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RESEARCH ARTICLE

Assessment of Construction Project Complexity

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Abstract:

Objective:

Project complexity is a crucial factor in project management that presents auxiliary obstacles to reaching project objectives (cost, time, safety, and quality). This study aims at understanding project complexity and factors affecting project complexity. The overall objective of the study is to determine the nature of complexity and characteristics, identify the important complex factors that influence the complexity of the project, factor weight of the complex factors, and develop a proposed construction complexity index (CCI).

Methods:

According to the literature review, the Analytic Hierarchy Process (AHP) method is used to measure the affecting factors of project complexity.

Results:

This paper developed an index to measure complexity based on factor weights called construction complexity index (CCI). The validity of this index was verified by studying 3 cases. The construction complexity index (CCI) proposed here allows measuring the complexity of the projects in Egypt. The results of this paper provide guidelines on how to successfully manage the complexity of the project.

Conclusion:

Project complexity management relates to the challenge of dealing with technical competence, professional diversity, uncertainties, and unforeseen events in project implementation. Project managers, who are critical to effectiveness or failure, need skills such as adaptation, creativity, and flexibility to meet this challenge. Therefore, this study provides guidelines to help practitioners to develop their capabilities in managing complex projects. Moreover, this paper enables participants to identify factors affecting the complexity of projects and how to calculate this complexity through the complex index. The outcomes of this study can be used by practitioners to develop a complexity assessment and management tool, which would enable industry practitioners to allocate resources effectively on complex construction projects. This research aimed to develop a measure by which the complexity of construction projects in Egypt can be evaluated and establish guidelines on avoiding complexity in projects.

Keywords: Project complexity, Project management, Complexity assessment, Analytic hierarchy process, Factor index, Construction industry.

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1. INTRODUCTION

Most of the previous studies have studied complexity as one of the factors affecting the achievement of project objectives, so there is a need to study complexity as a separate factor affecting projects, knowing what factors influence complexity, and how to measure it and set guidelines to overcome the expected complexity. Complexity is a word frequently used in literature and among practitioners to explain the cause of cost exceeding, delays in schedule, and lack of project performance [1 - 3]. Hence, an accurate understanding of the complexity of projects is important for successful management; therefore, a lot of scholars have concentrated on this topic [4 - 6]. Furthermore, the success of the project regarding cost, time, and quality has historically been poor in the construction industry [7, 8].

1.1. Project Complexity Definition

A common cause of poor performance is that the design and construction process are particularly complex due to many reasons [9, 10]. There is no standard definition for project complexity that can be applied to a variety of projects. Baccarini [9] was the first to propose a definition of project

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complexity consisting of many varied interrelated parts. Gidado [11] defined project complexity as measuring the difficulty of implementing a planned workflow in relation to the project objectives. Despite the many existing studies on project complexity, there is no universal agreement on the definition of project complexity [12]. Remington and Pollack [1] referred to project complexity as feedback and evaluated interrelationships between vagueness and lack of certainty. Project complexity is the attribute of a project which makes it difficult to realize, forecast, and keep under control, despite having complete data regarding the project system [13].

Custovic [14] defines complexity as that feature of a system that makes it difficult to formulate its overall behavior in one language, even when given reasonable complete information about its atomic components and their interrelations. For instance, Bakhshi *et al.* [15] define project complexity as an intricate arrangement of the varied interrelated parts in which the elements can change and constantly evolve to affect the project objectives. Dao *et al.* [5] defined project complexity as the degree of differentiation of project elements, interrelatedness between project elements, and consequential impact on project decisions. Uncertainty can be defined as a future event or situation, which cannot be predicted with the available information, and it may have both positive and negative influences on the project outcomes [16]. However, there is still no commonly accepted definition of project complexity.

1.2. Choosing the Analytic Hierarchy Process (AHP)

Generally, decision-making is the study of identifying and selecting alternatives based on the decision maker's values and preferences. Making decisions implies the need to consider some of the reasons and choose the alternative that might best suit the objectives, goals, desires, and values of the problem. Choosing the most appropriate multi-criteria methodology is in itself a multi-criteria choice [17]. Six criteria and 30 methods for this problem have been identified by Tecle [18]. Indeed, on evaluating the complexity of projects, preferences are given to the context of project management in terms of axioms, importance, notoriety, and sufficiency. Moreover, this method should be able not only to arrange the alternatives but also to suggest tables to ease the move to the computation of the complexity index.

There was a need for measuring the factors of complexity in order to manage project complexity efficiently. A lot of researchers have attempted to determine the weight of each factor of complexity and measure these factors [19 - 21]. However, characteristics of complexity do not all have the same negative impact and influence on the project's success [22], which makes it important to understand and measure the weight of each complexity parameter and its impact on the overall level of project complexity. The overall objective of the study presented in this paper is to develop a methodology to explore the complexity of the project and evaluate it completely. We have achieved this goal by (1) determining the complexity and characteristics, (2) identifying and testing the importance of the complex factors that influence the complexity of the project, (3) weighing the complex factors, (4) developing a proposed construction complexity index (CCI), and (5) providing guidelines on how to successfully manage the expected project complexity.

The ever-rising complexity of the project is the main source of project risk. Hence, identifying the sources and levels of complexity of projects has become a critical issue in order to aid in the management of modern projects. The main aim of this study is to develop an index of project complexity called Construction Complexity index (CCI) based on the previously identified relative weights of the input factors so that it can be used as an indicator, validate the developed index through some selected field case study applications, and provide guidelines on the management of various complexity factors. Moreover, this study adds to the information provided by previous studies regarding some of the guidelines directed to the participants involved in project management. The resulting assessment of project complexity adds significant value to researchers' existing body of knowledge and assists practitioners in allocating project resources to complex projects. From the perspective of complexity theory and complexity management, the research findings make a significant contribution to the theoretical foundation in the field of project management. This research develops an index by which the complexity of construction projects in Egypt can be measured and establishes guidelines on avoiding complexity in projects.

2. LITERATURE REVIEW

The construction industry has different characteristics that may lead to delays, which in turn lead to disputes between different parties related to the project and may cause complexity in projects [23]. Gidado [11] has defined project complexity and identified the factors that influence its effect on project success. Furthermore, he identified an approach that measures the complexity of the production process in construction. Lee and Xia [24] introduced a two-dimensional framework for assessing information system development (ISD) project complexity. The framework proposes four types of software project complexity: structural organizational complexity, structural IT complexity, dynamic organizational complexity, and dynamic IT complexity. Maylor *et al.* [25] developed a model of managerial complexity based on two rounds of workshops with project practitioners.

Vidal *et al.* [26] developed a method for measuring project complexity using the Delphi method and the process of Analytical Hierarchy (AHP). José R. San-Cristobal *et al.* [27] conducted a review on the latest concepts of complexity, and a conceptual framework was created to identify and justify complexity dimensions of engineering with a focus on naval-shipbuilding. Ward and Chapman [28] viewed the number of influencing factors and their interdependencies as constituents of complexity. Samimpey and Saghatforoush [29] identified prerequisites of constructability to solve current problems of the projects, including inadequate plans that could not be implemented, poor decision-making related to design, and a lack of adequate experience of implementation in the design engineering team. Chadee *et al.* [30] considered and reduced the factors contributing to delays and cost overruns from 80 to 24 critical factors and introduced a new method of calculating and measuring optimism bias in construction projects.

3. RESEARCH METHODOLOGY

In order to manage the project complexity and set guidelines for project managers and practitioners in the construction industry, we offer the methodology (approach), as shown in Fig. (**1**).

- From previous studies, 47 potential factors of project complexity of complex construction projects are assumed. The potential factors are then grouped into four categories. Afterward, through the analysis, 12 complexity factors have been identified, and these factors have the greatest influence on the complexity of the projects and thus affect the success of the project. Therefore, these 12 factors are called 12 critical factors.
- The study was conducted by: 1- determining the number of questionnaires distributed to practitioners through the sample size equation. 2-establishing the AHP questionnaire and sending it to construction industry practitioners and receiving answers.
- The collected data was analyzed using the AHP method, so the 12 critical complexity factors were weighted and ranked.
- Project complexity index is made by using the Analytic Hierarchy method.
- The project complexity index is tested and validated by case studies.
- This study provides guidelines to project managers to improve the management of the complexity of complex construction projects.

4. DATA COLLECTION

AHP questionnaire surveys have been implemented from 20th June 2020 to September 2020. However, the sample size was measured first. According to J. Bartlett [31], the required sample size can be expressed in below Eq. (1):

$$n = \frac{t^2 * p(1-p)}{d^2} \quad \textbf{(1)}$$

Where;

n: Sample size required.

t: Statistic for confidence level (=1.645 when confidence level 90%).

p: Expected prevalence or proportion of population (= 0.5 in critical value).

d: Precision or acceptable margin of error (= 0.1 for confidence level 90%).

The required sample size of this study of the finite population is 68.

The questionnaire included 2 parts. In the first part, an explanation regarding the use of the AHP method was given, and the solved examples were also provided to help respondents. In the second part, the respondents were requested to rate the importance of the factors contributing to project complexity according to Saaty's scale. The AHP questionnaire consisted of 12 critical factors. These 12 essential factors create a complex framework for the project and can be found in Table **1**.

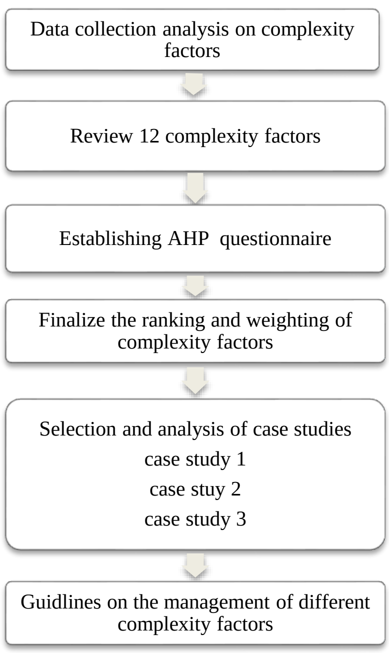

Fig. (1). Research approach.

Table 1. Refined project complexity framework.

Criteria	Factor
C1 –People	F1- Poor decision making
	F2-Lack of leadership
	F3-Lack of agreement on objectives between stakeholders
	F4-Experience and skill level of project manager
C2- Project characteristics	F5-Lack of clear and detailed drawings and specifications
	F6-Lack of the experienced local workforce
	F7-Conducting and managing a project for the first time
C3- Process	F8-Large number of critical path activities
	F9-Unpredictable subsurface (*e.g*., excavation in ancient city grounds)
	F10-Undefined work in a defined new structure
C4- Environment	F11-Technical core environmental layer (*e.g*., underground construction chemical)
	F12-Economic situation

5. DATA ANALYSIS

5.1. Assessing Project Complexity Using the AHP Method

From previous studies, the AHP method was found to have the best results compared to other methods. The analytical hierarchy process was developed by Thomas Saaty [32 - 34]. It is a way of making multi-criteria decisions to allow the relative assessment and prioritization of alternatives. The AHP uses a decision problem model just as a hierarchy. It consists of a general target, a set of alternative elements, and a collection of criteria that link alternative elements to the target. In the context of the project's improved complexity, a hierarchical frame of the project is established. The general target is to rank alternatives according to their complexity level, which means that the degree of AHP that is eventually obtained compares the significance of complexity factors of each alternative. The prime level criteria (intermediate objectives) coincide with the four sets of complexity factors (people, project characteristics, process, and environment). The next level criteria then coincide with the factors of the polished frame, weighting the factors shown in Table **2**.

All initial weights for each criterion and sub-criteria (factors) are summarized in Table **2**.

Fig. (**2**) presents the weight percentages for the four main criteria and the weight percentages for each main factor related to specific criteria. The “people” criteria are the most effective criteria in the complexity index with a relative weight of 0.321. The “lack of leadership” is the most effective factor in people criteria with a relative weight of 0.282. The “lack of clear and detailed drawings and specifications” is the most effective factor in project characteristics criteria with the relative weight of 0.488. The “unpredictable subsurface (*e.g*., excavation in ancient city grounds)” is the most effective factor in the process criteria having a relative weight of 0.342. The” economic situation” is considered the most critical factor in environment criteria because it obtains a relative weight of 0.556.

Table 2. Comparing project complexity factors.

Criteria (C)	Criteria Weight	Factor	Factor Weight
People	0.321	F1- Poor decision making	0.243
		F2- Lack of leadership	0.282
		F3- Lack of agreement on objectives between stakeholders	0.242
		F4-Experience and skill level of project manager	0.233
Project characteristics	0.302	F5- Lack of clear and detailed drawings and specifications	0.488
		F6- Lack of experienced local workforce	0.29
		F7- Conducting and managing a project for the first time	0.222
Process	0.209	F8- Large number of critical path activities	0.321
		F9- Unpredictable subsurface (*e.g* excavation in ancient city grounds)	0.342
		F10- Undefined work in a defined new structure	0.337
Environment	0.168	F11- Technical core environmental layer (*e.g* underground construction chemical)	0.444
		F12- Economic situation	0.556

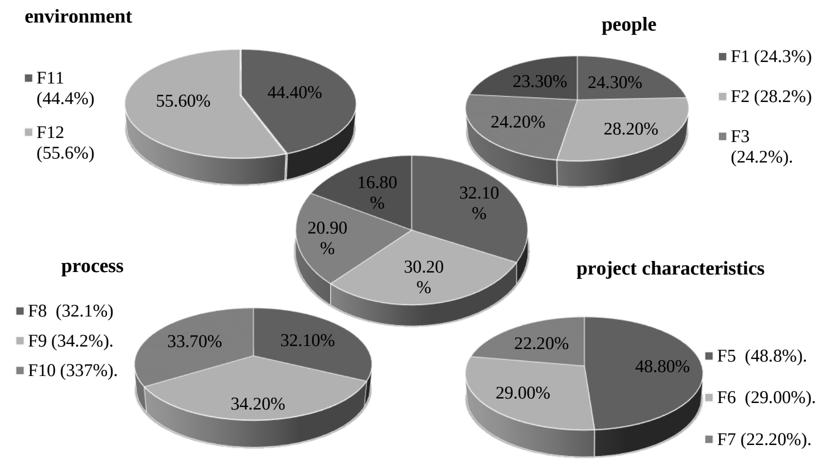

Fig. (2). Percentage of the weighting of the four main criteria and percentage of the weight of each key factor related to specific criteria.

5.2. Proposing a Construction Complexity Index

Factor weights developed from AHP have been used to make a composite indicator to evaluate the complexity of the construction project. Moreover, a Construction Complexity Index (CCI) has been developed, which can be represented in the following two formulas:

$$CCI = 0.321*people + 0.302*\text{ Project characteristics} + 0.209*process + 0.168*\text{ Environment} \quad \textbf{(2)}$$

$$\begin{aligned} CCI = {} & 0.321*[(0.243*F1)+(0.282*F2)+(0.242*F3)+(0.233*F4)] \\ & + 0.302*[(0.488*F5)+(0.29*F6)+(0.222*F7)] + \\ & 0.209*[(0.321*F8)+(0.342*F9)+(0.337*F10)] \\ & +0.168*[(0.444*F11)+(0.556*F12)]. \end{aligned} \quad \textbf{(3)}$$

To evaluate a certain project complexity, the input factors in the second Eq. (**2**) have been replaced with their relevant scores according to Table **3**.

The measure of relative project complexity is evaluated between 0 and 1 by evaluating factor sub-measures (this index allows projects to be classified in terms of complexity).

Table 3. Factors relevant score.

Criteria	Factor	Measure Unit	Factor Limitation		Score
People	Poor decision making	-	-		Score from 25
			The data does not be available		-
			Un Suitable organization structure		-
			Decision not based on detailed data analysis		-
			Lack of Using suitable decision making tool		-
			Total		-
	Lack of leadership	According to years of experience	Lower Limit	Upper limit	-
			< 3 years		100 %
			3 years	< 7 years	80 %
			7 years	<11 years	60%
			11 years	<15 years	40 %
			> 15 years		20%
	Lack of agreement on objectives between stakeholders	-	-		Score from 25
			Lack of agreement on cost		-
			Lack of agreement on Time		-
			Lack of agreement on Control		-
			Lack of agreement on Safety		-
			Total		-
	Experience and skill level of project manager	According to Project manager years of experience	Lower Limit	Upper limit	-
			0	<1year	100%
			1year	<3years	80%
			3years	<5years	60%
			5years	<7years	40%
			≥7years		20%

(Table 3) contd.....

Project Characteristics	Lack of clear and detailed drawings and specifications	-	-		Score from 20
			Incomplete drawings		-
			Unclear specifications		-
			Lack of Detailed specifications		-
			Un Detailed drawings		-
			Specifications does not match for drawings		-
			Total		-
	Lack of experienced local work force	According to past experience from last similar projects	1 projects		100%
			2 projects		80%
			3 projects		60%
			4 projects		40%
			≥ 5 projects		20%
	Conducting and managing a project for the first time	-	First time		100%
			Two time		75%
			Three time		50%
			Four time		25%
Process	Large number of critical path activities	According to number of critical path activities compared to all project path activities	Lower Limit	Upper limit	-
			< 20 %		20%
			20 %	< 40 %	40%
			40 %	< 60 %	60%
			60%	< 80%	80%
			> 80%		100%
	Unpredictable sub surface (e.g excavation in ancient city grounds)	-	-		Score from 25
			The number of bores are few compared to the total area		-
			Bores are not accurate enough		-
			Inaccurate Follow up of groundwater level		-
			The data are not clear and not correct		-
			Total		-
-	Unpredictable and Undefined work in a defined new structure(e.g as in new work added to old buildings without record drawings)	-	-		Score from 25
			The area of the added part is too large for the original part		-
			There are cracks in structure		-
			The groundwater level is high		-
			The height of the building is high		-
			Total		-
Environment	Technical core environmental layer (e.g under ground construction chemical)	-	-		Score from 25
			Field tests are not accurate		-
			Site tests are not accurate		-
			Soil bores are not accurate		-
			Groundwater level is not normal		-
			Total		-
	Economic situation	According to rate of inflation	Lower limit	Upper limit	-
			<5%		20%
			5%	< 10%	40%
			10%	< 15%	60%
			15%	< 20%	80%
			> 20%		100%

Table 4. Distribution of information on three case study projects used in the analysis of the results.

Project	Name of project	Project Area	Scheduled time	Actual time
Project 1	A large administrative building in the administrative capital	36000 ms	700 days	1050 days
Project 2	A group of factories and mills	105000 ms	380 days	600 days
Project 3	A group of residential buildings	30000 ms	600 days	890 days

Table 5. The comparison of the weighting of complexity factor score for case study.

Criteria	Factor	Project 1	Project 2	Project 3
People	F1-Poor decision making	0.6	0.7	0.35
	F2-Lack of leadership	0.2	0.2	0.4
	F3-Lack of agreement on objectives between stakeholders	0.77	0.72	0.5
	F4-Experience and skill level of project manager	0.2	0.2	0.2
Project characteristics	F5-Lack of clear and detailed drawings and specifications	0.56	0.69	0.8
	F6-Lack of the experienced local workforce	1	0.8	0.4
	F7-Conducting and managing a project for the first time	1	0.75	0.5
Process	F8-Large number of critical path activities	0.4	0.8	0.6
	F9-Unpredictable subsurface (*e.g*. excavation in ancient city grounds)	0.2	0.23	0.13
	F10-Unpredictable and undefined work in a defined new structure	0	0.2	0.35
Environment	F11-Technical core environmental layer	0.15	0.25	0.13
	F12-Economic situation	0.4	0.6	0.6

6. CASE STUDY

6.1. Selection and Analysis of Case Studies

To check the validity of the construction complexity index, three projects were selected for the case study (Project 1, Project 2, and Project 3) in order to calculate the levels of complexity and assessment of the differences between the three projects mentioned. Table **4** shows details of the information on the mentioned case study projects.

Table **4** shows that all the case studies involved residential and industrial projects. The first project was to build a large administrative building in the administrative capital. The scope of the second project was to build a group of factories and mills. In addition to that, the third case study project was the construction of a group of residential buildings. Three case studies were selected to test the effectiveness of CCI. Table **5** shows the comparison of complexity factor scores for the case study.

In the penultimate phase, the results of the case studies were compared with the actual values of the completed projects, as shown in Table **6**. The rate of the actual project time to the scheduled time was used as an indicator of complexity. Finally, the final results were obtained and allowed the projects to be ranked according to a complex scale/indicator (0 to 1), as shown in Fig. (**3**). It can be observed that project 2 was more complex than the other projects.

Table 6. The comparison between CCI and actual complexity.

Project	Construction Complexity Index (CCI)	Actual complexity
Project 1	46.7%	50%
Project 2	52.5%	57.8%
Project 3	44.4%	48.3%

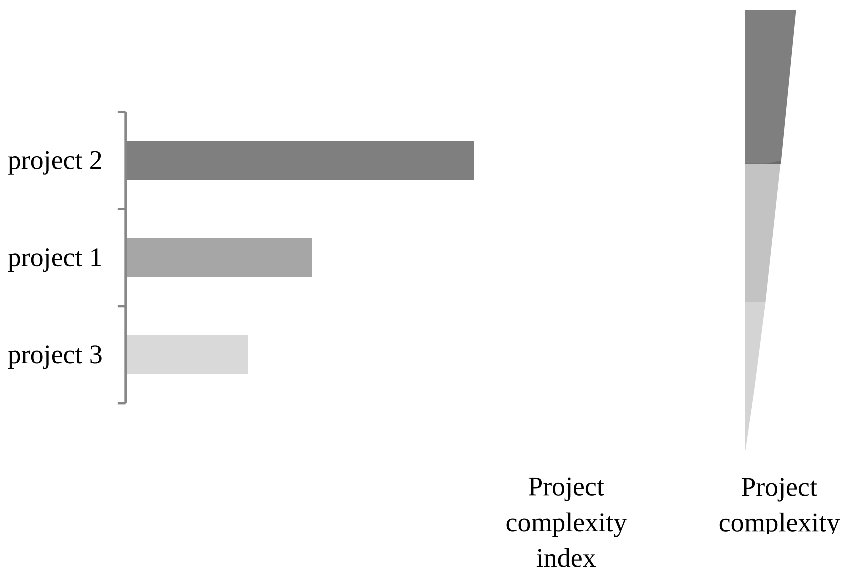

Fig. (3). The relative project complexity index in the case study.

Table 7. The problems with case studies and guidelines.

Case Study	Problems with Case Studies	Guidelines
Case study 1	Through the first case study, it was found that the majority of consultants were foreigners and they faced some legal problems during the implementation of the project, and this caused some delays in the project. In addition, the data collected related to the site and the surrounding environment were not accurate, and because of it, some problems appeared related to the surrounding environment during the implementation. And more than that, a lack of agreement on the objectives of the project was observed between the concerned parties.	1-Recruitment of local consultants for engagement.
		4-Incorporation of legal constraints into the project implementation plan.
		8 -Review the best practices and lessons learned and develop a logistics plan at the conceptual stage of border sites.
		12-Convergence of the objectives of the parties concerned is a critical strategic factor.
		13-Identification of scope, objectives, and initial requirements of the project before starting it.
		14-The unpredictability and certainty of the surrounding environment, the Earth's surface, and the Earth's layers, no matter how many tracts are implemented, should be considered as influencing the achievement of the scope, time, and cost of the project.
Case study 2	In the second case study, it was found that there were problems with the subcontractors and that some important and main works were assigned to a number of subcontractors who did not have sufficient experience, which led to the delay of the project beyond the specified period. Furthermore, there was a lack of a specialized team to follow up on all stages of the project from its inception until the date of its completion, and this led to poor decision-making. It did not take into account the obstacles and risks faced as a result of using new technology. Moreover, the appointed technicians did not have extensive experience in the technical field.	2-Recruitment of professionals with more expertise in the technical field of the project.
		9-Recognition of productivity, existing schedules, estimates, *etc*., must be adapted to take account of new technology.
		10-Evaluation of subcontractors based on project size, experience, financial stability, and reputation.
		11-Establishment of an ad hoc project team to participate in all phases.
Case study 3	In the third case study, problems regarding financing and how to finance the project due to the constantly changing economic conditions were evident. A large number of changes in orders led to an imbalance in the schedule. Accordingly, many critical paths appeared in the project.	3-Determining the senior management process in terms of obtaining funding.
		5-Understanding and documenting decision-making criteria and analytical requirements.
		11-Establishment of a well-defined and well-understood change management process, including approval time schedule and cost, impacts approval authorities.
		7-Making the timetable flexible to avoid too many critical paths.

6.2. Development of Complexity Management Guidelines

To cope with the complexity of projects and improve project performance, the following dimensions must be considered in construction projects: leadership qualities, good management skills, effective communication skills, assurance, effectiveness, cognitive ability, competence, security, and integrity. To reach these dimensions, the following elements must be overcome: weak project managers, economic instability in the country, political interference in projects, various types of soil issues for projects, an increase in the number of tasks involved in the project, lack of internal organizational support for project activities, unclear project objectives, the scope of the project, and lack of expertise in the technology used to implement the project. From previous studies, it has been concluded that leadership competencies, managerial skills, communication skills, and effectiveness are higher-level solutions to the complexities of construction projects. It should be noted that complexity has multidimensional effects, so in order to counter this, it is necessary for a manager to have multiple properties to treat any of the factors that cause complexity to construction projects. The second part of this study aims to set guidelines on managing the previously identified complexity factors. According to Azim [35], guidelines previously found through literature are as follows:

(1) Recruitment of local consultants for engagement.

(2) Recruitment of professionals with more expertise in the technical field of the project.

(3) Determination of the senior management process in terms of obtaining funding.

(4) Incorporation of legal constraints into the project implementation plan.

(5) Understanding and documenting decision-making criteria and analytical requirements.

(6) Establishment of a well-defined and well-understood change management process, including approval time schedule and cost, impacts approval authorities.

(7) Making the timetable flexible to avoid too many critical paths.

(8) Review the best practices and lessons learned and develop a logistics plan at the conceptual stage of border sites.

(9) Recognition of productivity, existing schedules, estimates, *etc*., must be adapted to take account of new technology.

(10) Evaluation of subcontractors based on project size, experience, financial stability, and reputation.

(11) Establishment of an ad hoc project team to participate in all phases.

(12) Convergence of the objectives of the parties concerned is a critical strategic factor.

(13) Identification of scope, objectives, and initial requirements of the project before starting it.

(14) The unpredictability and certainty of the surrounding environment, the Earth's surface, and the Earth's layers, no matter how many tracts are implemented, should be considered as influencing the achievement of the scope, time, and cost of the project.

7. RESULTS

The results of this paper are as follows:

(1) Using the AHP method, the weights of the criteria and sub-criteria were calculated.

(2) Using the AHP method, the Construction Complexity Index (CCI) was developed.

(3) The degree of project complexity was measured by CCI.

(4) The index was tested by studying cases and verifying their validity.

(5) The guidelines have been set for managing the potential complexity.

CONCLUSION

Project complexity management relates to the challenge in dealing with technical incompetence, professional diversity, diversity of interests, uncertainties, imbalances, and unforeseen events in project implementation. Project managers, who are critical to the effectiveness or failure of any project, need skills, such as adaptation, creativity, and flexibility to meet this challenge. Therefore, the aim of this research was to identify and weight the factors of project complexity associated with construction projects. This paper applied the analytical hierarchy process to identify and verify potential factors and weight their impact through the AHP method. Moreover, the 12 largest project complexity factors were also identified and presented. In this research, an index was developed to measure complexity based on factor weights called the construction complexity index (CCI). The validity of this index was verified by studying the 3 cases. The construction complexity index proposed here allows for measuring the complexity of the projects. Guidelines have been developed for participants to avoid project complexity at a pre-implementation stage, as shown in Table **7**.

The outcomes of this study can be used by practitioners to develop a complexity assessment and management tool, which would enable industry practitioners to allocate resources effectively for complex construction projects. Although this study was based on the complexity of Egyptian construction projects, the findings of this study would be useful to guide practitioners around the world. Moreover, these findings will assist practitioners in making appropriate modifications according to the physical and/or other characteristics of their construction projects. Although the authors of this study made a great effort to provide valid and reliable results, our study has some limitations. First, this study relied entirely on the AHP method. Secondly, this study focused on the construction industry associated with Egyptian projects. Furthermore, this study adopted the AHP method to identify, weight, and rank the complexity factors, which would serve as the basis for future researches. This research develops an index by which the complexity of construction projects in Egypt can be measured, and guidelines on avoiding complexity in projects can be established, thus adding scientific value to the existing literature in this field.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data supporting findings of this study are available from the corresponding author [A.E], upon reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

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