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EVALUATION OF RISK MANAGEMENT CONCEPTS AND THEIR APPLICATIONS IN THE CONTEXT OF CONSTRUCTION PROJECTS

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Abstract: This study aimed to identify the evaluation of risk management in construction projects, as risk management is an essential element to ensure the success of projects and reduce obstacles that may hinder the achievement of goals. The study includes an analysis of the concept of risk management, its various classifications, and response strategies such as risk avoidance, reduction, transfer, or acceptance. The study also highlights the importance of applying these strategies to improve project quality, reduce unexpected costs, and enhance stakeholder confidence. In addition, the study discusses the challenges associated with implementing risk management strategies, such as the lack of accurate data, changes in the project environment, and financial and human constraints. The study highlights the need to develop new strategies to address emerging risks and analyze the impact of risk management on financial performance and quality in construction projects.

Keywords: Risk management, construction projects, implementation efficiency, construction challenges, modern construction techniques, environmental sustainability.

Introduction

Construction projects are a fundamental pillar of the economic and social development of any country, whether it is the construction of infrastructure such as roads and bridges, the erection of residential and commercial facilities, or the implementation of major energy projects(Okate & Kakade, 2019). However, these projects are among the most complex activities due to their multidimensional nature, which involves the interaction of many parties (such as owners, contractors, engineers, and suppliers), and their exposure to uncontrollable external factors (such as climate fluctuations, legislative changes, or political unrest)(Enshassi et al., 2015). In this context, risk management emerges as a vital tool to avoid failure or mitigate its effects, making it an indispensable element in the success of any construction project (Isakova et al., 2024; Maree, 2020). Construction projects are also characterized by being long-term, high-cost, and relying on huge human and material resources (Uğural et al., 2020; Zhu et al., 2022). Hence, any flaw in planning or implementation can lead to serious financial and schedule consequences, such as budget overruns, delayed delivery, or even the complete collapse of the project (Abioye et al., 2021; Parekh & Mitchell, 2024). For example, studies show that more than 60% of major construction projects exceed their initial budget by up to 20%, while about 70% of them are behind schedule (KING'OINA, 2016). Therefore, risk management is a proactive process that aims to identify potential threats, analyze them, and develop plans to mitigate them, which enhances the ability to achieve objectives within the specified constraints (Oppong et al., 2017). In light of the increasing challenges facing the construction sector, risk management is an indispensable strategic approach to ensure the success of projects(Dubovi & Tabak, 2020) . By adopting scientific

methodologies and using technological tools, construction teams can transform threats into opportunities, enhancing the ability to achieve objectives efficiently(Timilsena et al., 2024). However, this requires a commitment from all parties to a proactive culture that values planning for the unknown, making risk management a fundamental pillar of modern project engineering. Risk management in this field is defined as a potential event or condition that could have negative effects on the organization in terms of its existence, its resources (whether employees or capital), products or services, or customers of the authority, and there may be an impact on the community and the surrounding environment (Salih & El-Adaway, 2024). Also, for each potential risk, there can be a pre-formulated plan to deal with its possible consequences (this is to ensure the emergency in the event that the risk becomes a legal liability) (Pan & Zhang, 2021).

Study Methodology:

The research methodology is more like the backbone on which the study is based, as the researcher provides an accurate description of the research to study a specific phenomenon, and includes the study plan, the method followed in the study, data collection tools, previous studies on the subject of the study, as well as the interpretation and explanation of meanings, as well as the study community and its sample (Betniar, 2017; Kothari et al., 2014; Rodríguez et al., 1996). Those interested in scientific research methods believe that the researcher is bound by the nature of the phenomenon and the goals he seeks to achieve through his research (Krippendorff, 2019; Snyder, 2019). The methodology also means the method or way that the researcher uses in studying a specific problem, related to specific goals, to answer questions and inquiries about the research, and then analyze the results that were reached and come up with study recommendations. In this study, the researcher relied on collecting information and data through literature, research, theses, scientific journals, and modern magazines related to the topic of literature on evaluating risk management concepts and their applications in the context of construction projects, as well as through a set of information, questions, and analysis elements, designed to be a primary tool for analyzing information, in order to identify the evaluation of risk management concepts and their applications in the context of Construction projects", and therefore the researcher relied in the procedures of the methodological study on employing the descriptive analytical approach that is concerned with studying phenomena and describing them accurately, through a database of theoretical data and information, clarifying their characteristics, analyzing their content, and placing them in the correct framework by interpreting the surrounding circumstances to reach in-depth results.

Literature Review

Comprehensive risk management refers to a systematic decision-making process in an environment of certainty about an event that can happen, whose probability and impact have adverse consequences should it materialize. (Cvetković et al., 2021)It is an issue that should not be avoided in the day-to-day development of business, but rather constitutes a strategic challenge if you want to achieve better performance, grow and compete within each sector, since it constitutes a component Basic business management (Megeid, 2017). In itself, integral management implies a holistic, global administration of risks at all levels of the organization, in order to facilitate the achievement of strategic addressing and decision-making, taking into account the interaction of the company with its environment, the relationship with stakeholders, the interrelation between processes, as well as the implementation of mechanisms that guarantee business continuity and the protection of resources and interests (Gu et al., 2019). Thus, risk

management requires that actions be established, not isolated, but in a structured, comprehensive and permanent manner to identify, analyze, measure, rate, evaluate and monitor all types of risks that may affect the fulfillment of the objectives of the organizations, with the purpose of responding with effective measures for their management and control through an action plan (Aldoseri & Worthington, 2016). In terms of regulations, international references are II where an integrated framework is established, based on strategic objectives, for the management of corporate risks with different application techniques, focusing on the risks related to financial information. This is one of the previous norms of risk management (Al Rahahleh et al., 2019).
Traditional risk management focuses on risks resulting from physical or legal causes (e.g. natural disasters, fires, accidents, death and lawsuits). Financial risk management, on the other hand, focuses on those risks that can be managed using financial instruments (Beck, 2020; Nygard et al., 2021). Regardless of the type of risk management, all large companies, as well as groups and small companies, have a team dedicated to managing their risks (Noomen & Abbes, 2018; Pritvorova et al., 2018). Ideal risk management follows a prioritization process, so that risks with high losses and high probability are treated first, while risks with lower losses and lower probability are treated later. In practice, this process can be very difficult, and the balance between high probability and low loss risks and low probability and high loss risks can be poorly handled. Intangible risk management introduces a new type of risk, which is the risk that has a 100% probability of occurrence but is ignored by the organization due to a lack of ability to recognize it. Examples include knowledge risks, which occur when incomplete knowledge is applied, and relationship risks, which occur when there is ineffective cooperation (Cvetković et al., 2021). All of these risks directly reduce the productivity of knowledge workers and reduce the effectiveness of spending, profit, service, quality, reputation and quality of earnings (Butler, 2000). Risk management also faces difficulties in allocating and distributing resources, which illustrates the idea of opportunity cost, as some of the resources spent on risk management could have been used in more profitable activities (Raut et al., 2017; Savov et al., 2020). Again, the ideal risk management process reduces spending while minimizing the negative consequences of risk. Risk management should be integrated into the culture of the organization and into effective policies and programs of senior management. Risk management should translate strategies into operational and tactical objectives and define responsibilities throughout the organization for each manager and employee responsible for risk management as part of his or her job description (Ali & Beh, 2019; Buganová & Šimíčková, 2019).

Stages of the risk management process

Risk management is a scientific approach to dealing with the problems that the organization may face. This indicates that it consists of a series of logical steps **As in Figure** 1 (Awalekar et al., 2019). The first step in the risk management process is to decide precisely what the organization wants its risk management program to achieve in order to get the most benefit from the expenses related to risk management (Liu-Lastres & Cahyanto, 2023; Vieira et al., 2020). Therefore, a precise plan must be developed, otherwise the perception arises that risk management is a series of isolated individual problems rather than a single problem. There are many potential objectives for the risk management function, and they mainly include the costs associated with pure risks such as worker injuries (Alzaabi et al., 2020; Merry, 2015). Many times this step is ignored, and therefore risk management efforts are disjointed and inconsistent. Ideally, the objectives and risk management policy should be issued by the board of directors, as they have the ultimate responsibility for preserving the company's assets (Brown, 2016). The second step is to identify

the risks facing the organization, as the risk manager must be aware of them. It is difficult to find designs on the risks to which the organization is exposed, because the difference in operations and situations leads to the emergence of different risks, some of which are obvious, while others can be ignored (Al-Gasawneh et al., 2022; Bland, 2017). There are many tools to identify risks, the most important of which are the organization's internal records, insurance policy checklists, risk analysis surveys, process maps, financial statement analysis, etc. The best applied approach to identify risks is the integration approach, by applying various risk identification tools, and here the importance of an effective information system in the facility or organization emerges. After the risks are identified, the risk manager must evaluate them, which includes measuring the size of the potential loss and the likelihood of the loss occurring, and then prioritizing the work, such as the loss, is built on that. Risks are usually classified into three groups (Al Rahahleh et al., 2019; Megeid, 2017; Shah & Raval, 2017; Skipper & Hanna, 2009; Torabi et al., 2016):

- **Critical risks:** All loss exposure conditions in which the potential losses are catastrophic and will result in bankruptcy.
- **Significant risks:** Risk exposure conditions in which the potential losses will not result in bankruptcy, but will require the organization to borrow to continue operations. Less significant **risks:** Risk exposure conditions for which the potential loss resulting from them can be compensated by relying on the organization's current assets or income without causing financial distress.

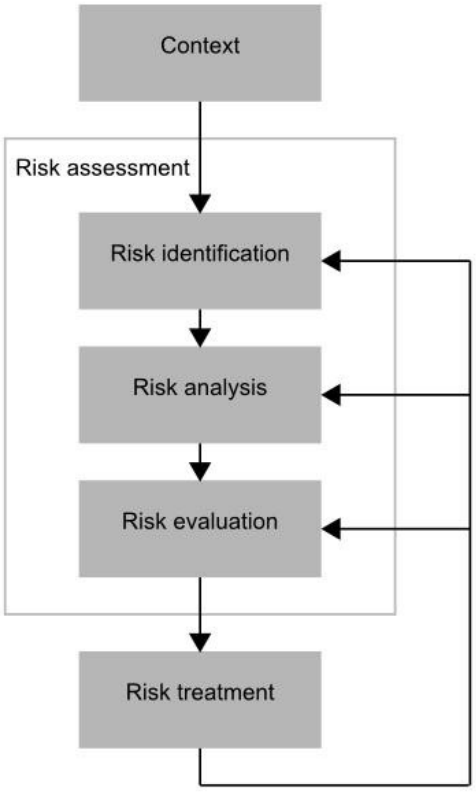

Figure 1 Stages of the risk management process

In addition to studying the alternatives and choosing the method of dealing with risks: This step is represented in studying the techniques that should be used to deal with each risk, and this stage represents a problem in decision-making, deciding which of the available techniques should be used, more specifically, to deal with each risk, and the degree to which the risk manager must make these decisions varies from one organization to another (Owusu-Boadi, 2019). When trying to decide what technology to use to deal with a particular risk, the risk manager must take into account the priority of the risk, then conduct an assessment of the returns and costs associated with each approach, then make a decision based on the best available information and guided by the company's risk management policy, and finally evaluate and review, as this process is very important, and must be included in the program for two reasons: (Awalekar et al., 2019)First, the risk management process does not take place in a vacuum, as change is continuous as new risks appear and old risks disappear, so the technologies that were appropriate last year may not be appropriate this year, and continuous attention is required. Second, mistakes are sometimes made, and conducting an assessment and review of the risk management program allows risk managers to review decisions and detect and correct errors before they become costly (Okate & Kakade, 2019). The review process can be done either by the organization's risk manager or in some organizations, external consultants are brought in to conduct the review process (Hammad & Inayat, 2018).

Risk Management in Construction Projects

Construction projects are complex and inherently risky due to their dependence on numerous variables such as labor, materials, environmental conditions, regulations, and economic fluctuations. Effective risk management is crucial to ensuring project success by minimizing potential threats and maximizing opportunities (Awalekar et al., 2019). The construction industry is inherently complex, involving numerous stakeholders, substantial financial investments, and dynamic environments (Hammad & Inayat, 2018). Projects often span years and face uncertainties ranging from fluctuating material costs to unpredictable weather conditions. Effective risk management is critical to ensuring projects are completed on time, within budget, and to the required quality standards (Oparin, 2020). This article explores the importance of risk management in construction, identifies common risks, outlines the risk management process, and highlights strategies to mitigate potential threats (Smith & Merritt, 2020). Construction projects are vulnerable to a wide array of risks that can derail objectives. Poor risk management can lead to cost overruns, delays, legal disputes, safety incidents, and reputational damage. For instance, a delayed project due to unforeseen ground conditions could escalate costs by 20–30%, eroding profit margins (Guidetti et al., 2022). Proactive risk management enables stakeholders to anticipate challenges, allocate resources efficiently, and implement contingency plans. It fosters collaboration among contractors, clients, engineers, and suppliers, ensuring alignment on project goals. Ultimately, robust risk management enhances decision-making, minimizes disruptions, and safeguards stakeholder interests (Gu et al., 2019).

Project risk management is a vital process that aims to identify, assess, and monitor potential threats or opportunities that may affect the achievement of project objectives (Syed et al., 2023). In the business world, risk management is an essential part of any successful project, as it contributes to reducing negative impacts and maximizing potential benefits by adopting thoughtful and sustainable procedures (Wolkowski, 2021). Construction risks refer to factors that pose a risk to the health and safety of construction workers who implement projects to create various buildings

and facilities, as their exposure to these risks can cause them physical injuries ranging from moderate to severe, and can reach chronic diseases and disabilities and sometimes may lead to death. In addition to human losses resulting from exposure to risks in construction, these risks may also affect property and the environment, in addition to stopping the project or at least affecting its success, which threatens the success of the institutions' business and their ability to remain competitive(Beck, 2020; Nygard et al., 2021). The factors that cause workers to be exposed to risks during the implementation of construction work are many, including natural, physical, biological and chemical factors. Therefore, it is necessary to take the necessary precautions that help reduce exposure to these risks or mitigate their repercussions. There are a set of strategic steps in this regard, the most important of which are: (bakkah.com)

- Collaborative Planning: Engage all stakeholders early to align expectations and clarify roles. Transparent communication prevents misunderstandings and ensures swift responses to emerging risks.
- Technology Integration: Building Information Modeling (BIM) detects design clashes before construction, while drones monitor site progress in real time. AI-driven analytics predict risks based on historical data.
- Contingency Reserves: Allocate 10–15% of the budget for unforeseen expenses. Time buffers in schedules accommodate delays without derailing deadlines.
- Training and Culture: Foster a safety-first mindset through regular training. Empower workers to report hazards without fear of reprisal.
- Contract Clarity: Define scope, timelines, and responsibilities explicitly. Include dispute resolution mechanisms to avoid protracted litigation.

Risk management is not a one-time task but an ongoing commitment integral to construction project success. By systematically identifying threats, assessing their implications, and deploying tailored mitigation strategies, teams can navigate uncertainties with confidence. In an industry where margins are tight and stakes are high, proactive risk management transforms potential crises into manageable challenges. Embracing technology, fostering collaboration, and learning from past experiences further strengthens resilience, ensuring projects meet their objectives while safeguarding people, profits, and reputations (Cvetković et al., 2021; Islam & Barghouthi, 2017; Noomen & Abbes, 2018).

The Importance of Risk Assessment and Management in Construction Projects

The construction industry is based on the integration of many factors, such as design, implementation and delivery, and requires effective cooperation between a variety of parties, such as architects, contractors, suppliers and clients (Okate & Kakade, 2019). With the complexities of these processes, construction projects involve multiple risks that must be dealt with carefully. Risk assessment and management in construction projects is a vital process to identify these potential risks and assess their impact, in addition to developing strategies to deal with them effectively (Akadiri et al., 2012; Mickovski & Thomson, 2017). Risk analysis in construction projects is of great importance and contributes significantly to the success of the project through many aspects, most notably early identification of risks (Enshassi et al., 2015; Isakova et al., 2024). This identification not only helps in avoiding potential negative consequences but also enables work teams to take preventive measures before these risks turn into real problems, which enhances the

stability of the project (Kitzinger, 2000). In addition, risk analysis plays a crucial role in saving time and costs, as early identification and effective handling of risks leads to avoiding costly delays and unexpected expenses that may arise in the absence of a sound risk plan. In this way, risk analysis in construction projects helps ensure that the project is delivered within the specified time frame and budget, which increases the chances of achieving success and profitability (KING'OINA, 2016; Oppong et al., 2017). To ensure the success of construction projects, it is necessary to adopt advanced tools and techniques to effectively assess risks. These tools help in identifying risks, analyzing them, and determining the best ways to mitigate or manage them. Here are some of the most important tools and techniques used in the field of risk assessment for construction projects (Abioye et al., 2021; Zhu et al., 2022):

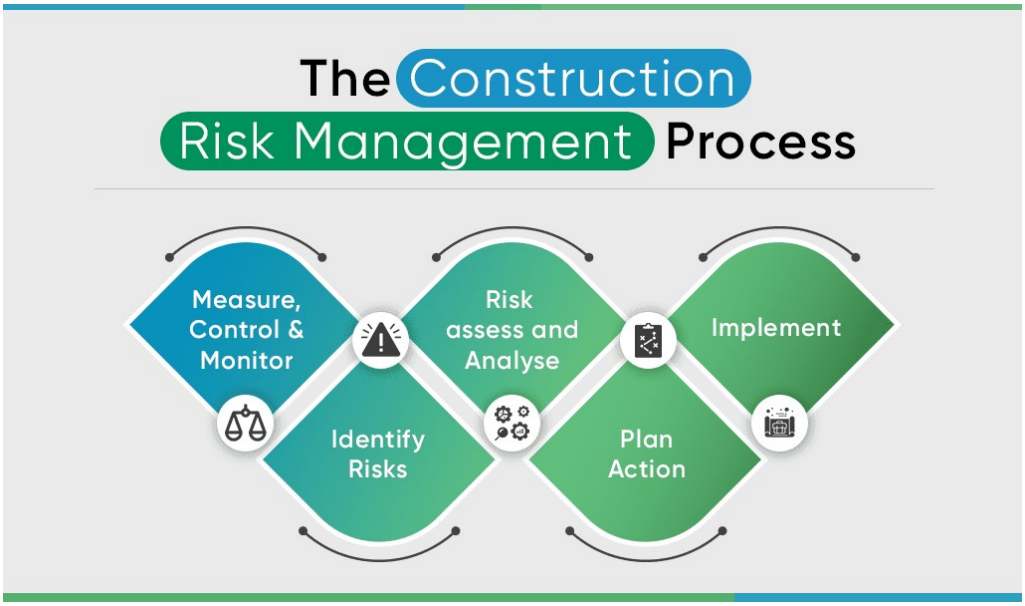

Figure 2risk assessment for construction projects (https://www.tejjy.com/construction-risk-management/)

- Risk registers: A risk register is a dynamic document used to record and track potential risks throughout the project. It is updated regularly to reflect new risks or changes in the level of existing risks.
- Probability and impact matrix: This tool is used to assess risks based on their likelihood of occurrence and their impact on the project. Risks are classified into different categories, which facilitates the process of prioritizing and making decisions regarding risk responses.
- SWOT analysis: SWOT analysis (strengths, weaknesses, opportunities, threats) is used to evaluate internal and external factors that may affect the project. This analysis helps identify risks and opportunities that may affect the achievement of project objectives.
- PERT Analysis: Project Evaluation and Review Technique (PERT) is a planning tool used to estimate the time required to complete various tasks within a project. By identifying critical tasks, managers can assess the risks associated with the schedule.

- Monte Carlo Simulation: The Monte Carlo technique is a simulation tool used to model the likelihood and impact of various risks on a project. This technique is particularly useful in assessing financial and schedule risks.
- Scenario Analysis Sessions: Scenario analysis sessions encourage participants to explore and discuss different scenarios and how they might impact the project. These sessions help assess risks by building a shared understanding of potential impacts.

Therefore, risk management in construction projects requires a great focus on accurately analyzing and assessing risks, and implementing effective strategies to manage them efficiently (Dubovi & Tabak, 2020; SAIF & SITI, 2022). When the right steps are followed and the right tools are used, project management teams can achieve success in executing projects and achieving the set goals, while avoiding delays and extra costs that may arise as a result of not properly assessing risks (Timilsena et al., 2024). The process of assessing and managing risks in construction projects must be supported by a deep understanding of the nature of the industry and its unique requirements, as this industry includes a variety of challenges that require careful handling, such as sudden changes in the market, price fluctuations, new technologies, and environmental, health and safety standards. By comprehensively understanding and accurately assessing potential risks, project managers can make sound decisions and plan appropriate responses to ensure the continuity of the construction process smoothly and efficiently(Salih & El-Adaway, 2024).

Risk Management in Construction

Effective risk management in the construction industry is vital to ensuring success in this dynamic and fast-paced sector(Mays, 2015). A good risk management plan serves as a strategic guide, identifying, assessing and mitigating potential risks that could impact a project's schedule, budget and overall performance. When developing a risk management plan for your construction project, you should consider a variety of risks that could arise and have potential consequences. These risks include cost estimation issues, unexpected design delays, material shortages, communication challenges between stakeholders, and safety risks. All of these aspects require careful assessment throughout the life of the project. The initial assessment is the first step in the process of developing a construction project risk management plan (Abioye et al., 2021; KING'OINA, 2016; Parekh & Mitchell, 2024). This assessment involves carefully examining the project scope, along with the project budget and schedule, as well as all stakeholders involved. It also reviews available resources and other considerations that may present potential challenges or impacts on the project's success. This early assessment greatly contributes to identifying potential risks at an early stage of planning, enabling effective strategies to proactively address these risks and prevent their negative impact on the project's progress. During the initial assessment phase, it is important to clearly define the project objectives and understand the desired outcomes precisely (Dubovi & Tabak, 2020; Oppong et al., 2017). This essential step helps to better direct risk management efforts and ensure that they are aligned with the project requirements and priorities. This helps to identify potential risks that may hinder the achievement of these objectives and thus specific mitigation strategies can be developed to deal with these risks. In addition, understanding the desired outcomes helps to better direct assessment and monitoring efforts to ensure that the

specified objectives are successfully achieved (Pan & Zhang, 2021; Salih & El-Adaway, 2024; Timilsena et al., 2024).

Conclusion

Risk management in construction projects plays a crucial role in achieving goals and ensuring the successful continuity of projects. Through a proactive approach that focuses on identifying and analyzing risks and developing mitigation plans, companies can reduce negative impacts and improve overall performance. Moreover, the use of modern technologies such as Building Information Modeling (BIM) and quantitative analysis enhances the accuracy of predictions and preparedness for potential risks. Ultimately, effective risk management is not just a preventative measure, but a vital strategy to ensure sustainability and success in modern construction projects. Risk management in construction projects is an essential tool to ensure the success of projects and reduce obstacles that may hinder the achievement of goals (Al Jayyousi, 2021; Hrakam & Fakataah, 2024; Jahankohan & Mirmohammadsadeghi, 2018; Schutte, 2010; Zhang et al., 2021). By implementing appropriate response strategies, construction organizations can improve the level of safety, quality and sustainability, which positively reflects on the performance and success of projects. Adopting a comprehensive approach to risk management, which includes identifying and analyzing risks and developing effective response plans, helps enhance project sustainability and reduce unexpected costs. Furthermore, technological developments such as artificial intelligence and building information modeling (BIM) play an increasing role in improving the risk management process and making it more accurate and effective. In the future, risk management is expected to become more integrated with digital innovations, enhancing companies' ability to effectively predict and manage risks, and thus achieve successful and sustainable construction projects.

Limitations and future research

This study faced several limitations, starting with the use of a relatively small dataset and limited sources. The research mostly relied on secondary data, like academic publications and industry reports, which can introduce biases and make the findings less broadly applicable due to the relevance and timing of the data. Additional limitations include the sample size, geographic coverage, and the study's inability to account for rapidly changing factors in the construction industry, such as evolving technologies and environmental impacts. Future research could address these gaps by expanding the sample and incorporating more dynamic data sets.For future studies, I think expanding the sample size would be key, as well as using more primary data to reduce biases. It would also be to integrate emerging technologies like artificial intelligence, IoT, and big data analytics in risk management strategies. Additionally, providing a comparative analysis across different regions could offer valuable insights into global construction challenges.

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