the included studies, the reviewers conducted a thorough review that covered the title, author, year, study type, country, software, projects, outcomes, and results (Table 1).

2.8. Risk of bias in individual studies

All studies were independently reviewed by two reviewers (MA and MEl). An agreement was reached by referring to a third reviewer (Dr.Davoudi) if scores differed.

2.9. Synthesis of results

Two reviewers (MA and MEl) synthesized and analyzed the data. The discrepancy between them was resolved by consensus, and only data that both reviewers agreed upon was included. An evidence synthesis with narrative and descriptive summaries, as well as tables, was prepared.


Identification of studies via databases and registers
Identification of studies via other methods
Identification
Screening
Included
Records identified from*:
Databases (n =)
Weily (n= 7)
Scopus (n= 149)
Web of Science (n= 2)
Science Direct (n= 891)
Records removed before screening:
Duplicate records removed (n =126)
Records identified from:
Websites (n =4)
Records screened
Weily (n= 5)
Scopus (n= 130)
Web of Science (n= 2)
Science Direct (n= 867)
Records excluded**
(n = 882)
Reports sought for retrieval:
Weily (n=3)
Scopus (n=36)
Web of Science (n=2)
Science Direct (n=81)
Reports not retrieved
(n =101)
Reports sought for retrieval
(n = 4)
Reports not retrieved
(n =0)
Reports assessed for eligibility
(n = 21)
Weily (n=1)
Scopus (n=11)
Web of Science (n=0)
Science Direct (n=9)
Reports excluded:
Reason 1 (n = supply chain software)
Reason 2 (n = multimedia-based model)
Reason 3 (n = project management software)
etc.
Reports assessed for eligibility
(n = 2)
Reports excluded: (n=2)
Reason 1 (risk management for medical device)
Reason 2 (risk assessment)
Studies included in the review
(n =6)
Reports of included studies
(n =2)

Figures 1

3. Result

The developed risk management software systems demonstrated a broad application scope, having been designed for use in various countries, including Iraq, China, Korea, and the United Kingdom. These systems were successfully deployed across diverse projects such as hospitals, railways, metro lines, bridge construction, coal chemical enterprises, and small and medium-sized enterprises (SMEs) in the construction sector. Crucially, the majority of the custom-designed software solutions were BIM-based, underscoring the trend towards integrating advanced information modeling into risk management practices across the global engineering sector.

We presented the results section in three distinct stages: 1. A review of the literature, 2. the synthesis of the study findings, and 3. the proposal of a new model.

3.1. A review of the literature

3.1.1. BIM-Supporting System

This study proposes an integrated model to support **Building Information Modeling (BIM)** by combining **Risk Management (RM)** and **Value Management (VM)**. The model employs RM techniques to identify risks and quantify their impact on cost, while VM is used to determine effective mitigation measures for each risk factor. The research developed a software system that supports BIM and RM, assessing risks and their cost impact to ensure this information flows to all project parties. A total of **52 risks** were identified, each with multiple mitigation measures determined through brainstorming sessions. The **Fuzzy Analytical Hierarchical Process (FAHP)** was used to establish the relative importance of risks and the cost range of selected items. The case study, the design development for a private hospital in Iraq, demonstrated the software's ability to calculate the cost impact of unmitigated risks, such as local currency fluctuation, and integrate this revised unit price directly into the BIM quantity take-off process(10).

3.1.2. BIM Platform for Semantic Data

This study addresses the challenges of adopting standard BIM software in Asian construction markets, where management relies heavily on unit pricing and legacy data, by developing a specialized in-house BIM platform called CEV .The core of this system is the semantic integration of 4D BIM data (linking geometric models with schedule information) within a standardized Work Breakdown Structure (WBS) framework. This platform creates a highly transferable tool that supports effective construction management by embedding semantic data based on established WBS codes, thereby facilitating accurate risk profiling, cost prediction, and leveraging crucial legacy project data within the BIM environment(١١).

3.1.3. Dynamic risk early warning system

This paper proposes a **Dynamic Risk Warning System** for tunnel construction to overcome the limitations of static, subjective risk assessment practices .The system employs a **Knowledge-Data Dual Drive** approach: the **Consequence** dimension of risk is evaluated using a **knowledge-driven** expert system. The **Likelihood** dimension is dynamically assessed using a **data-driven** approach based on continuously updated construction and monitoring data .To couple and quantify the inherent uncertainty in both dimensions, a probability algorithm based on a **Two-Dimensional Cloud Model** is utilized .Application of the algorithm to the construction of **Guiyang Metro Line** 3 demonstrated good stability. It showed that the two-dimensional cloud model is superior to its one-dimensional counterpart for accurately reflecting and identifying complex, uncertain risks(١٢).

3.1.4. Risk Information Management for Bridges

This paper proposes a new method for Risk Information Management in bridge projects by integrating the Risk Breakdown Structure (RBS) into٣ D/4D BIM environments (3D models linked to schedule information). The primary goal is to overcome the lack of effective methods for managing risk data within BIM. The approach involves establishing a systematic link between risk data and the BIM model and proposes a new framework for a BIM-based risk information management system. The developed prototype tool allows for the identification and documentation of potential risks associated with construction activities in the 3D BIM model. It enables the visualization of identified risks in the 4D environment (including time) using a color-coded matrix. This ultimately helps project managers understand and manage activity-related risks more effectively(13).

3.1.5. Dynamic risks hierarchical

This paper studies the dynamic risk management and control model for coal chemical enterprises to enhance their risk management capabilities and develops the corresponding supporting application software. A dynamic risk classification control algorithm is constructed by combining an optimized neural network with a control chart .By analyzing the control chart, the optimized neural network is used to predict and provide early warnings for the risk development trend of the enterprises, thereby improving dynamic risk management capabilities through model parameter optimization. The application of this algorithm in a real-world case demonstrated that the accuracy of risk prediction can reach over 90%, contributing to more effective safety control and production process management(14).

3.1.6. Framework for Risk Management Software

This study develops a Risk Management Software System Framework to empower Small and Medium-sized Enterprises (SMEs) in the engineering construction sector to proactively identify, analyze, and manage risks. Evidence confirms that these firms are vulnerable and underperform due to the lack of a formal risk management system. The research framework, based on the Balanced Score Card, highlights risk indicators affecting performance (assessed in terms of completion time, execution cost, and overall quality of delivery). The developed software guides the operator to avoid, minimize, or mitigate relevant risks, providing a systematic and proactive approach to risk management to ensure successful performance outcomes(15).

3.1.7. OrigamiRisk

With integrated solutions on a specially designed, cloud-native platform, Origami Risk empowers leaders in risk, safety, and insurance. Origami Risk helps the insurance and risk ecosystem create more robust, secure, and resilient companies. Risk management across a portfolio of projects is a complex challenge which affects timeframes, compliance and the welfare of staff. With so many moving parts, it is essential to have a solution that simplifies security monitoring, ensures compliance of suppliers and provides real-time information on risks that could lead to costly delays. Origami Risk centralizes risk and security programmers, making it easier to identify risks, monitor incidents and actively mitigate risks, thus helping projects to be completed on time and within budget.(16).

3.1.8. ALICE TECHNOLOGIES

The goal of generative construction scheduling and optimization is to assist in determining the best course of action, beginning with the BIM model for project(17).

Table 1: included studies from databases

title	author	year	methodology	country	Software	projects	conclusion
BIM-Supporting System by Integrating Risk Management and Value Management	Ali AbdulJabbar Alfahad, Abbas M. Burhan	2023	Mixed Methods (Qualitative Assessment, Quantitative Assessment)	Iraq	Software to assist with BIM and risk management, including methods t o evaluate risks and how they affect the process of cost estimation, should be included in the data that is sent to the project parties.	Case study: private hospital	This study demonstrated that the majority of risk factors can be reduced with the help of the system's suggested measures, and if the project takes the necessary factors into account, it can quantify the risk factors' cost impact. The results of the case study in Iraq indicate that the unstable economy is causing the local currency's current situation to change quickly. The impact of this risk factor on the cost and input to the quantity take-off is computed by the suggested software.
Development of BIM Platform for Semantic Data Based on Standard WBS Codes	Dongwook Kim, Jose Matos, Son N. Dang	2025	Platform Development	Korea	The CEV platform, which was created with an emphasis on on-site usability and the WBS standard code, turned out to be a good fit for on-site process management .	A pilot test was conducted at a domestic railway constructio n site.	The results show that the suggested strategy is both practical and flexible in actual construction situations. Current platform development trends have mostly concentrated on process planning, although n-D BIM systems usually expand on information regarding processes, costs, and other object-related factors. This study successfully achieved integration between models and processes by expanding the coding system without changing standard WBS codes or existing legacy data, which was verified through real-world application.
Dynamic risk early warning system for tunnel construction based on a two-dimensional cloud mode	Huaiyuan Sun, Mengqi Zhu , Yiming Dai, Xiangsheng Liu, Xiaojun Li	2024	A knowledge-data dual-driven dynamic risk warning system	China	dynamic risk warning system for tunnel construction	tunnel constructio n, case study: Guiyang Metro Line 3 is located in Guiyang City	The system assesses risks by taking into account the possibility and impact of possible incidents. It uses data-driven methods for likelihood assessment and expert systems for consequence assessment, dynamically choosing pertinent indices and updating them for ongoing evaluation. This approach circumvents the problem of weight concentration in conventional methods by dynamically generating datasets in two dimensions. To efficiently handle two-dimensional datasets, a new algorithm based on the two-dimensional cloud model has been created. Through in-depth simulations and

title	author	year	methodology	country	Software	projects	conclusion
							statistical analyses, it quantifies uncertainties resulting from expert knowledge of cognitive processes and various data-driven sources. In the end, it combines these two aspects to produce knowledge-driven, intelligent risk-level decision-making.
Risk Information Management for Bridges by Integrating Risk Breakdown Structure into 3D/4D BIM	Yang Zou, Arto Kiviniemi, Stephen W. Jones, and James Walsh	2018	A Concept Model for Linking RBS, WBS and BIM	UK	3D/4D BIM environment	bridge projects	It shows how the linkage rules can be applied, why risk information should be connected to BIM, and how risk information can be visualized in 3D/4D BIM for improved communication. Specifically, in this framework, risk data is stored in an external database and connected to BIM rather than being integrated into BIM.
Dynamic risks hierarchical management and control technology of coal chemical enterprises	Dejun Miao, Kai Yu, Lujie Zhou, Yu Chen, Weiqiang Jin, Hu Chen	2021	-	China	“dynamic risks hierarchical management and control system	coal chemical enterprises	The potential risk situation was promptly identified and fixed. It reduces the risk before it arises, decreases the frequency of accidents, lessens the financial loss resulting from accidents, and achieves positive economic outcomes.
Framework for Risk Management Software System for SMEs in the Engineering Construction Sector	Chike F Oduoza, Onengiyeofori Odimabo, Alexios Tamparapoulos	2017	-	UK	risk management software system	Small and medium-sized enterprises	Initiating a risk assessment of a project, identifying potential key risk factors, and determining the likelihood of their impact on the project objectives of cost, quality, and time are the ways in which this user-friendly software, appropriate for all levels of users (from novice to expert), operates. Before the project starts, the user would be able to proactively manage, mitigate, accept, or eliminate these high risk factors.

3.2. The synthesis of the study findings

Based on a review of the literature, the crucial components that should be integrated into software applications are **risk assessment**, **risk management and planning**, and the **sharing of results and presentation of findings**.

To provide effective strategies for addressing potential hazards, project managers and project control team members require a comprehensive understanding of the **types of risk factors** that may arise, the **level of loss** that could result if these factors materialize, and the **probability of their occurrence**.

The analysis phase typically encompasses **risk identification**, **risk analysis and evaluation**, and **determination of control criteria**.

- **Risk Identification:** This step involves compiling a comprehensive list of potential risks that could impede project execution.
- **Risk Analysis and Evaluation:** In this stage, the potential losses resulting from the occurrence of each identified risk are estimated, along with their probability of realization.
- **Determination of Control Criteria:** This involves **categorizing the risks** into groups such as highly critical, critical, medium, minor, and negligible, and defining the appropriate **preventive measures** for each group or for each risk independently.

The **Risk Management and Planning** phase must address the central question: **What action should be taken in response to the risk?** This involves developing mitigation, avoidance, transfer, or acceptance strategies.

Finally, the results must be communicated to other team members in a **clear, comprehensible, and actionable format**.

In most studies, **Building Information Modeling (BIM)** has been utilized for the development of risk management software, particularly in construction-related applications, due to its capability for detailed visualization, simulation, and data integration.

As Building Information Model (BIM) is a tool to manage accurate building information over the whole life cycle. it is adequate to support data of maintenance and deconstruction processes(18).

3.3. The proposal of a new model

We have reviewed all relevant articles and, based on the extracted findings from the studies, we report a **new model for designing risk management software in construction projects**. The proposed model is structured around a three-stage cyclical process (Figure 2), ensuring continuous risk mitigation. The model suggests the following stages, which should be viewed as an iterative loop:

Stage 1: Risk Assessment and Identification

An initial assessment must be conducted to identify risks (Figure 3).

Stage 2: Risk Planning and Mitigation

Planning for hazard resolution and managing the identified risks must be performed (Figure 4).

Stage 3: Information Sharing and Reporting

Information must be shared with other team members, and a work report must be provided (Figure 5).

A critical aspect of this model is the iterative nature: upon completion of this process, the assessment must be performed again, and any residual risks must be re-entered into the problem-solving cycle.

The Risk Breakdown Structure (RBS) methodology is utilized for conducting the assessment. RBS is employed to identify risks and manage related information.

In this stage, we have categorized the risks into two main groups: External Risks (4 subgroups) and Internal Risks (3 subgroups).

Detailed Internal Risk Classification

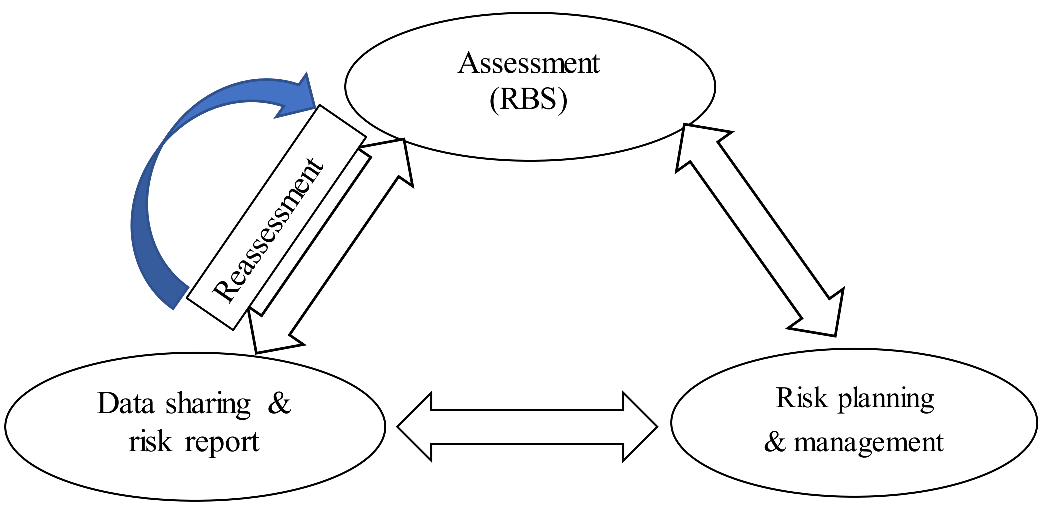
Within the Internal Risks group, the following subgroups and sub-subgroups are proposed:

- General Risks (6 sub-subgroups)
- Locational/Site-Specific Risks (5 sub-subgroups)
- Management and Planning Risks (8 sub-subgroups)

Risk Planning and Mitigation Sub-Categories

Specifically, the Risk Planning and Management stage is designed around three distinct, essential activities:

- Risk Review
- Statistical Analysis of Risk Data
- Risk Classification and Prioritization of Significance



Figures 2: new model for Risk Management software or simulator for Construction Projects

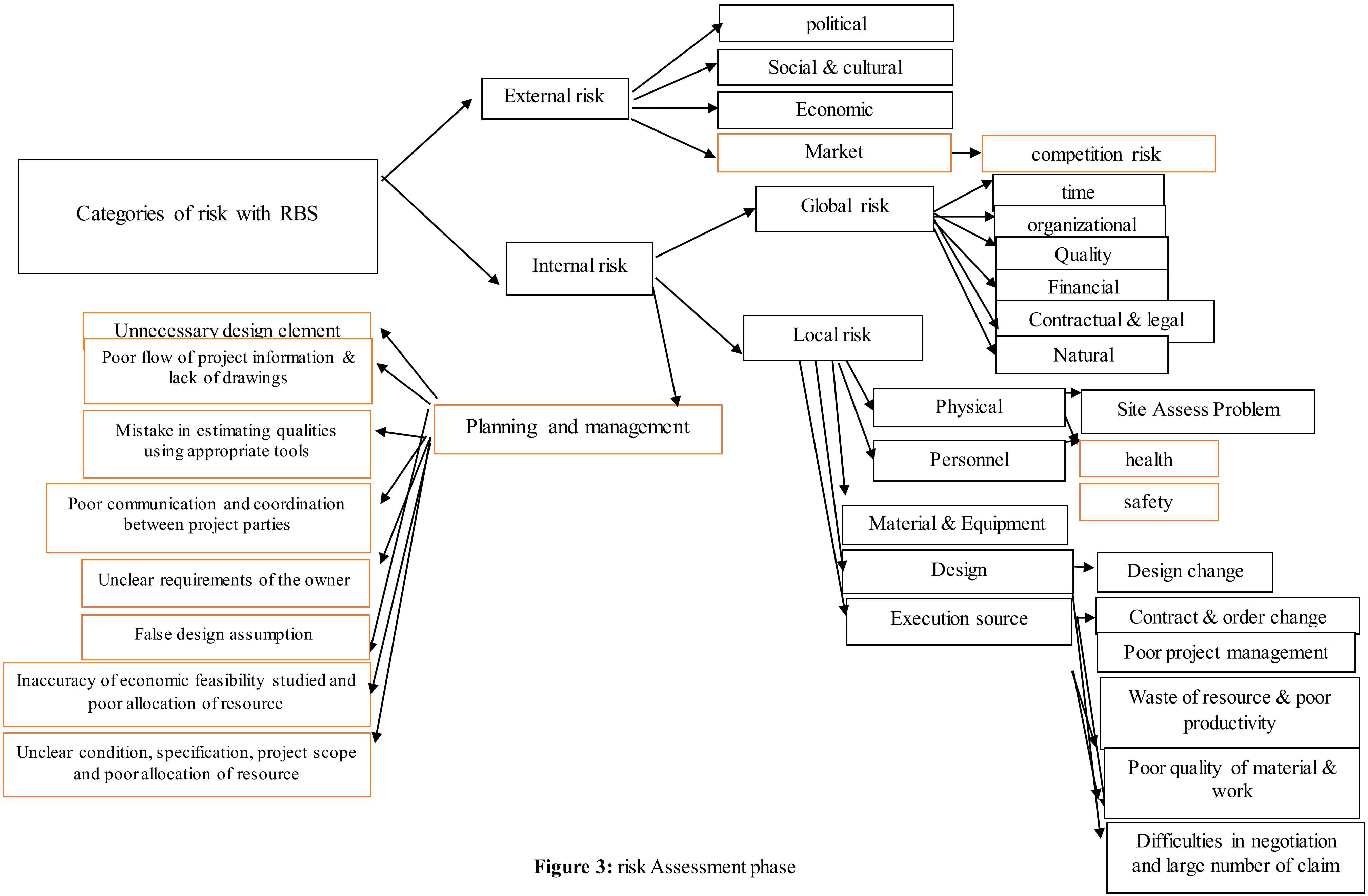


Figure 3: risk Assessment phase

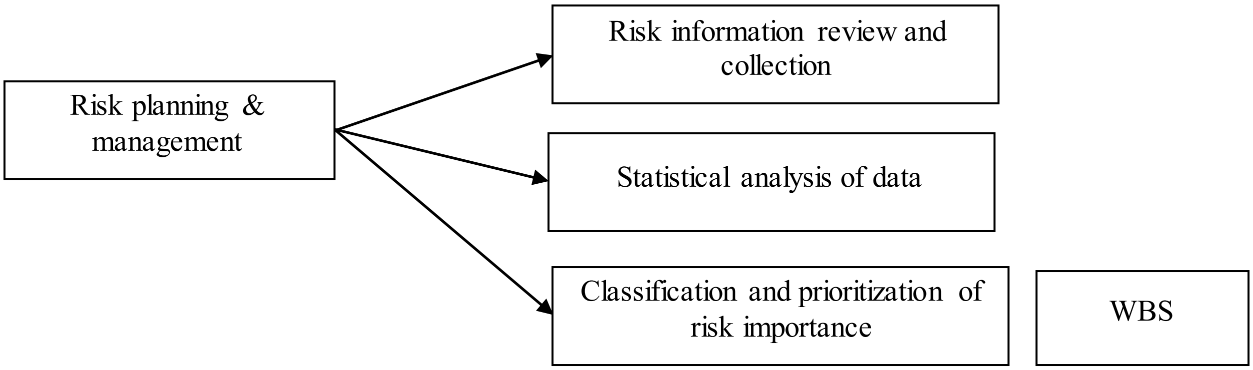


Figure 4: risk planning & management

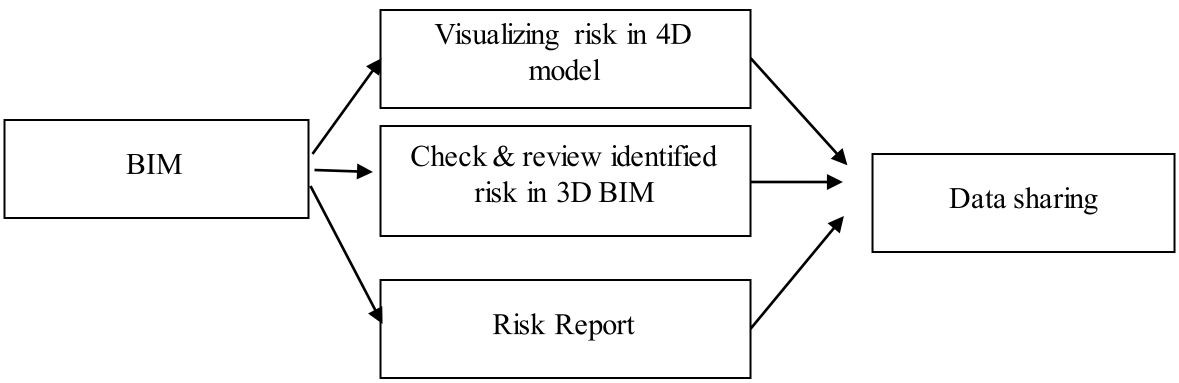


Figure 5: Information Sharing and Reporting

4. Conclusion

The developed risk management software systems demonstrated a wide application scope, having been designed for use in various countries, including **Iraq, China, Korea, and the United Kingdom**. These systems were successfully deployed across diverse projects such as **hospitals, railways, metro lines, bridge construction, coal chemical enterprises, and small and medium-sized enterprises (SMEs)** in the construction sector. Crucially, the majority of the custom-designed software solutions were **BIM-based**, underscoring the trend towards integrating advanced information modeling into risk management practices across the global engineering sector.

BIM is an intelligent 3D model-based tool that gives users a digital depiction of the functional and physical aspects of a facility. Increased understanding of the planning, design, construction, and management of the space is made possible by this type of representation. When properly applied, building information models can address communication issues in the construction industry and offer a shared knowledge base that can serve as a trustworthy foundation for decisions made throughout a building's lifecycle. To choose appropriate software, we need to determine what level of risk management we are looking for:

Project Planning Level (General): If our goal is to analyze the impact of risk on schedule, Primavera Risk Analysis or MS Project with risk add-ons are the best options.

Modeling Information Level (BIM-centric): If we need to link risks to 3D model elements and visualize them over time, you should look for BIM tools or add-ons that have 4D/5D (time and cost) capabilities.

Assessment and Alerting Level (Intelligent/Specialized): If we need an advanced and dynamic decision-making system to alert you to critical risks, we should probably look for solutions developed in-house or derived from academic research.

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