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A comprehensive risk evaluation method for sustainable building construction

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Abstract: Effectively mitigating the risks associated with sustainable development is a key problem when building in developing nations. This method requires businesses to act following moral and ethical standards while balancing financial goals. Stakeholder consensus is critical for executing sustainable risk management, which strives to reduce risks while increasing possibilities. The research focuses on sustainability concerns in Iraqi construction projects, with the primary goal of identifying reasons causing project delays using a comprehensive framework and rigorous methodology. The initial stage of the approach is gathering data from several construction sites. To assess project risks, the weighted product approach was employed, which included factor scores from prior research to create structured questionnaires that were then used to study the influence of various aspects. To establish the significance of each aspect, the relative relevance index was used, and Delphi expert consultations were held to provide additional insights. Historically, Iraq's construction sector has disregarded risk management and restrictions of finance. The project hazards were assessed using surveys, expert comments, and exploratory research. Logistic challenges were also considered in the assessment process. Microsoft Excel made performance evaluations easier, and MAT F5 obtained the highest rating for sustainable materials in WPM's risk assessment. Furthermore, equipment output has emerged as a critical aspect in guaranteeing technical compliance. This study introduces a structured risk evaluation approach for improving sustainable construction practices in developing countries.

1 Introduction

The identification and resolution of the root causes of a risk can often prevent the occurrence of a risk event or an unwanted consequence. Furthermore, it is imperative to enhance the efficiency of the scheme by guaranteeing that any remaining risks are recovered by the members. To achieve these objectives, it is recommended to follow a systematic approach: first, identify potential sources of danger; then, assess and analyze the impact of these sources through risk assessment; next, develop a management response to the risks; and finally, include any remaining risks in the scheme's estimations [1-3]. The definitions of risk and uncertainty are as stated below: Risk arises when a decision is made with multiple possible outcomes, each of which has a quantifiable probability attached to it. Uncertainty arises when having knowledge of the probability of several potential outcomes is not enough to make an educated decision [4]. The primary goal of project management is to guarantee the effective culmination of a project while minimizing the probability of its failure by implementing specified procedures, frameworks, knowledge, and proficiency [5-6]. A multitude of technologies have been developed to assist managers in effectively managing project control and assuring compliance with specified budgets, scopes, and schedules due to the complex nature of modern projects. In the coming years, effective, durable, and environmentally friendly handling of intricate projects will require the adoption of related fiscal strategies [7-8]. Multiple factors can lead to a project experiencing delays. Hence, it is imperative to closely monitor the progress of the project and assess the potential impact of any changes on the schedule or budget. If any component were to malfunction, we would be able to implement preventive steps. The Earned Value Method is considered the standard for monitoring the development of a project over a specific duration. The main duties [9] of this role involve overseeing the project's advancement and producing reliable projections about time and expense. Hence, it is imperative for cost models to possess adequate adaptability in order to accommodate user specifications, produce reliable projections, and effectively handle various cost factors. The model's course of action should be determined by management's actions, aiming to achieve a balanced state of cost-effectiveness and excellent product quality [10-13]. Imports consist of reinforcing bars, concrete and cement, which are fundamental constituents of reinforced concrete. The employment of reinforced concrete framed structures in the stone pulverizing mills in the Besparmak highlands leads to environmental damage, dust emission,

and noise pollution [14]. The lack of recycling or export options for the imported construction materials has resulted in an excessive accumulation of construction sector waste in landfills [15]. Other factors that contribute to the issue include the supervisor's lack of care and attention, incorrect accounting practices, poor inventory management, a high rate of deterioration due to prolonged storage on the job site, an excessive amount of materials issued from central stores, and the lack of returns for unused surplus materials [16].

2 Literature review

2.1 Risk management strategy

Typically, the strategic documents and excellence management system include the comprehensive risk management policy and strategy of the client or project owner, which might be a corporation or organization. The primary concerns in project owners' risk management approaches are risk ownership and risk backing [17]. The significance of the past lies solely in its ability to influence our future expectations through historical occurrences or prior demonstrations. The likelihood of control diminishes as the strategy advances. You have control over two significant occurrences [18]. This suggests that before these two commitments, clients have a strong probability of exerting influence. They ascertain the necessary actions and devise the most efficient plan for project implementation. These decisions have an impact on the obligations of the parties involved; they influence the manner in which design, construction, commissioning, change, and risk are handled; ultimately, they influence the cost, schedule, and quality [19]. Risk identification should take place during the preconstruction phase of the project [20] to address potential hazards before accepting them with a certain level of tolerance. Convening the project team and stakeholders for brainstorming sessions is an effective approach to examining dangers. Following the brainstorming session, it is necessary for the project team to convene frequently. This will facilitate the examination of current risk management strategies and the categorization of any potential future hazards. The user's text is [21]. An additional crucial measure is to transfer the risk. Ultimately, this approach can prove to be more cost-effective than assuming the risk. In order to alleviate the load, the contractor has the option to shift the risk to the insurance provider or establish a contractual agreement with a supplier before engaging the subcontractor [36]. Furthermore, when contractors mitigate risk, they also develop tactics to lower it. To illustrate, the contractor can mitigate safety threats by imparting essential training and equipping workers accordingly [22].

2.2 The effective risk factors

The contractor's reaction strategy will be contingent upon their ability to adapt to risks and potential benefits following the completion of the project. The potential risk may be deemed reasonable if the contractor has the potential to achieve greater benefits in the future, such as the chance to penetrate an untapped market or secure a loyal repeat customer [23]. The study's findings elucidate the distinctive traits that differentiate the perspectives of green project managers. Given these factors, it is highly recommended for project managers to emphasize using assessment and identification methods to promote the production of eco-friendly products that minimize environmental harm. Self-sufficient program administrators have numerous challenges, including the volatility of resource expenses and the complexities of job hunting. This section assesses the competencies and capabilities of the project administrators and emphasizes the factors that the individuals in charge should take into account to fulfill this need. The bulk of the research sample, comprising green project leaders and construction administrators, exhibit a significant inclination to enhance their environmental consciousness by actively engaging in conservation initiatives [24].

2.3 Sustainable material factors

Considering the appropriate materials is essential when creating anything. It is imperative to identify cost-effective alternatives that nevertheless meet the objectives of the created product. Recently, there has been a growing realization of the importance of using environmentally friendly items in this particular situation. The longevity of a structure is greatly reduced by the deterioration of its quality. Long-term exposure to environmental factors and the gradual deterioration of building materials lead to slow degradation (Table 1). The longevity of a structure is typically considered a gauge of its success, which can be attributed to the materials used in its construction.

Table 1 Material risk factors for sustainable buildings

	Material risk factors
MAT F1	Designing waste collection units that facilitate sorting waste for recycling purposes to reduce the negative impact on the environment.
MAT F2	Study the quantities of materials needed by the project to reduce transportation.
MAT F3	Choose recyclable materials so that we can recycle or reuse them in the future.
MAT F4	Choose materials with low VOC emission (such as wood panels containing urea formaldehyde resin) to preserve the environment.
MAT F5	Support the use of locally available materials.
MAT F6	Using sustainable materials for buildings is financially costly.
MAT F7	There is a social demand for the use of sustainable materials for buildings as society realizes their strategic importance.

3 Methodology

3.1 Sustainable management factors

The scope of managerial responsibility can be influenced by several things. Supervisors depend on them to strategize, coordinate, guide, and manage. Furthermore, globalization, technology, variety, and integrity are crucial contributing variables (Table 2). Extensive research has been conducted on several factors that impact the efficiency of educators' teaching construction. In contrast, the predominant body of academic research has primarily examined the impact of management and human variables, such as incentives, resources, and the work environment, on teachers' research productivity [25].

Table 2 Management risk factors for sustainable buildings

	Management risk factors
ADM F1	Weak supervision causes major financial losses to the project.
ADM F2	Weak supervision causes delays in the project work schedule.
ADM F3	Weak supervision may not be a reason for obstructing work according to plans.
ADM F4	Projects managed by a specialized road engineering contractor are characterized by good performance.
ADM F5	Good decision-making depends on the project manager.
ADM F6	Good decision-making depends on the contractor's experience.
ADM F7	The administrative structure of the project is a critical factor for its success.
ADM F8	The project management structure depends on the project manager.
ADM F9	The project's administrative structure depends on the contractor's experience.
ADM F10	Increasing the number of supervisors causes confusion in work management.
ADM F11	Weak project management structure causes project loss.
ADM F12	The weak administrative structure of the project caused the project to be delayed
ADM F13	Weak staff consultation is a direct reason for project disruption.
ADM F14	The weakness of the consulting staff is determined by resolving the obstacles during the implementation of the work
ADM F15	The weakness of the consulting staff extends from project design until the completion of work implementation.
ADM F16	Weak supervision by the project beneficiary is one of the biggest reasons for project delays.
ADM F17	The precision of the beneficiary's staff is a success factor for the project.
ADM F18	Poor management of beneficiary cadres is a major reason for project delays.
ADM F19	Slow decision-making by the beneficiaries causes the project significant financial consequences.
ADM F20	The number of supervisors is proportional to the size of the project.

3.2 Equipment risk factors

Several scholars have extensively examined several facets of effective project management. The primary differentiation lies in the fact that while conventional performance metrics such as financial resources, time, and quality are associated with effective project management, project success is contingent upon evaluations of whether all project objectives have been achieved. There are other models that can be utilized for project management and completion (Table 3). Nevertheless, discerning between these models can prove to be difficult because of their interconnectedness [26].

Table 3 Equipment risk factors for sustainable buildings

	Equipment Risk Factors
EQ F1	The type of equipment used is a significant reason for the success of the project.
EQ F2	The efficiency of the equipment must be proportional to the type of work and the time required to complete the work.
EQ F3	Equipment productivity is the primary factor for implementing technical specifications.
EQ F4	The equipment used must be completely new.
EQ F5	Old equipment cannot be used.
EQ F6	The size of the project is proportional to the type of equipment used.
EQ F7	The cost of equipment is a factor in the success of the project.
EQ F8	The equipment must be owned by the implementing company for the project to be successful.
EQ F9	Delayed arrival of equipment causes loss to the project.
EQ F10	There is a direct relationship between the type of equipment, the size of the machinery, and the time the equipment arrives to the project.
EQ F11	The most productive machines are the ones with the highest technology.
EQ F12	The size and number of machines are determined according to the planned productivity in the work progress schedule.
EQ F13	Balancing the number of machines for each paragraph of the contractual bill of quantities is the basis for the success of the work.
EQ F14	The skill of workers in using machinery is a decisive factor in increasing productivity.
EQ F15	The skill of the worker depends on the type of equipment and its techniques.

EQ F16	Market inflation is a major reason for companies' reluctance to offer competitive prices.
EQ F17	Cost inflation can be contained by reducing the number of workers.
EQ F18	Cost inflation relates to materials only and not to labor wages.
EQ F19	Cost inflation is dealt with by the contractor with the amount of capital invested.
EQ F20	Increasing the financial capacity of the contractor increases profits.

3.3 The Delphi method

The Delphi technique is employed when many written questions are received from subject-matter experts. The individual supervising the procedure will gather the responses from each specialist and furnish them with a succinct summary after they have completed a set of inquiries. The assessor's subsequent duty is to evaluate the extent to which the executive summary of the report reinforces its conclusions. After finishing the executive summary, participants are requested to provide further details on their latest viewpoints in a subsequent question. In order for the Delphi technique to be effective, it is imperative to have complete unanimity regarding future estimates [27]. Prior to commencing any actual building, it is feasible to calculate the whole cost of a project, establish administrative protocols, and carry out surveys. Expert selection can commence once a well-defined process outline has been established. The process is reiterated until a consensus is reached among all members of the group over the interpretation of the results [28].

3.4 Relative important index (Rii)

The decisions made at each level of cost management are influenced by the decision-makers particular cost threshold, as well as the magnitude and nature of the expenditure. Assessing the level of acceptability of the risks is the subsequent stage after their evaluation. The entities in question can be more accurately described by utilizing the surety equivalent, which refers to the anticipated alteration in value of a specific amount of resources in both risk-free and hazardous situations [29]. The following equation (1) was utilized to calculate the Relative Importance Index (RII).

$$RII = \sum \frac{PiUi}{Nn} \tag{1}$$

RII = relative importance index

P_i = respondent's rating of cost

U_i = number of respondents placing identical weighting/rating on the cost

N = sample sized people responded to the survey

n = the highest attainable score for each cost

3.5 Weighted product method

The weighted product model (WPM) is a widely recognized approach used in multi-criteria decision analysis (MCDA) and multi-criteria decision-making (MCDM). The Weighted Product (WP) approach is a component of the decision-making framework that connects attribute ratings by means of multiplication. When characteristics are multiplied together, weight and rating assign a negative rank and a positive rank, respectively, to the cost attributes [30]. Like other MCDA/MCDM procedures, a limited number of option choices are provided, each defined by a set of decision criteria. In order to evaluate different options for a decision, various ratios are multiplied, with each ratio corresponding to a certain criterion for choice. Each ratio is multiplied by the corresponding weight of each condition. Let's assume that there are *m* possible solutions to a given Multiple Criteria Decision Analysis (MCDA) problem and *n* options to consider as criteria. Additionally, let us assume that each criterion represents a utility function for the purpose of argumentation. In other words, the greater the values, the more favorable the outcome. The calculations of this technique are illustrated in the subsequent basic numerical illustration. We employ identical numerical values for our data as those utilized in the numerical illustration of the weighted sum model. The numerical data provided below has been replicated for your convenience. The computing steps of the WPM method are as follows [31]:

1. List the criteria used in the computation based on the weight and category.

2. Calculate the relative weight of j-th criteria to the total weight of all criteria using the following equation (2).

$$\overline{\overline{W_j}} = \frac{W_j}{\sum_{j=1}^{N} W_j} \tag{2}$$

$$Where \sum_{j=1}^{N} W_j = 1$$

3. Calculate the preference value of every i-th alternative using equation (3).

$$S_i = \prod_{j=1}^{N} x_{ij}^{\overline{W}_j} \tag{3}$$

Where the value of w is positive if the criteria is a benefit, otherwise its value is negative.

4. Calculate relative preference value of each alternative to all alternatives using equation (4).

$$V_i = \frac{S_i}{\sum_{i=1}^{M} S_i} \tag{4}$$

5. The higher the *V* value the better the alternative.

4 Results and discussion

One of the challenges that sustainable construction initiatives in poor countries have is the requirement to efficiently handle the risks associated with these projects. This business approach aims to maximize financial returns by considering the enterprise's influence on various aspects of society, the environment, and the government. The objective of risk management in the context of sustainability is to attain an optimal equilibrium between mitigating adverse impacts and enhancing favorable outcomes. This thesis has highlighted several potential hazards that could impede the sustained progress of Iraqi construction projects. Implementing this approach decreases the probability of supply chain disruptions caused by occurrences such as natural calamities or labor conflicts. Ensuring that suppliers adhere to optimal labor and waste management protocols is crucial. This guarantees the continuity of operations in the event of pollution or labor disruptions. The primary objective of risk management is to mitigate the likelihood of losses and minimize their consequences in the event that they do transpire. Investors with a focus on capital preservation may opt to invest in construction projects. There is a growing apprehension that politicians may be influenced by money interests, resulting in this prevailing trend. The primary objectives of this business strategy are to optimize financial gains while minimizing adverse effects on society, the environment, and corporate governance. Sustainability risk management aims to enhance the alignment between sustainability objectives and risk management practices in order to efficiently address possible risks and leverage opportunities related to sustainability. This thesis focuses on the sustainable aspect of construction projects in Iraq, specifically addressing risk issues. It offers a thorough framework for understanding and managing these risks.

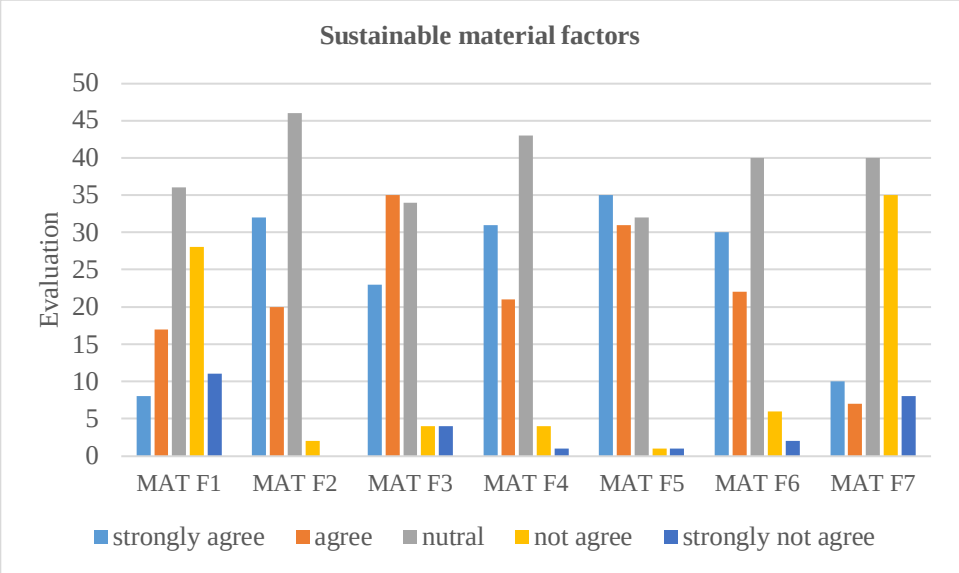

Figure 1 Evaluation of sustainable material risk factors

The risk appetite and tolerance of management play a crucial role in assessing the significance of a matter, as depicted in Figure 1. An in-depth analysis of both quantitative and qualitative factors is required to assess materiality. These motivations may encompass the desire to adhere to societal norms or the apprehension of jeopardizing one's reputation. The notion of materiality is crucial in sustainability reporting as it enables firms to identify and prioritize the most pertinent sustainability issues to incorporate in their reports. Consequently, stakeholders can receive more substantial and pertinent flow of information. Various categories of assets and types of investments require specific approaches to effectively manage the risk associated with sustainability. Quintet will implement the procedures specified below if they are deemed necessary to effectively reduce sustainability risk. Adherence to international standards set by relevant international organizations Quintet's business operations and investment strategy conform to a diverse array of global standards. Quintet's active ownership strategy encompasses investments in single-line equities, fixed income, and externally managed investments. The quintet asserts that controversy monitoring is a viable instrument for tackling the obstacles to sustainable development. Quintet employs a comprehensive technique for monitoring disputes, encompassing both fixed-income markets and individual stocks. This technique relies on data obtained from external sources.

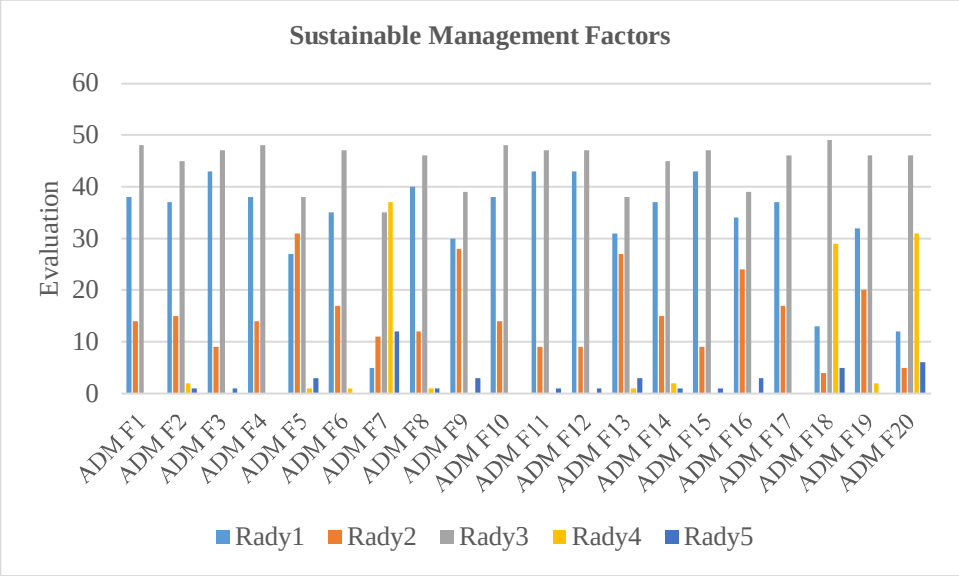

Figure 2 Evaluation of sustainable management risk factors

Quintet strategically combines specialized assets at the portfolio level using three sustainable perspectives: leader, improver, and theme. The sustainable lens can be used for a diverse array of assets, akin to growth and value investment theories. Micro-finance and green bonds are key components of sustainable development. These methods expose many things to common sustainability-related causes and risks, rendering them vulnerable (Figure 2).

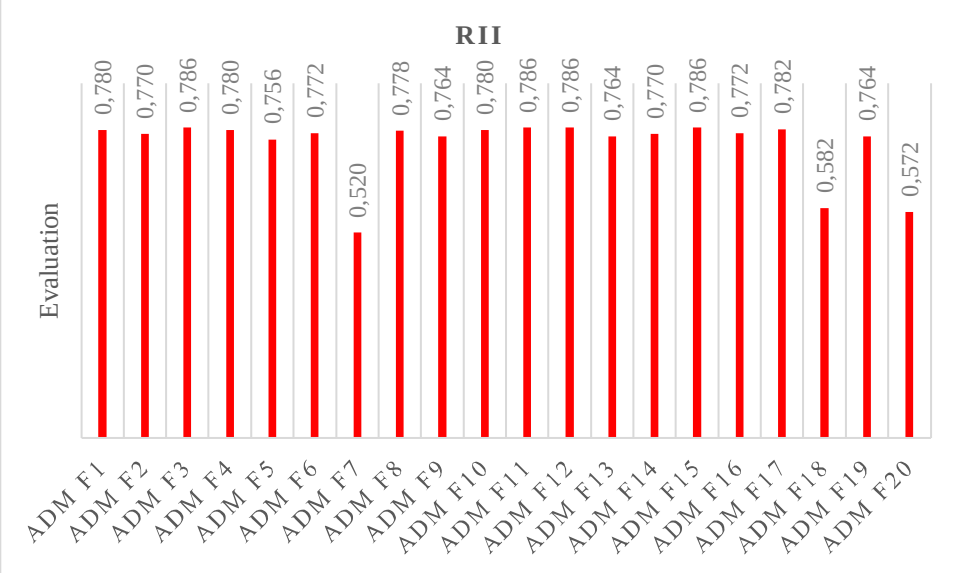

Figure 3 RII of sustainable management risk factors

The RII results shown in Figure 3 indicate that the following issues were ranked as the most significant: (ADM F11) Delays are attributed to an inadequate project management framework; (ADM F12) An inadequate project management framework results in project failure; and (ADM F15) Achieving sustainable development is challenging due to the consulting staff's lack of proficiency in all aspects of project planning, execution, and implementation. Quintet provides a comprehensive approach to monitoring conflicts that encompasses several markets, such as individual equities and fixed-income assets. This plan is derived from data obtained from external sources.

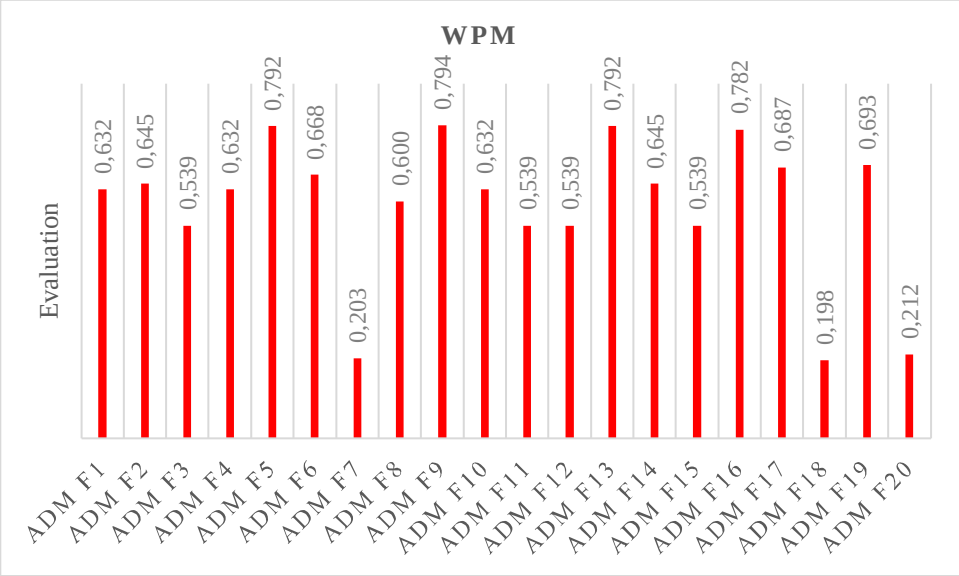

Figure 4 WPM of sustainable management risk factors

ADM F9 receives flow of information from the WPM's report regarding risk factors in sustainable management, shown in Figure 4. The job's administrative structure will be determined by the contractor's level of proficiency. In order to integrate a strategic sustainability viewpoint into product creation, leaders must effectively establish a direct correlation between measurable short- and long-term advantages of finance and sustainability criteria. Only individuals who possess genuine motivation to employ ethically sound manufacturing processes will be the ones who actually implement them.

All forms of construction equipment have the capacity to present difficulties. Individuals are accountable for any harm caused by using a device without knowing its possible hazards. Every occupation necessitates some form of machine engagement. Engaging in risk management without the requisite tools is unwise. Equipment management is an essential component of every aspect of a construction project, spanning from concept to execution. Inadequate planning for ventures utilizing expensive equipment often leads to the most significant financial losses.

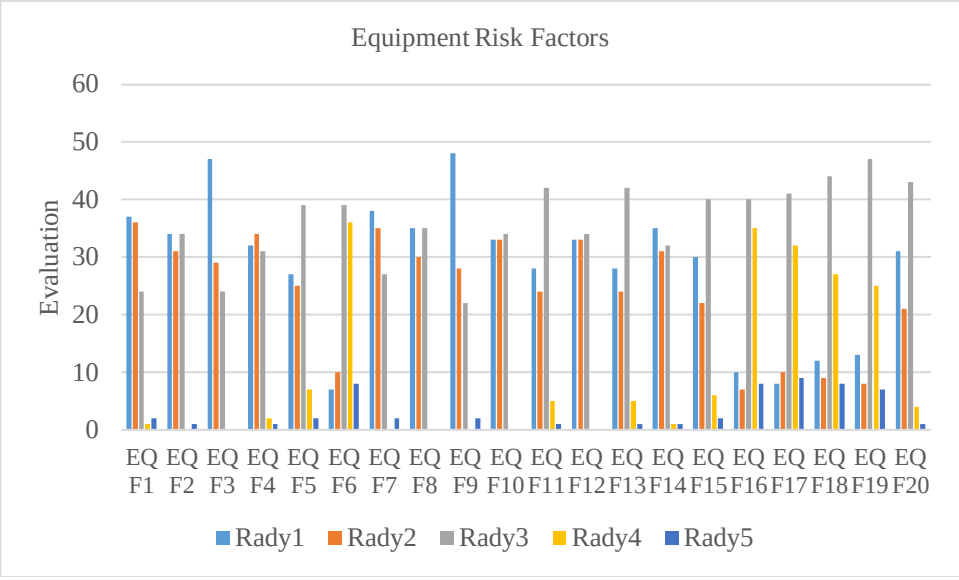

Figure 5 Evaluation of equipment risk factors

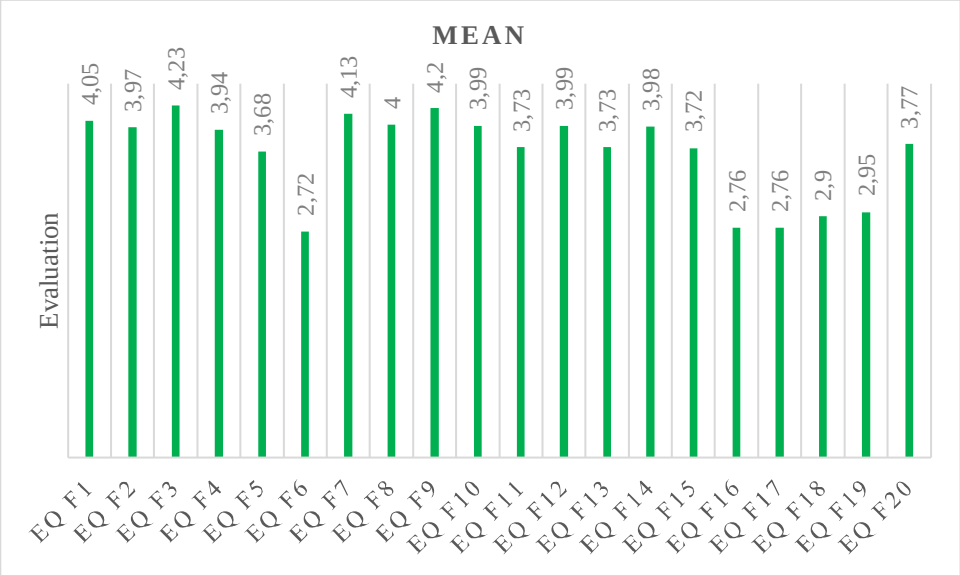

Figure 6 Mean of equipment risk factors

Given these concerns, contractors must meticulously evaluate the instruments they select and employ risk mitigation strategies. The findings indicate that the productivity of equipment is the paramount aspect of fulfilling technical criteria. Additionally, they demonstrate that both equipment risk and financial risk have had a role in the occurrence of EQ F3, as shown in Figures 5 and 6. The RII results demonstrate that both equipment risk and financial risk significantly influence EQ F3.

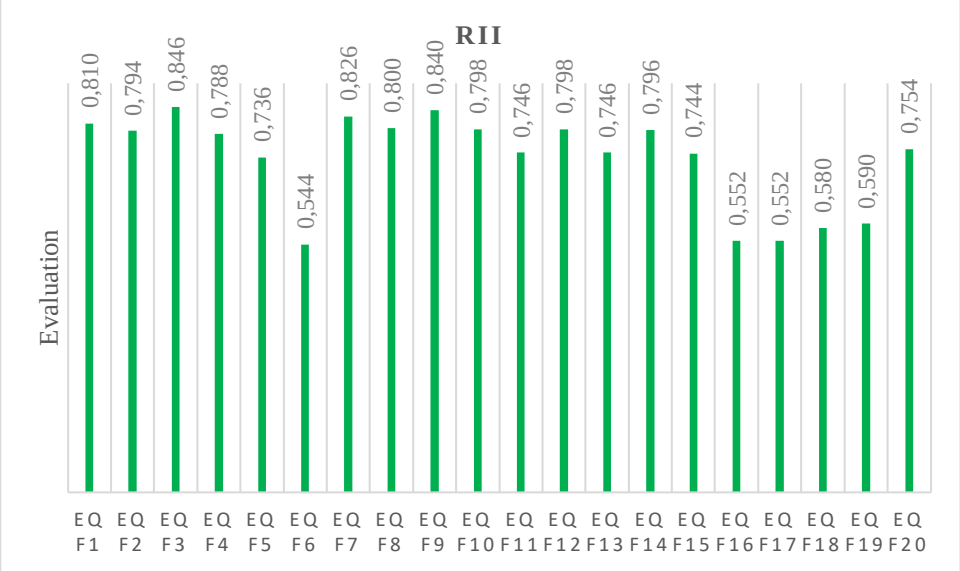

Figure 7 RII of equipment risk factors

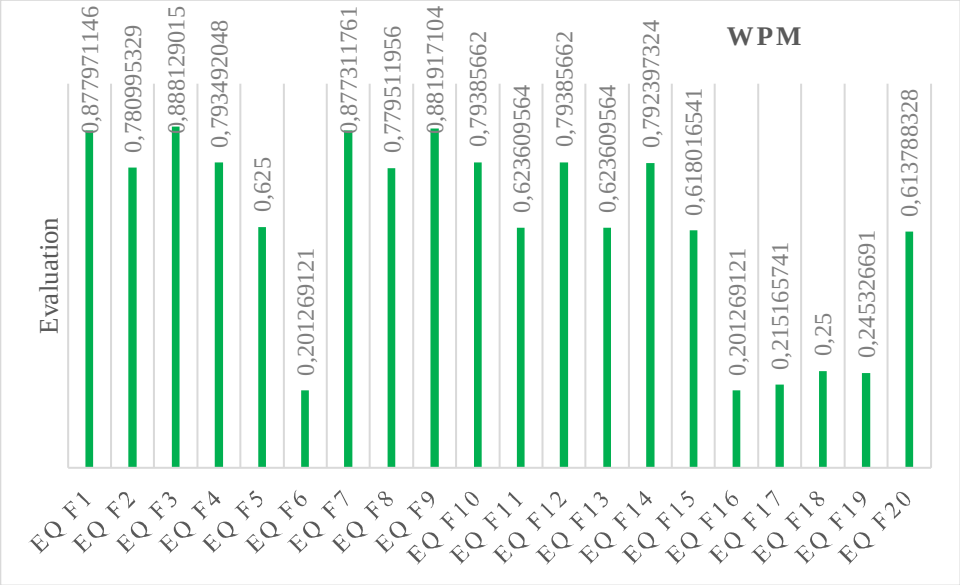

Figure 8 WPM of equipment risk factors

The efficiency of the equipment depicted in Figure 7 and 8 is the primary determinant of implementing technical standards. The findings of the WPM analysis on Equipment Risk Factors indicate that both financial risk and equipment risk significantly influence the EQ F3 Equipment Productivity, which is the paramount factor in fulfilling technical specifications.

5 Conclusions

There is a notable gap in the existing literature regarding the relationship between the benefits and drawbacks of a solution for a company's operations and competitiveness and how it aligns or diverges from strategic sustainable growth. Examining this connection is crucial for understanding the significance of integrating sustainability issues into decision-making and determining the causes of different events. The assessment of sustainability is based on an organization's capacity to effectively control and manage its expenditures. The building sector in Iraq has a long history of not following risk management rules and budgetary limitations. Extensive research has focused on the causation of project hazards. The aim of this thesis is to identify and evaluate the root causes of dangers at building sites. The current inquiry utilized a wide range of approaches and procedures to achieve its objectives. The initial study examined the operation and effects of performance criteria by utilizing a blend of surveys, expert comments, interviews, and exploratory research based on previous studies of building projects. Reformatting the user's content in an academic style is not possible because it is extremely compact. The first step of the RII extrapolation procedures entailed the choice of suitable modelling software. Microsoft Excel was chosen for its efficient performance evaluations because of its intuitive interface and robust analytical capabilities. Consequently, we were able to determine the weight of different types of achievements with enhanced accuracy. MAT F5 has the highest rating in WPM's risk assessment when it comes to sustainable materials. The user's input cannot be completely altered. The data supplied illustrates the results that were deliberated upon at the World Congress on Risk Factors in Sustainable Management. The level of proficiency demonstrated by an employee will determine the organizational framework that supports the project. Moreover, according to the analysis of Equipment Risk Factors, the equipment's output is the primary factor that determines compliance with technical standards. The prevalence of dangers linked with the use of technologies and financial transactions could have a substantial impact on this.

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