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Risk Breakdown Structure of Construction Projects from an Extended Sustainable Perspective

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Abstract

It is crucial to manage risks in any construction project, but it becomes especially crucial when it comes to sustainable construction. Sustainable construction involves integrating environmentally friendly practices, social responsibility, and economic feasibility into the project. Compared to traditional construction projects, sustainable construction is more risky. Even though risk and uncertainty are unavoidable components of the sustainability issue, they are frequently ignored in discussions of sustainability, particularly in the context of sustainable development's economic analysis. It is widely acknowledged that risk management in construction projects plays a significant role in helping to achieve project objectives in terms of time, cost, quality, safety, and sustainability. This study examines project-related risks in sustainable construction projects and aims to gain a deeper understanding of them. Based on a literature review, this study also identifies the risks associated with sustainable construction projects. This will assist project participants in appropriately managing these risks within their projects. Another objective of this study is to examine the methodologies used in data collection to determine and categorize risk in sustainable project construction. Finally, through a critical review, 180 risk factors were determined and classified under fourteen risk categories.

Keywords: *Risk Management, Sustainability, Sustainability Risk Management.*

Introduction

A popular paradigm for evaluating choices that have long-term effects has surfaced: sustainability. This applies to decisions made at the firm and political levels. Some fundamental issues have, however, gotten surprisingly little attention despite significant progress in defining, measuring, and applying sustainability. Concerning risk and sustainability, this is one of these issues (Krysiak, 2009).

Sustainable construction projects are becoming more prevalent in the market, and green codes and standards are advancing, establishing the way for the advancement of technology and materials used. Risks increase with each new material and technology used in the field. As a result, the importance of risk management in sustainable construction projects is growing, and more experience and expertise are required. The process of meeting current needs while protecting Earth's primary resources for future generations is known as sustainability. The design, development, and management of green building projects to attain sustainability as one of the project's goals is known as sustainable construction. Environmentally and economically, the construction sector has a significant impact on society. As people's awareness of environmental issues has grown, including waste, sustainability has become a hot topic (El-Sayegh et al., 2018).

The PMBOK defined risk as “an uncertain event or a condition that, if it occurs, has a positive or negative effect on one or more project objectives” (PMI, 2017). Due to the complex nature of construction projects, which involve a wide range of risks relevant to various stakeholders, risk management is critical to achieving project objectives. The management of risk in construction projects has been thoroughly examined in the literature on project management (Qazi et al., 2021).

Meanwhile, risk is an inherent component of any building project and can result in large delays and overruns that negatively impact the project's objectives. Risks in construction projects can have a

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negative effect and cause losses for the people working on the project as well as for the owners, contractors, and society in general. Sustainability-specific risks, however, differ from traditional risks associated with short-term project performance indicators in that they typically do not appear on risk lists and risk portfolios. Furthermore, risks connected to sustainability have a wide range of likelihood and effect evaluations since these risks are complex and ever-changing (Okoye et al., 2022). As this study also analyzes the risks in sustainable construction projects based on a literature analysis, its goal is to investigate and obtain a deeper knowledge of project-related risks in sustainable building projects.

Methodology

The nature of this article is to review the studies that have already been conducted in risk management for projects that are considered sustainable principles. The researcher reviewed more than 15 studies that were conducted in different locations and at different times. The objectives, methodologies, and results of each contribution are summarized and explored. The methodological procedures of Xavier et al. (2017) and Denyer and Tranfield (2009) were used for this study and accordingly, the following steps should be taken: The formulation of the research question; the location of the study; Study selection, and evaluation; Synthesis and analysis Reporting and utilizing research findings.

In total 15 papers were selected to conduct a systematic review of this study. The next stage involved defining the study's location, which involved determining the search terms and databases to consult. "Risk management," "sustainability," and "project sustainable risk management" were the three keywords. These keywords were searched in various combinations. The following databases were consulted: Scopus, Taylor & Francis, Wiley, Springer, Science Direct, and Emerald Insight. The considered paper title, and published time are shown in Table 1.

The researcher tried to select the most recent papers, and all are related to risk management in sustainable projects. Based on the information in Table 1 it can be concluded that the oldest paper was published in 2009 while the most updated one was published in 2023 and 4 papers were published in 2018.

Table 1. Papers Title and Published Information

Author and Published year	Title
(Krysiak, 2009)	*"Risk Management as a Tool for Sustainability"*
(Rafindadi et al., 2014)	*"Global Perception of Sustainable Construction Project Risks"*
(Hwang and Chen, 2015)	*"Sustainable Risk Management in The Construction Industry: Lessons Learned from The IT Industry"*
(Gurgun et al., 2016)	*"Impacts Of Construction Risks on Costs In LEED-Certified Projects"*
(El-Sayegh et al., 2018)	*"Risk Identification and Assessment in Sustainable Construction Projects in the UAE"*
(Ismael and Shealy, 2018)	*"Sustainable Construction Risk Perceptions in The Kuwaiti Construction Industry"*
(Schulte and Hallstedt, 2018)	*"Company Risk Management in Light of the Sustainability Transition"*
(Gurgun et al., 2018)	*"Schedule Risk Assessment in Green Building Projects"*
(Bizon-Gorecka and Gorecki, 2019)	*"Risk Management in Construction Project: Taking sustainability Into Account"*
(Koulinas et al., 2019)	*"Risk Assessment Using Fuzzy TOPSIS and PRAT for Sustainable Engineering Projects"*
(Durst and Zieba, 2020)	*"Knowledge Risks Inherent in Business Sustainability"*
(Qazi et al., 2021)	*"Prioritizing Risks in Sustainable Construction Projects Using a Risk Matrix-Based Monte Carlo Simulation Approach"*
(Okoye et al., 2022)	*"Risks Of Implementing Sustainable Construction Practices in The Nigerian Building Industry"*

(Othman and Abdelrahim, 2023)	*"A Lean Management Framework for Achieving Sustainability Through Reducing Risks During the Design Process"*
(Zainuddin et al., 2023)	*"Sustainable Risk Management Practice in The Organization: A Malaysian Case Study"*

Risk management tools and techniques in sustainable projects were the main objective of the reviewed papers. Each paper's aim and it is objective are shown in Table 2.

Bizon-Gorecka and Gorecki (2019) identified risk management as a critical process that helps achieve project objectives regarding timeliness, cost, quality, safety, and sustainability. Ismael and Shealy (2018) and El-Sayegh et al. (2018) investigated risks in sustainable construction projects in a different country. Qazi et al. (2021) developed a procedure to rank risks in sustainable building projects according to decision-makers' risk appetite about risk exposure zones across a risk matrix, while also capturing the uncertainty surrounding risks.

Krysiak (2009), established a connection between risk management tools and sustainability. Rafindadi et al. (2014), investigated how project stakeholders perceived risk sources affecting sustainable construction projects. Hwang and Chen (2015), determined organizations' perceptions of risk management (RM) and its advantages, standing, and implementation challenges. Gurgun et al. (2016), 2016 identified risks in US LEED-certified projects and evaluated their severity. Ismael and Shealy (2018) studied the risks in the Kuwaiti construction industry. Schulte and Hallstedt (2018) examined the dynamics and effects of the shift to a more sustainable society from the standpoint of corporate risk management.

Gurgun et al. (2018) classified risks in certified green construction projects and assessed their likelihood and impact. Bizon-Gorecka and Gorecki (2019) emphasized the importance of risk management in time, money, quality, safety, and sustainability concerns. Koulinas et al. (2019) 2019 proposed a methodology that integrates the fuzzy TOPSIS extension of the TOPSIS multicriteria method with a basic quantitative process (PRAT) based on actual accident data.

Durst and Zieba (2020) explored the effects of knowledge risks on organizational sustainability dimensions and how businesses can manage information risks to become truly sustainable. Qazi et al. (2021) created a procedure to rank risks in sustainable building projects based on decision-makers risk appetite and uncertainty surrounding risks. Okoye et al. (2022) evaluated the degree of risk involved in using sustainable building techniques. Othman and Abdelrahim (2023) created a framework for Lean Management (LM) to deliver sustainable construction projects by lowering risks during the design phase.

Table 2 Each Paper's Objective

No.	objective
(Krysiak, 2009)	Established a connection between widely used risk management tools and a potentially useful concept of sustainability.
(Rafindadi et al., 2014)	Investigated and contrasted how project stakeholders perceived various sources of risk that could affect the success of a sustainable construction project.
(Hwang and Chen, 2015)	Determined how organizations feel about risk management (RM) in terms of its advantages, standing, and implementation challenges
(Gurgun et al., 2016)	Determined the risks involved and the anticipated financial effects of those risks in US building projects that are LEED-certified.
(El-Sayegh et al., 2018)	Identifying risks in sustainable construction projects is the first goal. The identified risks are to be evaluated according to their risk severity as the second goal.
(Ismael and Shealy, 2018)	To comprehend the risks that the Kuwaiti construction industry believes come with building in a more sustainable manner
(Schulte and Hallstedt, 2018)	examined the dynamics and effects of the shift to a more sustainable society from the standpoint of corporate risk management.

(Gurgun et al., 2018)	In certified green construction projects, risks that might interfere with the schedule are classified and their likelihood and impact are assessed.
(Bizon-Gorecka and Gorecki, 2019)	Regarding time, money, quality, safety, and sustainability concerns, risk management is regarded as a critical process that helps construction projects achieve their objectives. The article aims to focus especially on the latter aspect.
(Koulinas et al., 2019)	The primary contribution of the suggested methodology is the integration of the fuzzy TOPSIS fuzzy extension of the TOPSIS multicriteria method with a basic quantitative process (PRAT) whose operation is grounded in actual accident data.
(Durst and Zieba, 2020)	What possible effects might knowledge risks have on the three organizational sustainability dimensions? and how can businesses manage information risks to become genuinely sustainable?
(Qazi et al., 2021)	created a procedure to rank risks in sustainable building projects according to decision-makers' risk appetite about risk exposure zones across a risk matrix, while also capturing the uncertainty surrounding risks.
(Okoye et al., 2022)	evaluated the degree of risk involved in using sustainable building techniques
(Othman and Abdelrahim, 2023)	created a framework for Lean Management (LM) to deliver sustainable construction projects by lowering risks during the design phase.
(Zainuddin et al., 2023)	Examined the epistemic basis of workplace risk management practices

Based on a critical review of each paper it can be concluded that the most useful data collection methods for determining risk probability and impact are questionnaire methods. The steps of methodology can be summarized as follows:

The first step involved conducting a literature review to determine the risks associated with sustainable construction projects. This included books, journals, and articles that address risks generally and risks specific to sustainable construction projects. The second step is to design the questionnaire and distribute it. The questionnaire can be designed based on the risk categorization and factors obtained from the first step. Most papers used Likert skills as a method for determining the risk impact and probability. The final step will be data analysis and tabulation of the result, based on most reviewed papers it can be demonstrated that the probability-impact method and risk matrix analysis were used for the analysis of the responded questionary forms. The methods and approach of analysis for each reviewed paper are shown in Table 3

Table 3. Methods and Approach of Analysis

Study	Methods	Approach of analyses
(Krysiak, 2009)	literature review	Decision theory framework
(Rafindadi et al., 2014)	Questionnaire design and distribution	Probability-impact method
(Hwang and Chen, 2015)	Questionnaire design and distribution	One-sample t-test
(Gurgun et al., 2016)	Systematic literature review, Questionnaire design, and distribution	Probability-impact method
(El-Sayegh et al., 2018)	Literature review, Questionnaire design, and distribution	Relative Importance Index (RII)

(Ismael and Shealy, 2018)	Literature review, Questionnaire design, and distribution	Probability-impact method
(Schulte and Hallstedt, 2018)	workshop session and semi-structured interviews	Framework for Strategic Sustainable Development (FSSD) Lens
(Gurgun et al., 2018)	Questionnaire design and distribution	Probability-impact method
(Bizon-Gorecka and Gorecki, 2019)	Case study and survey	Data analysis and discussion
(Koulinas et al., 2019)	Propose approach and application	The fuzzy extension of the TOPSIS multicriteria method
(Durst and Zieba, 2020)	literature review and conceptual research methods	Iterative process of analysis
(Qazi et al., 2021)	Propose process and application	Risk matrix-based Monte Carlo Simulation
(Okoye et al., 2022)	Questionnaire design and distribution	a quantitative risk analysis outcome determined by using the risk prioritization number and mean value technique
(Othman and Abdelrahim, 2023)	Theoretical (literature review) practical (field studies) and survey questionnaire	Risk matrix, likelihood, and severity
(Zainuddin et al., 2023)	Extended case study and interview	Qualitative analysis

Results and Discussions:

Construction project success is impacted by risks. There are risks unique to sustainable construction projects, but there are also risks that apply to conventional construction projects as well.

Bayer and Maier (2006) defined knowledge risk as Operational risks resulting from non-exclusive or scarcity of knowledge transfer resources due to reliance on, loss of, unsuccessful deliberate or accidental methods of knowledge transfer. Durst and Zieba (2020) provided a fresh viewpoint on corporate sustainability by examining knowledge risks and, more broadly, knowledge management. Based on the analysis provided, it appears that the fundamental idea of knowledge management is destined to become the fundamental idea of sustainable business development. The knowledge risks

Table 4 Knowledge Risk

No.	knowledge risks
1	Human knowledge risks
2	Knowledge hiding
3	Knowledge hoarding
4	Unlearning
5	Forgetting
6	Missing/inadequate competencies regarding sustainability among organizational members
7	Technological knowledge risks
8	Risks related to cybercrime
9	Risks related to old technologies
10	Risks related to digitalization
11	Risks related to social media
12	Risks related to waste and pollution (due to resource-wasting machines etc.)
13	Operational knowledge risks
14	Knowledge waste
15	Risks related to knowledge gaps
16	Relational risks
17	Knowledge outsourcing risks
18	Risk of using obsolete/unreliable knowledge
19	Risk of improper knowledge application
20	Espionage
21	Continuity risks
22	Communication risks
23	Knowledge acquisition risks
24	Knowledge transfer risk
25	Merger & Acquisition risks

knowledge management. Based on the analysis provided, it appears that the fundamental idea of knowledge management is destined to become the fundamental idea of sustainable business development. The knowledge risks are shown in Table 4.

A tight schedule is a risk, which may be more severe in green construction because sustainable construction projects take longer than traditional ones. El-Sayegh et al. (2018) divided 30 risks in sustainable projects into five categories: “management, technical, green team (stakeholders), green materials and technology, and regulatory and economic”.

Rafindadi et al. (2014) predefined 27 risk factors. They sorted them into five categories: “Market Risks, General Project Risks, Risks in the Feasibility and Design Phase, Risks in the Construction Phase, and Risks in the Operating Phase”.

Gurgun et al. (2016) outlined 13 risk factors that were divided into four categories such as; “consultant, contractor, and subcontractor issues, material, product, and process issues, legal, regulatory, and contractual issues, and financial, cost, and economic issues”.

Ismael and Shealy (2018) Identified nine categories of risk in sustainable construction including “design, management, construction, material, technology, labor and equipment, external factors, finance, and certification”. Each category identified different risk factors and based on the survey results they ranked the top ten risk factors that have the highest probability as follows: Lack of market demand, lack of practical experience, lack of political support and incentives, and lack of knowledge among the general public about the advantages of sustainability, high initial costs associated with sustainable construction, lack of specific equipment availability, lack of market availability for sustainable building materials, contractors' lack of experience with sustainable buildings, Ambiguous official policies.

Hwang and Chen (2015) a total of 11 risk factors were determined including lack of conviction in advantages, familiarity with present operations, not asked by the customer, not authorized by the client, inadequate funds, time limitation, absence of tools and systems, PMs are untrained, personnel are untrained, there is no culture in the organization, and there is no risk to manage. In this study, it can be inferred that the advantages of risk management were not fully appreciated or acknowledged by the participating organizations.

According to Koulinas et al. (2019), risk managers can evaluate safety risks and decide how best to allocate a limited budget to optimize health and safety in the workplace by using the integrated multicriteria approach. This study categorized nine risk factors related to safety in sustainable projects.

Qazi et al. (2021) identified 30 risks under five categories, Management Risks, Technical Risks, stakeholder-related risks, Green Materials and Technology Risks, and Regulatory and Economic Risks. As well as they also concluded that the most critical risk factors in sustainable construction projects could be lack of funding, incorrect sustainable design operation, and design changes, while sustainability-related risks include poor labor productivity, unreasonable schedules, and poor scope definition.

Okoye et al. (2022), demonstrated a correlation between sustainable construction practices and both high and medium-level risk factors. Also showed that, of the 47 risk factors, 24 were medium-level risk factors and 23 were high-level and critical risk factors.

A Lean Management (LM) framework was created by Othman and Abdelrahim (2023) to produce sustainable construction projects by lowering risks during the design phase. Eighteen design risk factors were found in the study, along with their causes and effects on the completion of sustainable projects. Furthermore, it established a correlation between LM tools and methods that could be applied to lower risks throughout the design phase.

Through reviewing fifteen different studies it can be concluded that risk and uncertainty in sustainable projects should be carefully managed and controlled. This study determined 180 risks in sustainable projects under 14 categories as shown in Figure 1.

For each category, different risks were defined as illustrated in Table 5, as well as according to each study's results the important risks can be concluded as follows.

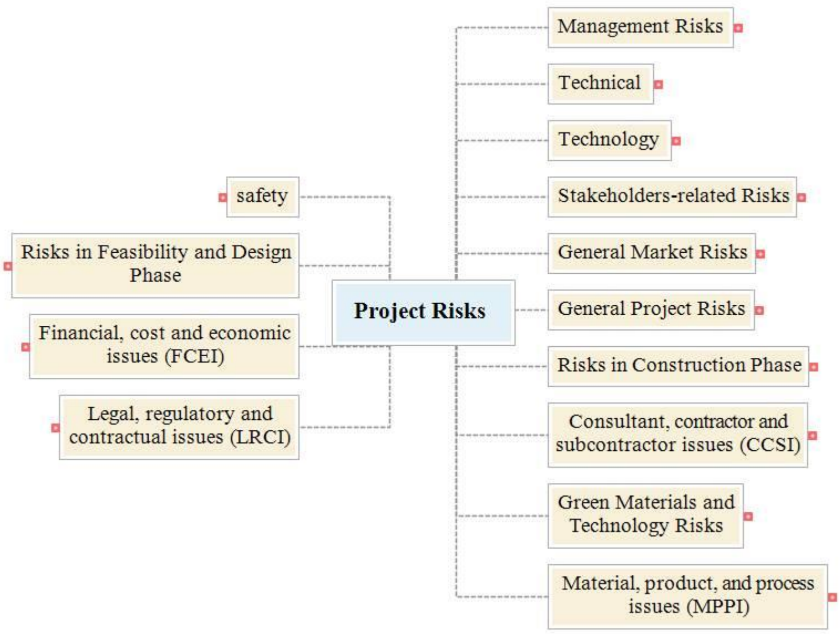

Figure 1 Risk category

1. El-Sayegh et al. (2018) ranked risks based on probability and it is impact, accordingly, the top five risks are unreasonably long deadlines for sustainable construction, inadequate client money, incomplete or erroneous information concerning sustainable design, design revisions,

and a poorly defined scope for sustainable building. Ismael and Shealy (2018) summarize that the lack of sustainable construction experience among designers and contractors is the potential risk factor with the largest negative impact on future projects. Additional hazards were high initial material costs and total project expenditures.

2. As opposed to the most important risks Qazi et al. (2021) identified the conventional scheme, which includes inadequate or incorrect sustainable design operation, design modifications, and a lack of client funding, risks such as low labor and equipment productivity in sustainable construction, an unreasonable tight deadline for sustainable construction, and a poorly defined scope for sustainable building are prioritized in their suggested method.

The results discovered by Othman and Abdelrahim (2023) revealed that "Brief changes by the client" were the largest risk found throughout the design process, with a likelihood of (4.2/5) and a severity of (3.4/5). After that, there was a "Lack of coordination between design parties," with a severity of (4.2/5) and a likelihood of (3.2/5). Changes made by the client to the project brief may occur for a variety of reasons, including the need to adapt to market demands, a lack of understanding of the client's culture and customs, or an inability to communicate the client's requirements to the designer.

The risk and feature that has the biggest influence on project outcomes, according to Rafindadi et al. (2014), is political conditions. This risk is also the one that few studies on sustainable projects have taken into account. The risks that have the most impact on a project's life cycle stages are those related to project complexity, designer capabilities, financial resources, resource difficulties, and human performance.

The decision-maker considers the “horizontal or vertical impact with or against a stationary object” to be the most significant risk factor in the project, according to Koulinas et al. (2019). subsequently ranks "Contact with electrical voltage, temperature, hazardous substances," "Struck by an object in motion-collision with," and "Trapped, crushed, etc." in order of preference.

The risk factors in sustainable projects can be summarized as the fourteen risk types and each type of risk has different risk factors. Twenty risk factors related to management recorded, ten technical risks, and nine technological risks can be considered during executing sustainable projects. Limited contractors' experience in sustainable practices with another nine risk factors was recorded as a risk-related stakeholder. There are 36 risk factors during the design and feasibility study for sustainable projects while 24 risk factors are defined for risks in the construction phase.

Table 4 Risks of Implementing Sustainable Construction Practices.

Sustainable Project Risks			
Risks category no.	**Risks category**	**Risks Factor No.**	**Risks Factor**
1	Management Risks	1.1	*Unreasonably tight schedule for sustainable construction*
		1.2	*Improper sustainable project feasibility and planning*
		1.3	*Shortage of client's funding*
		1.4	*Inaccuracy in project budgeting due to unfamiliarity with green projects*
		1.5	*Poor project manager skills related to sustainable construction*
		1.6	*Additional costs due to green material and equipment*
		1.7	*Poor quality of sustainable construction work*
		1.8	*Lack of quantitative evaluation tools*
		1.9	*Not achieving client expectations*
		1.10	*Difficulty in the selection of subcontractors who provide sustainable construction services*
		1.11	*Poor interrelationships between supply chain partners*
		1.12	*Lack of upfront planning by all parties*
		1.13	*Sustainability measures not considered early by stakeholders*
		1.14	*Delays in resolving disputes*
		1.15	*Slow approval processes due to sustainable specifications*
		1.16	*Outdated contractual agreements*
		1.17	*Lack of sustainable construction management experts*
		1.18	*Poor and inefficient communication among project participants*
		1.19	*Lack of practical experience*
		1.20	*Additional responsibilities for construction maintenance*
2	Technical	2.1	*Design changes*
		2.2	*Insufficient or incorrect sustainable design information*
		2.3	*Improper or incomplete green specifications*
		2.4	*Poor scope definition of sustainable construction*
		2.5	*Failure to meet green code or certification*
		2.6	*Delay caused by frequent meetings with green specialist*
		2.7	*Poor selection of construction techniques in sustainable construction*
		2.8	*Poor productivity of labor and equipment in sustainable construction*
		2.9	*Lack of sustainable technical experts*
		2.10	*Project delay due to incremental time caused by sustainable construction*
3	Technology	3.1	*Challenges for operating renewable energy systems*
		3.2	*Unacceptable performance of modern technologies*
		3.3	*Technological failures*
		3.4	*Misunderstanding of sustainable technological operations*
		3.5	*Certification*
		3.6	*An event that causes the loss of certification*
		3.7	*Lower certification than what was expected due to design defects*
		3.8	*Changing certification procedures*
		3.9	*Loss of financing or losing loans for not achieving certification*
4	*Stakeholders-related Risks*	4.1	*Resistance from the client to adopt new green ideas*
		4.2	*Limited experience of the consultant about sustainable construction practices*
		4.3	*Limited experience of the contractor about sustainable construction practices*
		4.4	*Limited availability and reliability of green subcontractors*
		4.5	*Limited availability and reliability of green suppliers*
		4.6	*Shortage in labor skilled in sustainable construction*
		4.7	*Lack of planning and early consideration of sustainability measures by stakeholders*
		4.8	*Failure to meet sustainable construction certification requirements*

Table 5. continued

Risks category no.	Risks category	Risks Factor No.	Risks Factor
5	**General Market Risks**	5.1	*Political conditions*
		5.2	*Economic conditions*
		5.3	*Legal conditions*
		5.4	*Corruption presence*
		5.5	*Lack of market demand*
		5.6	*Lack of political support*
6	**General Project Risks**	6.1	*Project Complexity*
		6.2	*Team Integration*
		6.3	*Stakeholder Collaboration*
7	**Risks in Construction Phase**	7.1	*Ground conditions*
		7.2	*Design quality*
		7.3	*Contract adequacy and elements*
		7.4	*Contractor skills*
		7.5	*Resource issues*
		7.6	*Financial resources*
		7.7	*Engineer skills*
		7.8	*Expropriation*
		7.9	*Climatic conditions*
		7.10	*Accidents on construction site*
		7.11	*Force Majeure*
		7.12	*Unforeseen circumstances in execution of the sustainable project*
		7.13	*More complex construction techniques*
		7.14	*Safety issues*
		7.15	*Project delay*
		7.16	*Contractors' inexperience with sustainable buildings*
		7.17	*Incremental time caused by sustainable construction*
		7.18	*Construction defects*
		7.19	*Climatic uncertainties*
		7.20	*Resource scarcity*
		7.21	*Human performance*
		7.22	*High sustainable construction premiums*
		7.23	*More complex and unfamiliar construction techniques and processes*
		7.24	*Design changes during construction*
8	**Consultant, contractor and subcontractor issues (CCSI)**	8.1	*Lack of green construction experience and qualification*
		8.2	*Contractors and subcontractors agreeing to standards that are not within their expertise and competence*
		8.3	*Lack of qualified professionals with requite sustainable building expertise*
9	***Green Materials and Technology Risks***	9.1	*Poor performance of green materials*
		9.2	*Shortage of green materials*
		9.3	*Long lead time for green materials*
		9.4	*Inappropriate handling and storage of green materials*
		9.5	*Lack of documents and information for new green technologies*

Table 5. continued

Risks category no.	Risks category	Risks Factor No.	Risks Factor
10	Material, product, and process issues (MPPI)	10.1	*Doubts about long-term viability and performance of new and untested products, materials and technologies*
		10.2	*Faulty performance of HYAC/electrical/plumbing systems and alternative water systems/alternative power generating equipment*
		10.3	*Failure to receive materials/products in a timely fashion causing delays*
		10.4	*Lack of expertise in new products/technologies*
		10.5	*Unavailability of sustainable building materials*
		10.6	*Poor material quality*
		10.7	*Uncertainty in the performance of sustainable materials*
		10.8	*Non-complying products and materials*
		10.9	*Change in material types and specifications during construction*
		10.10	*Handling recycled materials puts construction workers at safety risks*
		10.11	*Unavailability of specific equipment*
		10.12	*Additional responsibilities for construction maintenance*
		10.13	*Lack of practical experience*
		10.14	*Fluctuations in labour and material rate*
		10.15	*Uncertainty with specialized sustainable equipment*
11	Legal, regulatory and contractual issues (LRCI)	11.1	*Inadequate definition of project parties' contractual roles and responsibilities*
		11.2	*Inconsistencies between formal regulations (e.g., existing federal, state and local legislation) and LEED*
		11.3	*Concern that project owners and participants lose potential benefits because of the stringent standards of LEED*
		11.4	*Delay in government approvals for green construction*
		11.5	*Changes in sustainable construction codes and regulations*
		11.6	*Inflation of prices for green materials*
		11.7	*Currency volatility worsened by the import of green materials*
		11.8	*Uncertain government policies*
		11.9	*Unattainable expectations or requirements*
		11.10	*Culture issues*
		11.11	*Complex approval process due to sustainability specifications*
		11.12	*Liable to undue claims*
		11.13	*Unclear contract conditions for claims, litigations and dispute resolution*
		11.14	*Changing sustainable building certification procedures and policies*
		11.15	*Disputes arising from additional requirements*
12	Financial, cost and economic issues (FCEI)	12.1	*High cost of certification process*
		12.2	*Scarcity of insurance solutions*
		12.3	*Rental loss due to delay related to green construction procedures and conditions*
		12.4	*Failure to use financial incentives (tax/loan discounts, low financing rates) because of delays or lower certification levels than expected*
		12.5	*Cost estimation inaccuracy*
		12.6	*Payback period is too long*
		12.7	*Performance problems since sustainable building projects face a greater potential in failure*
		12.8	*Increased soft costs due to delays in sustainable building completion*
		12.9	*High cost of sustainable materials and equipment*
		12.10	*Cost overrun due to lack of sustainable building knowledge*
		12.11	*High initial sustainable construction costs*
		12.12	*Investor cannot fund the high sustainability measure costs*
		12.13	*Costs of investment in skills development*
		12.14	*High sustainable construction premiums*
		12.15	*Shortage of clients' funding*
		12.16	*Inflation and fluctuation of exchange rate*

Table 5. continued

Risks category no.	Risks category	Risks Factor No.	Risks Factor
13	Risks in Feasibility and Design Phase	13.1	*Client skills*
		13.2	*Prefeasibility/Feasibility studies*
		13.3	*Quality of initial surveys*
		13.4	*Brief and Terms of Reference*
		13.5	*Design contract parameters*
		13.6	*Designer skills*
		13.7	*Design changes during construction*
		13.8	*Slow response to meet design changes*
		13.9	*Design-team inexperience*
		13.10	*Design defects which could result in failure to achieve certification*
		13.11	*External*
		13.12	*Lack of market demand*
		13.13	*Lack of political support and incentives*
		13.14	*Lack of public awareness and knowledge*
		13.15	*Uncertain governmental policies*
		13.16	*Design cost overrun*
		13.17	*Brief changes by the client*
		13.18	*Design variations by architect*
		13.19	*Design delay*
		13.20	*Lack of coordination between design parties*
		13.21	*Incomplete environmental analysis*
		13.22	*Tight project design schedule*
		13.23	*Design errors and omission*
		13.24	*Noncompliance with building standards*
		13.25	*Qualifications gap among qualified architects and organizational requirements*
		13.26	*Stakeholders' late changes in the project*
		13.27	*Uncoordinated and incorrect construction documents*
		13.28	*Using outdated construction materials and technology*
		13.29	*Lack of Consideration of environmental studies*
		13.30	*Failure to complete work following the contract.*
		13.31	*Failure to consider the project's life cycle cost*
		13.32	*Lack of coordination and communication between the government and design firms*
		13.33	*Public objections*
		13.34	*Unforeseen sustainable projects requirements*
		13.35	*Insufficient or incorrect sustainable design information*
		13.36	*Poor scope definition and unclear allocation of roles in sustainable construction*
14	safety	14.1	*Contact with electrical voltage, temperature, hazardous substances*
		14.2	*Drowned, buried, enveloped*
		14.3	*Horizontal or vertical impact with or against a stationary object (the victim is in motion)*
		14.4	*Struck by object in motion collision with*
		14.5	*Contact with sharp, pointed, rough, coarse material agent*
		14.6	*Trapped, crushed etc.*
		14.7	*Physical or mental stress*
		14.8	*Bite, Kick etc. (animal or human)*
		14.9	*Other contacts-modes of injury not listed in this classification*
		14.10	*Safety and health issues*

Conclusions

Since sustainability initiatives present particular difficulties and uncertainties, risk management is an essential component of any project, but it becomes even more so when it comes to sustainable projects. This study aimed to critically review the studies that have already been conducted to define risk categories and find out the top-ranked risk factors in sustainable construction projects. The majority of the reviewed study used Likert skills to assess risk impact and probability, as well as the data, was analyzed using the probability-impact method and risk matrix analysis. The risks in sustainable projects are categorized into 14 types of risks which include: Management risks, technical risks, technology risks, stakeholders-related risks, general market risks, general project risks, risks in the construction phase, consultant, risks in feasibility and design phase, contractor, and subcontractor issues (CCSI), green materials and technology risks, material, product, and process issues (MPPI), legal, regulatory and contractual issues (LRCI), financial, cost and economic issues (FCEI), and safety risks.

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