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A risk management model for large projects in the construction phase in Egypt

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A B S T R A C T

The implementation of major projects is complicated by the multiplicity of beneficiaries, owners, and all participants in the project as well as the technical overlap between the various engineering, financial and administrative works, while the specific features of the construction activity have a clear influence in shaping the nature of construction projects because the implementation processes were associated with a deep and long-term intervention in the natural environment, where construction is a burden on the environment, both in the construction phase and during the maintenance and liquidation phases: it requires depreciation of a large number of material resources. Through that, this study focused on clarifying the most important concepts of risk management and modern strategies in risk analysis and how to respond to them and monitor projects. The study then presented a questionnaire for the risks facing major projects in Egypt. Through analyzing the results of the questionnaire, a qualitative risk analysis was conducted that can be used to prioritize response to risks, in addition to conducting a Monte Carlo simulation based on theoretical foundations and providing a new process for prioritizing project risks related to sustainability, where the (Primavera Risk Analysis) program was used to clarify the impact of risks on project time and cost. All analyses are based on the theoretical background regarding risk, risk management process, and project life cycle approach in the sustainable construction sector. with the help of this study, it is possible to address ways of mitigating the harmful effects on the environment through the implementation of sustainable management in the planning of future projects and better management of current projects.

1. Introduction

Excessive urbanization and unbridled globalization have led to runaway waste generation, warming, pollution of air, soil, and water, and depletion of natural resources. The main factor largely responsible for environmental degradation and global warming is the construction industry. The construction industry consumes about 40% of the resources extracted and is responsible for 35% of total carbon dioxide emissions(Srinivas, 2021), but the change results from the participation of stakeholders who describe specific management practices or policies before the start of the project. For example, the reason may be the limited qualified manpower available to the enterprise or the insufficiency of this power for the tasks assigned to it. Thus, the result will be evident in the additional cost or imbalance in the work schedule, the length of the implementation period, the quality of implementation, or more consumption of resources.

2. Literature review

There are differences between priority risks in traditional construction and sustainable construction, for example, in traditional construction, modifications have the greatest impact on projects, but on the other hand, poor labor and equipment productivity in sustainable construction, and tight schedule, come at the forefront of risks sustainable construction (Qazi et

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al., 2021). The use of project risk control practices are essential to the growth and sustainability of construction operations, as there is a positive, statistically significant relationship between risk reassessment and project success (Obondi, 2022). The quantitative method is the most efficient and widely used in risk analysis, as it detects deviations in the budget and schedule using Monte Carlo analysis (Nabawy, M., & Khodeir, 2020). However, qualitative risk analysis is an effective method when the study aims to prioritize the order of dealing with risks. The owner shall provide independent monitoring teams with significant technical expertise and an experienced workforce to carry out project risk management tasks, to ensure that projects are delivered on pre-determined time, budget and quality (Sichone, 2020). Each knowledge area of PMI contains some or all the project management processes (Banaitiene & Banaitis, 2012). For example in Fig. 1, project risk management includes (PMI, 2019).

Fig. 1. Clarify the elements of project risk management,
Fig. 1. Alt Text: The risk management starts with the risk management plan, then identifying risks, then qualitative and quantitative analysis, developing and implementing a response plan, and monitoring risks (Source, (PMI, 2019) PMI 2019)

2.1 Plan risk management

The importance of this process is that it ensures the degree, type, and clarity of risk management in a manner commensurate with the project management and the importance of the project to stakeholders and the organization (GUIDE, 2017).

Include risk management in your Project Management Plan (Wiley, 2018).

- Determine the level of project risk assessment.
- Integrate the impact of risks and management of their activities into the project schedule.
- Make risk management an important component of your regular project meeting schedule.
- Communicate the importance of project risk management to the entire team.
- Documenting and reporting risks, and then managing them.

2.2 Identify risks

Several researchers have identified risk factors affecting construction projects (Abd Karim et al., 2012). There are 25 factors categorized into five groups which are, construction, contract policy and provision, financial, design, and environmental (Banaitiene & Banaitis, 2012). Risks can be divided into seven categories: design risks, environmental risks, external risks, regulatory risks, project management risks, construction risks within the project team's control, and right-of-way risks (PMI) (GUIDE, 2017). Risks are divided into four categories: technical risk, management risk, commercial risk, and external risk. Hence, for this study, an extensive literature review was conducted to identify common hazards that may occur on construction projects. This resulted in the identification of 27 factors classified into five groups shown in the Table. 1:

Table 1
Classification of risk factors according to previous studies into five classifications: management risk, technical risk, design risks, external risk, and financial risks (Source, author)

Risk Category	Risk factor		
1- Management Risk	Inadequate planning	**4- External Risk**	Changes in law and regulation
	Coordination Problems		Unavailability of facilities on site
	Shortage of material		Difficulty to access the site
	Late deliveries of material		Competition
	Delays in the construction schedule		Bureaucracy
	Construction cost overruns		Environmental (Weather, Natural disasters,..)
	Inefficiency of subcontractors	**5-Financial Risks**	lack of financial resources
	Poor supervision		Delayed payment of contractors
2-Technical Risk	Lack of Employment specialized and Performance		Suppliers and vendors' problems
	Shortage of equipment		Exchange rates changed
	lack of technology		Inflation
	The difficulty of some Technical Operations		
3- Design Risks	Incomplete design		
	Design errors and omissions		
	Stakeholders request late changes		
	Delay in acceptance of details		

2.3 Perform Qualitative Risk Analysis. (GUIDE, 2017)

Probability and impact matrix: It is a grid of the diagram showing the probability of occurrence of risks and the extent of their impact on the project objectives in the event of each risk. This matrix identifies groups of possibilities and impacts that assess individual project risks and divides them into groups ranked according to their importance.
Qualitative method PI factor = Probability × Impact. Fig. 2 Example probability and impact matrix.

Probability	Threats					Opportunities					Probability
Very High (0.90)	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05	Very High (0.90)
High (0.70)	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04	High (0.70)
Medium (0.50)	0.03	0.05	0.1	0.2	0.4	0.4	0.2	0.1	0.05	0.03	Medium (0.50)
Low (0.30)	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02	Low (0.30)
Very Low(0.1)	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01	Very Low (0.1)
	Very Low	Low	Moderate	High	Very High	Very High	High	Moderate	Low	Very low	
	0.05	0.1	0.2	0.4	0.8	0.8	0.4	0.2	0.1	0.05	
	Negative Impact					Positive Impact					

Fig. 2. Example probability and impact matrix (Source, (GUIDE, 2017; PMI, 2017)

2.4 Perform Quantitative Risk Analysis

It is a method of estimating the probability that a project will meet time and cost objectives. Quantitative analysis is based on a simultaneous assessment of the effects of all assessed and identified risks (Banaitiene & Banaitis, 2012).

2.4.1 Monte Carlo simulation

It determines the probability distribution for each risk and then considers the impact of the risks combined, where it calculates the quantitative estimates of the risks considering that the risks may occur together in the project (Steyn, 2018). Analyses the impact of risks on construction projects, examining the impact on project budget and schedule. Decision-making is improved by customizing possible outcomes (Nabawy & Khodeir, 2021).

2.5 Plan Risk Responses

The project manager and the organizational structure should take a set of actions to respond to the identified risks. Focusing on the most significant project risks can shift the odds in favor of the project's success plan. (Wiley, 2018). Fig 3 presents five alternative strategies for dealing with risks facing projects.

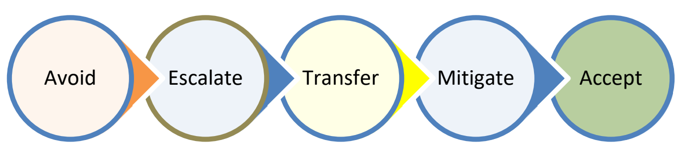


Fig. 3. Five Alternative Strategies for Dealing with Project Risks
Fig. 3 Alt Text: Five Alternative Strategies for Dealing with Project Risks: avoid, escalate, transfer, mitigate, and accept (Source, (GUIDE, 2021; PMI 2021)

2.6 Implement Risk Responses

After the planning process responses to risks are completed, the approved response actions identified in the relevant response plans are initiated. The procedures are then monitored to determine their effectiveness and to identify any side risks that may arise due to the implementation of the response plan. (PMI, 2019)

2.7 Monitor Risks

The primary purpose of risk monitoring and control in construction projects is to monitor the progress and monitor the project environment and the state of the risks (ROPEL & GAJEWSKA, 2011). The importance of risk monitoring is in determining whether

- The implemented risk responses are effective or not
- The overall project risk level has changed
- New individual risks have arisen during the project
- The risk management approach is still appropriate or not.

3. Risk management framework for sustainability-related risks:

Table 2 shows a comparison of typical sustainability risk management efforts.

Table 2
Risk management of typical vs. sustainability-related risks (Giannakis & Papadopoulos, 2016)

	Typical supply chain risks	Sustainability-related risks
Risk Identification	Disruptions to supply chain (forecast errors intellectual property, delays, capacity, inventories, etc.)	Deterioration of ecosystems, effect on societal values and responsible management.
Risk Assessment	Based on operational or financial metrics/methods	Inductive studies
Risk Treatment	Shared, organization-wide understanding of supply-chain risk through stress testing and tailoring.	Portfolio of strategies for managing all three dimensions of sustainability.
Methods for risk treatment	Based on management and assessment of risks and proper business planning	Scenario planning and simulation automatic fault detection, automatic recovery
Risk treatment opportunities	Opportunities for business improvement (internal) and win business from competitors.	Competitive advantage and a chance for business excellence

4. Problems of sustainable development on the map of project risks

Project risk can be defined as the cumulative effect of the possibility of uncertain events that could have a negative or positive impact on the project implementation phase in the advanced economic stages because the reason that gives a competitive advantage is not an increase in profits but an improvement in cost. Risk management can be considered a vital component of a project that, if not managed sustainably, can lead to a significant increase in costs. (Bizon-Gorecka & Gorecki, 2019).

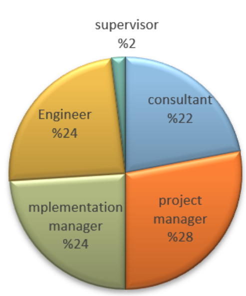
5. Activating environmental and economic sustainability in risk analysis

The importance of risk analysis in assessing the economic and environmental sustainability of projects has recently been highlighted. In a report by Davis, Langdon Management Consulting provides a methodology that outlines some specific practical steps in risk analysis. After the risk has been identified, initial uncertainty assessments (Qualitative Risk Analysis) are performed, followed by a Detailed Risk Analysis (Quantitative Risk Analysis), then sensitivity analysis is performed to calculate and present the risk-adjusted LCC values. This underlines the importance of sensitivity analysis and the Monte Carlo Method (MCM) as key tools for sustainable risk management. (Fregonara et al., 2019)

6. Data collection and analysis

The study was conducted on 50 engineers in various major projects in Egypt. The data was collected using a questionnaire to understand the practitioners' perceptions of risk factors. The results of the questionnaire were analyzed using the (IBM SPSS Statistics) program.

6.1 Demographic Result



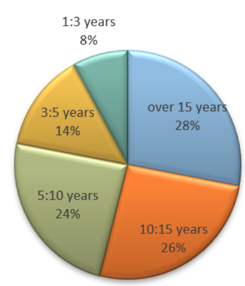


Fig. 4: Rate of respondents based on years of experience and occupation.
Fig. 4 Alt Text: Rate of respondents based on years of experience and occupation. It shows that many respondents (28%) have more than 15 years of work experience in the construction industry, (28%) working as project managers.

Fig. 4 shows that many respondents (28%) have more than 15 years of work experience in the construction industry, while (26%) of respondents have 10 to 15 years of work experience, and many respondents (28%) work as project managers, while (24%) of respondents work as implementation managers or technical office managers, in addition (22%) of respondents work as engineering consultants for major projects.

6.2 Ranking Study of Risk Factor

Fig. 5 shows samples of the questions asked to 50 engineers from different projects in Egypt. Each hazard had four questions related to the probability of occurrence and impact on time, cost, and quality in different projects. The answers are arranged with graduated options from 1 to 5 where 5 represents the highest probability of occurrence or impact and 1 represents the lowest probability of occurrence or impact.

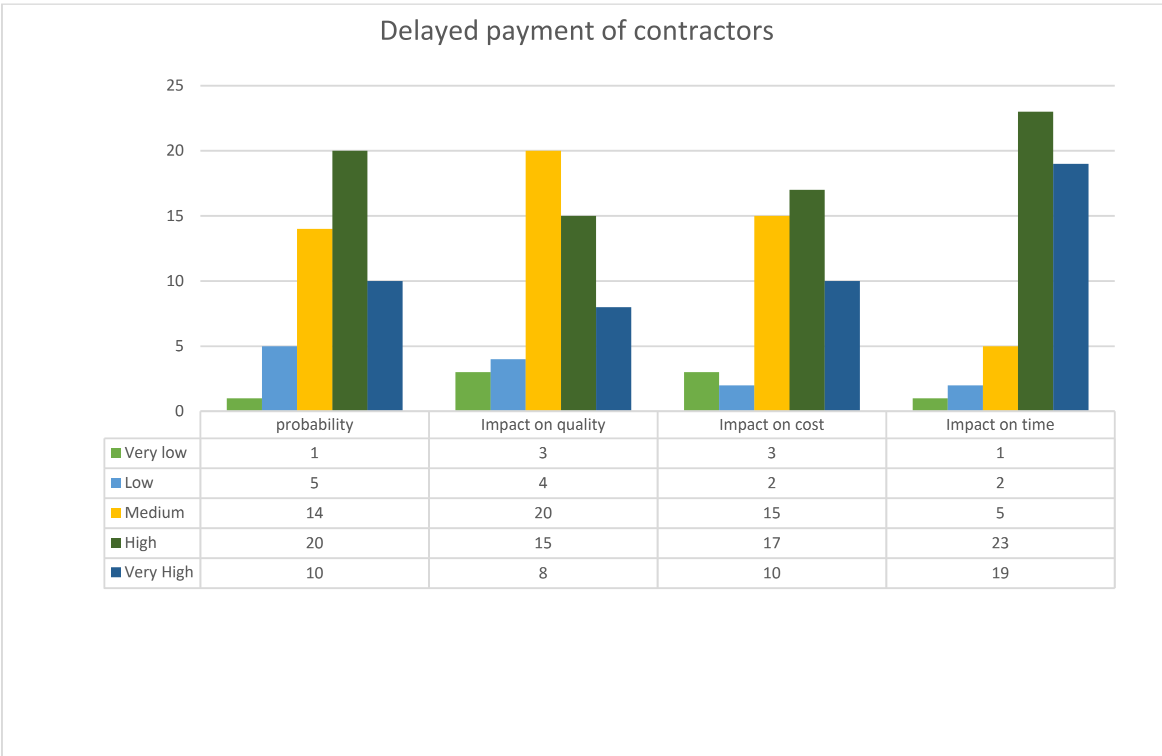


Fig. 5. Sample survey results (delayed payments to contractors)

Fig. 5. Alt Text: Sample survey results (delayed payments to contractors), Where the majority chose that the impact of this risk is high on the time and cost of the project, in addition to the high probability of its occurrence.

Table 3 shows the analysis of the questionnaire results on the SPSS program. The probability of occurrence and impact on the project was placed on the horizontal axis and using the probability and effect matrix we obtain the risk factor, then the results were entered into the program (Primavera Risk Analysis) program to obtain a score so that the risks are arranged in order of priority, where the results were classified into three colors, where the red color is the most dangerous, yellow is medium, and green is the least dangerous.

By analyzing the results of the questionnaire using the probability and impact matrix, the study showed that the ten most important risk factors in the construction project are: Delayed payment of contractors, Inefficiency of subcontractors, Stakeholders requesting late changes, Coordination Problems, Incomplete design, Delays in the construction schedule, Design errors and omissions, Poor supervision, Lack of Employment specialized and Performance, and lack of financial resources. Table 3 illustrates the arrangement of the risk factors.

After reviewing the literature and conducting a set of interviews with experts and with the help of the planning director and planning engineers in major projects, a proposed model was developed for a response plan for the risk group that has the greatest impact on major projects in Egypt, to apply this to one of the major projects, and this was clarified in Table 4.

Table 3
Ranking of risk factors

IDENTIFIED RISK	PROJECT OBJECTIVE	PROBABILITY	IMPACT	MATRIX	SCORE
Inadequate planning	QUALITY		0.2	0.1	
	COST		0.2	0.1	
	TIME	0.5	0.4	0.2	13
Coordination Problems	QUALITY		0.4	0.28	
	COST		0.4	0.28	
	TIME	0.7	0.4	0.28	28
Shortage of material	QUALITY		0.2	0.1	
	COST		0.2	0.1	
	TIME	0.5	0.4	0.2	13
Late deliveries of material	QUALITY		0.2	0.1	
	COST		0.2	0.1	
	TIME	0.5	0.4	0.2	13
Delays in the construction schedule	QUALITY		0.2	0.1	
	COST		0.4	0.2	
	TIME	0.5	0.8	0.4	23
Construction cost overruns	QUALITY		0.2	0.1	
	COST		0.4	0.2	
	TIME	0.5	0.2	0.1	13
Inefficiency of subcontractors	QUALITY		0.8	0.56	
	COST		0.4	0.28	
	TIME	0.7	0.8	0.56	47
Poor supervision	QUALITY		0.4	0.2	
	COST		0.4	0.2	
	TIME	0.5	0.4	0.2	20
Lack of Employment specialized and Performance	QUALITY		0.4	0.2	
	COST		0.4	0.2	
	TIME	0.5	0.4	0.2	20
Shortage of equipment	QUALITY		0.2	0.06	
	COST		0.2	0.06	
	TIME	0.3	0.4	0.12	8
lack of technology	QUALITY		0.2	0.1	
	COST		0.2	0.1	
	TIME	0.5	0.2	0.1	10
The difficulty of some Technical Operations	QUALITY		0.2	0.06	
	COST		0.2	0.06	
	TIME	0.3	0.2	0.06	6
Incomplete design	QUALITY		0.4	0.2	27
	COST		0.4	0.2	
	TIME	0.5	0.8	0.4	
Design errors and omissions	QUALITY		0.4	0.2	20
	COST		0.4	0.2	
	TIME	0.5	0.4	0.2	
Stakeholders request late changes	QUALITY		0.2	0.14	33
	COST		0.4	0.28	
	TIME	0.7	0.8	0.56	
Delay in acceptance of details	QUALITY		0.2	0.14	19
	COST		0.2	0.14	
	TIME	0.7	0.4	0.28	
Changes in law and regulation	QUALITY		0.1	0.01	2
	COST		0.2	0.02	
	TIME	0.1	0.2	0.02	
Unavailability of facilities on Site	QUALITY		0.2	0.1	10
	COST		0.2	0.1	
	TIME	0.5	0.2	0.1	
Difficulty to access the site	QUALITY		0.1	0.03	5
	COST		0.2	0.06	
	TIME	0.3	0.2	0.06	
Competition	QUALITY		0.2	0.1	10
	COST		0.2	0.1	
	TIME	0.5	0.2	0.1	
Bureaucracy	QUALITY		0.1	0.05	12
	COST		0.2	0.1	
	TIME	0.5	0.4	0.2	
Environmental (Weather - Natural disasters - etc.)	QUALITY		0.1	0.03	5
	COST		0.2	0.06	
	TIME	0.3	0.2	0.06	
lack of financial resources	QUALITY		0.2	0.14	19
	COST		0.2	0.14	
	TIME	0.7	0.4	0.28	
Delayed payment of contractors	QUALITY		0.4	0.36	48
	COST		0.4	0.36	
	TIME	0.9	0.8	0.72	
Suppliers and vendors' problems	QUALITY		0.2	0.1	17
	COST		0.4	0.2	
	TIME	0.5	0.4	0.2	
Exchange rates changed	QUALITY		0.2	0.1	13
	COST		0.4	0.2	
	TIME	0.5	0.2	0.1	
Inflation	QUALITY		0.2	0.1	17
	COST		0.4	0.2	
	TIME	0.5	0.4	0.2	

Table 4
Risk response plan template

RISK	RESPONSE	Description
Delayed payment of contractors	Mitigate	Reduction or elimination with preventative controls and continuous monitoring.
Inefficiency of subcontractors	Mitigate	Reduction or elimination with preventative controls and continuous monitoring.
Stakeholders request late changes	Avoid	Set a deadline for making any modifications to the project.
Coordination Problems	Mitigate	Good coordination between different departments using information systems and others.
Incomplete design	Avoid	Reduction or elimination with preventative controls and continuous monitoring.
Delays in the construction schedule	Mitigate	An increase in the number of workers and an increase in the rate of completion.
Design errors and omissions	Mitigate	Reduction or elimination with preventative controls and continuous monitoring
Poor supervision	Mitigate	Continuously developing the skills of the project supervision team.
Lack of Employment specialized and Performance	Accept	Achieving positive acceptance of risks by developing a contingency plan that can be launched in case of danger.
lack of financial resources	Transfer	Use expert advice to better plan your financial situation.
Delay in acceptance of details	Avoid	Good coordination between the contractor and the consultant in the project.

6.3 Findings of quantitative risk analysis studies

There is a group of programs through which Monte Carlo can be simulated such as (Excel) and (Primavera), where the (Primavera Risk Analysis) program was used for ease of handling, and quantitative analysis of risks was carried out in one of the major projects, which is the (Mangroovy residence El Gouna) project, Table 5 shows the project data. Table 6 shows the project risk register from within the (Primavera risk analysis) program.

Table 6
Data about the (Mangroovy residence El Gouna) project

Name	Mangroovy residence El Gouna
Location	Hurghada, Red Sea Governorate, Egypt.
Start Date	16/03/2020
End date as planned	30/6/2021
Completion Date	31/12/2021
Cost as planned	320,147,907.0 $
Total Units	702
Population	3500

Qualitative | Quantitative

Risk			Pre-Mitigation (Data Date = 16/03/2020)					Mitigation			Post-mitigation				
ID	T/O	Title	Probability	Schedule	Cost	Quality	Score	Response	Title	Total Cost	Probability	Schedule	Cost	Quality	Score
001	T	Delayed payment of contractors	VH	VH	H	H	48	Reduce	Reductio...	$0	H	VH	H	M	33
002	T	Inefficiency of subcontractors	H	VH	H	VH	47	Reduce	Reductio...	$50,000	M	VH	M	H	23
003	T	Stakeholders request late chan...	H	VH	H	M	33	Avoid	Set a dea...	$0	M	H	M	M	13
004	T	Coordination Problems	H	H	H	H	28	Reduce	Good co...	$100,000	M	M	M	M	10
005	T	Incomplete design	M	VH	H	H	27	Avoid	Reductio...	$0	L	VH	H	H	16
006	T	Delays in construction schedule	M	VH	H	M	23	Reduce	An increa...	$300,000	L	H	H	M	10
007	T	Design errors and omissions	M	H	H	H	20	Reduce	Reductio...	$30,000	L	H	M	H	10
008	T	Poor supervision	M	H	H	H	20	Reduce	Continuo...	$50,000	L	M	H	H	10
009	T	Lack of Employment specialize...	M	H	H	H	20	Accept	Achievin...	$0	M	H	H	H	20
010	T	lack of financial resources	H	H	M	M	19	Transfer	Use exper...	$100,000	M	H	M	M	13
011	T	Delay in acceptance to details	H	H	M	M	19	Avoid	Good co...	$50,000	M	H	M	M	13
012	T	.....	N	N	N	N	0	Accept		$0	N	N	N	N	0
013	T	......	N	N	N	N	0	Accept		$0	N	N	N	N	0

Fig. 6. proposed model for the project's risk register

The planned periods were reviewed by running a Monte Carlo simulation, and then a thousand iterations were applied to the largest number of activities, Thousands of operations were chosen as the optimal number of iterations to take into account the most possibilities.

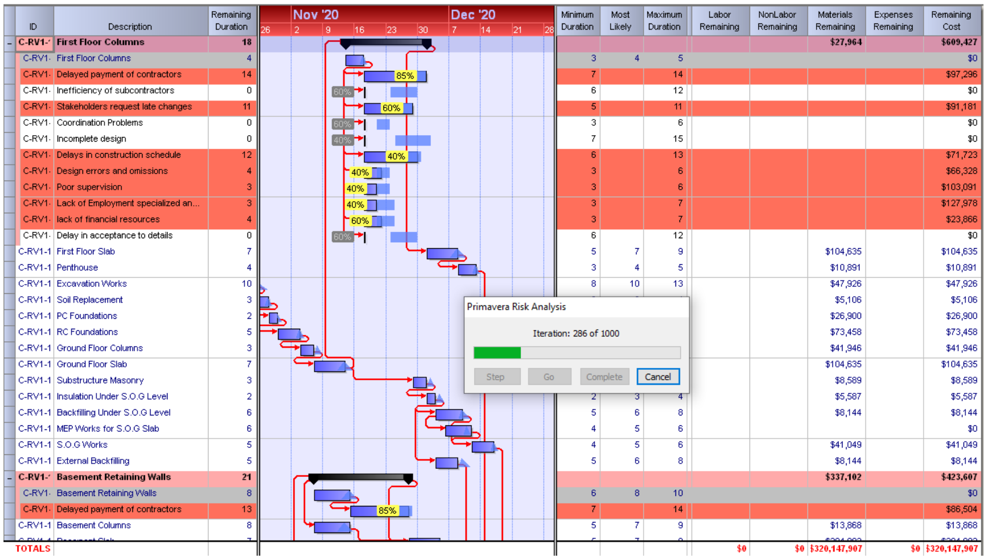


Fig. 7. Running Monte Carlo simulation
Fig. 7. Alt Text: Apply a thousand iterations to the largest number of activities by running a Monte Carlo simulation.

6.3.1 Simulation outputs

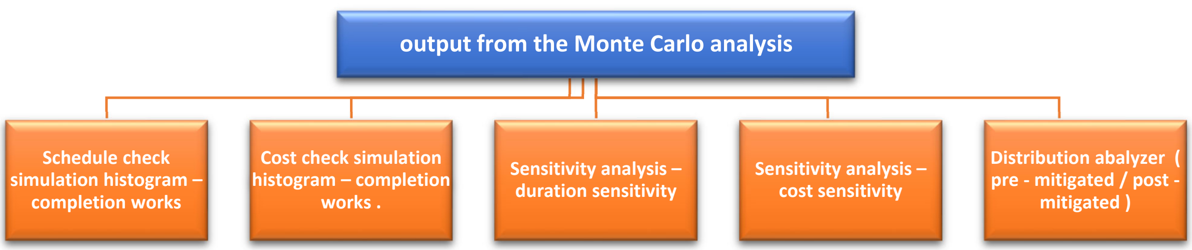


Fig. 8. The output from the Monte Carlo analysis.
Fig. 8. Alt Text: shows the output from the Monte Carlo analysis: Schedule check simulation histogram, Cost check simulation histogram, Sensitivity analysis, and distribution analyzer (pre - mitigated / post - mitigated)

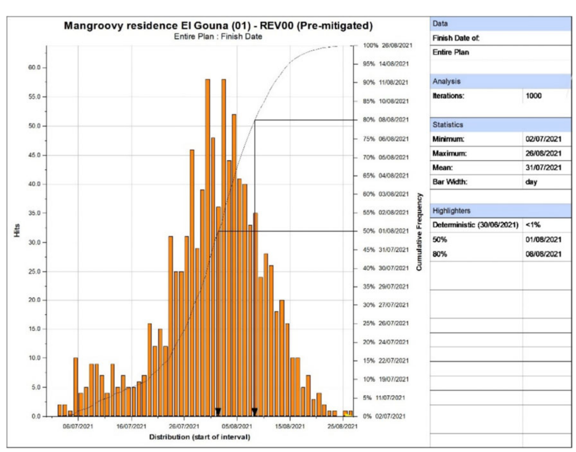


Fig. 9. Schedule check simulation histogram – completion works
Fig. 9. Alt Text: Schedule check simulation histogram – completion works: Under the influence of risks with 80% confidence, the project will be completed on 8/8/2021

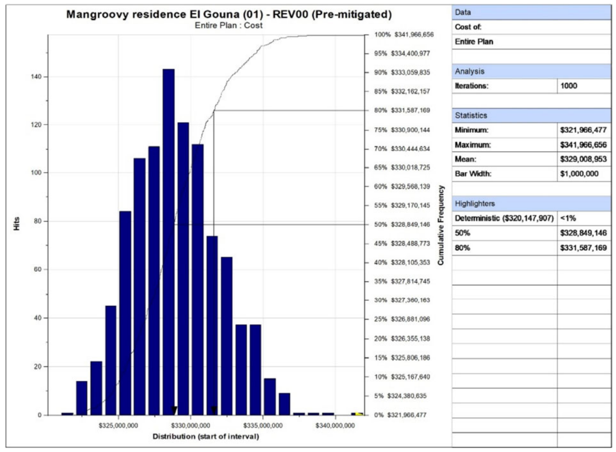


Fig. 10: Cost check simulation histogram – completion works

Fig. 10. Alt Text: Cost check simulation histogram – completion works: Under the influence of risk with a confidence of 80%, the project cost will reach 331,587,169.0 $

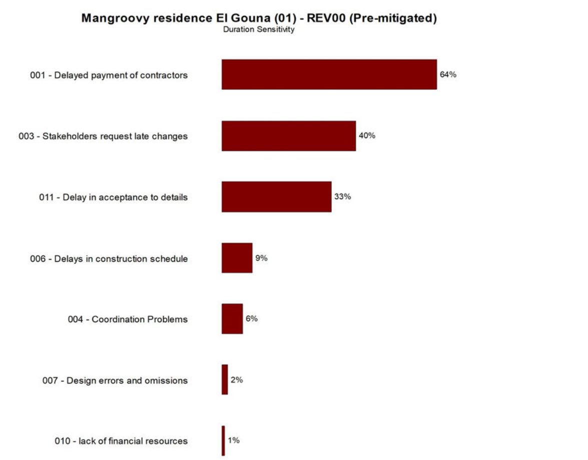


Fig. 10. Sensitivity analysis – duration sensitivity

Fig. 10. Alt Text: Sensitivity analysis – duration sensitivity: Subcontractor late payment risk is one of the most significant risks affecting project time with a sensitivity of 64%.

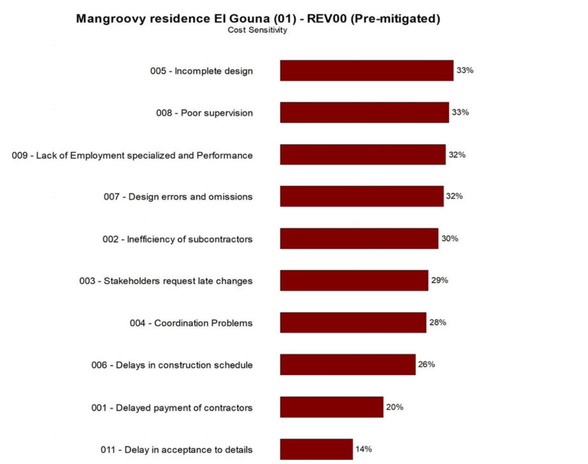


Fig. 11. Sensitivity analysis – cost sensitivity

Fig. 11. Alt Text: Sensitivity analysis – cost sensitivity: Incomplete design risk is one of the most important risks affecting project cost with a sensitivity of 33%.

The output of the Monte Carlo analysis included a probability graph showing the probability of the planned completion dates of activities and the probabilities of completion dates. The output is based on the approved pessimistic duration values. The results showed that there is less than a 1% probability that the project will finish on the planned date according to schedule 30/06/2021, while the probability of confirmation rate is 80% that the project will finish on 08/08/2021, which is a date closer to the actual completion time of the project. 31/12/2021. The output also included a probabilistic graph showing the total planned project cost, where the results showed that there is a less than 1% probability that the project cost is the estimated cost according to the plan which is (320,147,907.0 $), while 80 certainty that the total cost of the project is (331,587,169.0 $). As shown in Fig. 10, and Fig. 11, the sensitivity to the impact of risk on project time is shown, where we primarily find the risk of late payments to contractors at 64%, while the risks of stakeholders who request late changes have an impact of 40%, and Fig. 12 shows: Sensitivity to the impact of risk on the cost of the project, where We mainly find the risk of incomplete designs at 33%, followed by the risk of poor supervision with an effective ratio of 33%.

Fig. 13 includes activating the proposed plan to respond to risks, which will reduce the total cost of the project under the influence of risks to (326.415,112.0 $), which saves (5,172,057.0 $) from the total cost of the project and activating the response plan will reduce the delay in the project time by 8 working days So that the project completion date is 31/07/2021, but it should be taken into account that there is a backup plan, which depends on the probability of 100% in the study, This results in a total project cost of (341,966,656.0 $), and delays the delivery of the project until 26/08/2012.

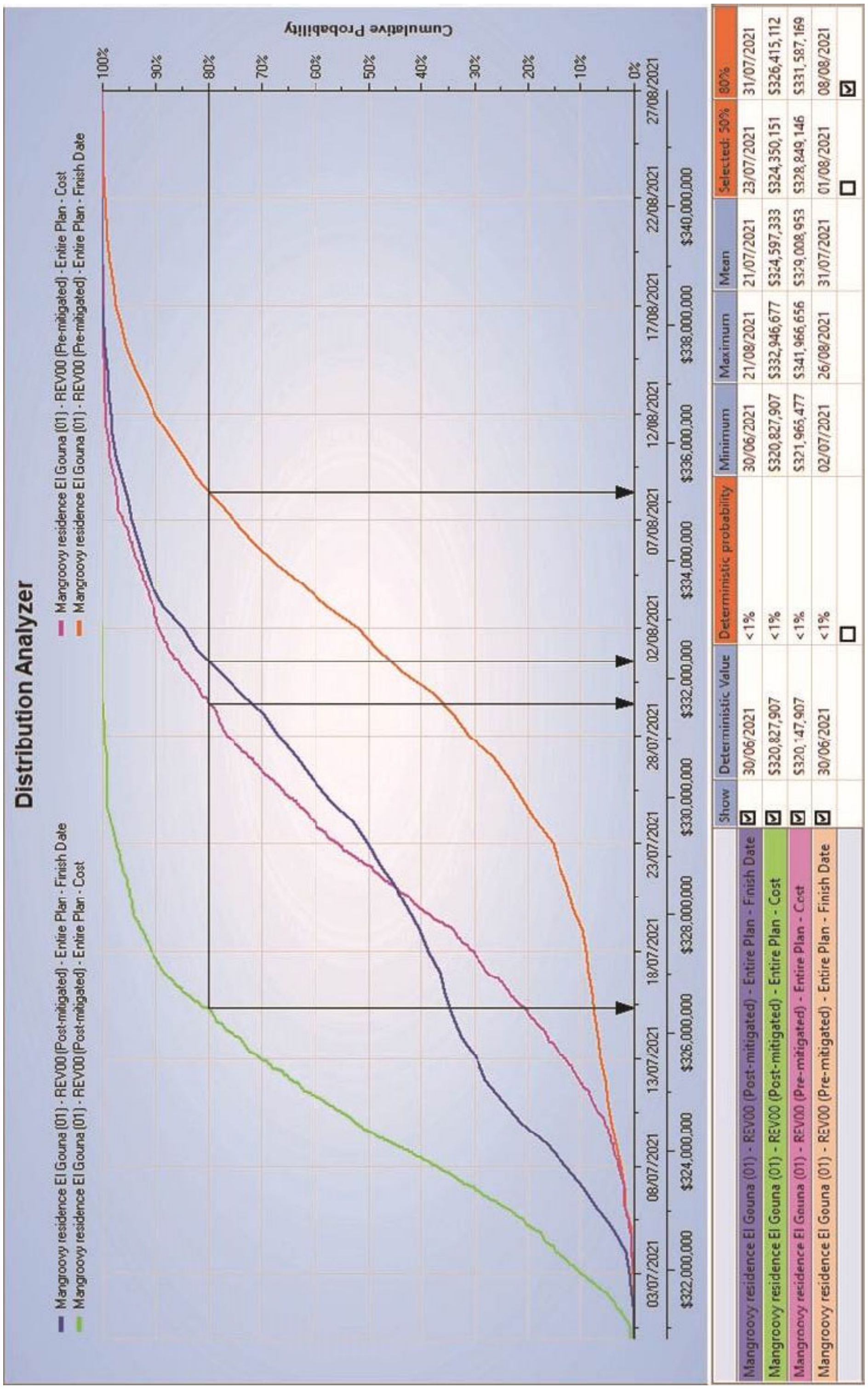


Fig.13. Distribution Analyzer (pre - mitigated / post - mitigated).

Fig.13. Alt Text: Distribution Analyzer (pre - mitigated / post - mitigated): Activating the response plan saves ($ 5,172,057.0) from the total cost of the project and reduces the delay in the project time by 8 working days so that the project completion date is 07/31/2021

7. Conclusion

The principles of sustainable development about construction include considering the environmental impact of the building in the various stages of the project, starting with the idea of the project through the implementation, operation, and maintenance processes, considering the economic aspect, and reducing the increase in cost and resource exploitation, as it was found that the quantitative analysis of risks is necessary for the process of sustainable risk management. The results of the analysis are more efficient results, with which the impact on time and cost can be clarified using Monte Carlo analysis. But qualitative analysis and traditional methods of analysis cannot be dispensed with because both can be applied in projects.

At the forefront of the risks that affect major projects in Egypt is the late payment of subcontractors, their inefficiency in implementing projects, and the lack of coordination between the different departments in the project, as Monte Carlo analysis showed that the possibility of implementing the project on time and at the estimated cost without taking into account the risks It is a low probability that may reach less than 1%, and with the help of sensitivity analysis of the risks facing the project at the time of implementation, it is possible to prioritize the response to the risks at each stage differently, activate the risk response plan by employing a follow-up team, dealing with risks, and conducting a continuous analysis of deviations. It will help reduce the increase in cost and activate the sustainable management of the project.

8. Recommendations

- We should consider reducing the consumption of non-renewable resources and energy, especially in the construction phase, reducing the number of emissions of harmful substances, especially during the operating phase of facilities, and the possibility of recycling during the shutdown phase.
- Emphasis on the importance of applying the basics of sustainable risk management (identification, analysis, and follow-up) to reduce or prevent the occurrence of risks and mitigate their impact on the environment, the need to develop a plan for risks in the planning stage of the project before implementation, stress the need for quantitative analysis of risks, and the need to conduct a risk sensitivity analysis at the time of implementation To clarify the most influential risks at present to activate sustainable management.
- Continuous development of cadres in construction projects and training them to follow up and monitor risks and the various ways to deal with them, emphasizing the necessity of having a risk register that monitors project risks and helps in quantitative analysis on an ongoing basis.
- Studies have shown that the most influential risks are the risks of contractors, and therefore it is preferable to work on developing contractual formulas between the employer and the contractor and between the contractor and the consultant regarding the risks faced by the project, which guarantees the rights of all parties through the risk management program. Where one of the participants in the questionnaire suggested conducting a study on the effect of adding (Dispute Adjudication Boards) to the project.

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