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Murat Gunduz and Mohammed Almuajebh



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Critical Success Factors for Sustainable Construction Project Management

Murat Gunduz ^{1,*} and Mohammed Almuajebh ²

¹ Department of Civil Engineering, Qatar University, P.O. Box 2713 Doha, Qatar

² Engineering Management Program, College of Engineering, Qatar University, P.O. Box 2713 Doha, Qatar; ma1200822@student.qu.edu.qa

* Correspondence: mgunduz@qu.edu.qa

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Abstract: It is necessary to identify critical success factors (CSFs) that affect the construction process. This paper's aim is to define the CSFs considering views of all construction project stakeholders. The contribution of this paper is to categorize project success factors into categories and quantify the effect of each category taking into account the effect of all stakeholders on project efficiency and progress. To achieve this objective, a comprehensive literature review was carried out. After literature review, 40 success factors were compiled into seven categories: project-related factors, company- and work-related factors, client-related factors, project management factors, design-team-related factors, contractor-related factors, project-manager-related factors. Consequently, a survey including these listed success factors was prepared and distributed to various experts in the construction field to be ranked; 148 responses were received. Employing the Relative Importance Index (RII) and traditional Analytic Hierarchy Process (AHP) method with Saaty random index that prioritizes these CSFs, the collected data were analyzed after receiving responses. Even though there were disagreements in stakeholders' views and their goals, significant areas have been identified as project financial issues, managerial aspects, and authorities' approval mechanism. The outcome of this paper would be used by construction industry professionals to support, evaluate, and measure the success of projects for better allocation of resources.

Keywords: project success factors; project management; sustainable construction; analytical hierarchy process; planning; productivity

1. Introduction

Performance is a critical concern and the success of the construction projects will face several challenges during project delivery. A lot of researchers in the project management area have studied critical success factors (CSFs) in projects [1–5]. However, the concept of project success and performance metrics is still ambiguous, and this is due to variations in expectations of project success among stakeholders of various projects in a project. Therefore, there is a gap in studying all relevant factors that affect performance of projects considering the perception of success by project stakeholders.

The main objective of this paper is to identify the CSFs that contribute to the project success. The major contribution of this paper is to categorize project success factors into categories and quantify the effect of each category on project performance and success considering all project stakeholders. This study is different from the others in the literature because it considers the effect of project stakeholders on project success. Factors from past research were gathered and compiled under seven categories, namely, project-related factors, business- and work-environment-related factors, client-related factors, project management factors, design-team-related factors, contractor-related factors, and project-manager-related factors. A survey including these listed success factors was

prepared and distributed to various experts in the construction field to be ranked. These factors and their relevant categories were used to gather perceptions of the owners, contractors, and design, supervision, and project management consultants about project success. The effect of each category on project success was quantified with the help of Analytic Hierarchy Process (AHP). A list of prioritized factors is provided with the help of AHP and Relative Importance Index (RII). This prioritization would result in a suitable allocation of limited project resources such as money, manpower, and equipment. This prioritization would lead to sustainable construction management practices. The discussion of results provided industry with recommendations on the basis of priority values.

2. Literature Review

Many studies attempted to capture success factors for the construction industry. According to research, due to different interpretations of success or failure by different participants in construction projects, classification of a project into a good project or a failure project is difficult. Literature review was carried out to capture these various perceptions by different researchers. Wide-ranging studies were performed by researchers to capture CSFs. [1] evaluated and ranked the attributes of success patterns in the construction industry through factor analysis and fuzzy approaches. [4] prepared a survey considering cost, time, safety, and quality to assess CSFs. [3] used AHP to rank CSFs for Lithuanian construction projects. [2] ranked 20 CSFs in the Chinese construction industry using various statistical techniques. Structural equation modeling (SEM) was used by [5] to check the relationship between six success factors and five performance factors to assess organizational effectiveness.

An extensive checklist for CSFs was prepared through an extensive literature review. Table 1 presents the seven categories and 40 CSFs with the relevant references. The seven categories are developed based on their characteristics and discussion with professionals in the construction management field.

Table 1. Seven categories and 40 critical success factors (CSFs) with respect to their relevant references.

I. Project-Related Factors	Reference No.
1-Project's Location	[6–8]
2-Project's Size	[8,9]
3-Clear and realistic goals/objectives	[10,11]
4-Project's adequate funds/resources	[12–14]
5-Effective procurement and tendering methods	[15–19]
II. Business- and Work-Environment-Related Factors	
6-Economical environment	[20,21]
7-Social environment	[22–24]
8-Political environment	[9,16,25]
9-Statutory approvals environment	[26,27]
III. Client-Related Factors	
10-Influence of client/client's representative	[25,28]
11-Client's experience in construction field	[16,25]
12-Mechanism of financial payments	[26,29,30]
IV. Project Management Factors	
13-Effective communication systems	[16,31,32]
14-Feedback mechanism from employees and other parties	[33,34]
15- Planning, monitoring, and controlling mechanism	[16,25]
16-Decision-making effectiveness	[35,36]

Table 1. Cont.

I. Project-Related Factors	Reference No.
17-Appropriate organizational structure	[24,34,37]
18-Implementing an effective safety program	[35,38–40]
19-Implementing an effective quality assurance program	[41,42]
20-Risk identification and allocation	[16,43]
21-Formal dispute resolution process	[44,45]
22-Project team motivation	[16,25,46]
23-Top management support	[16,47]
V. Design-Team-Related Factors	
24-Design team experience	[48,49]
25-Design complexity	[49,50]
26-Design errors/mistakes	[49–51]
27-Design team's contribution to construction (constructability review, value engineering, etc.)	[16,52,53]
28-Adequacy of plans and specifications	[16,28,46]
VI. Contractor-Related Factors	
29-Contractor financial strength	[16,54]
30-Contractor's technical capacity	[16,54]
31-Effective subcontractor coordination	[55,56]
32-Effective allocation and control of manpower	[13,24]
33-Availability of experienced managers & skillful workforce	[31,57]
VII. Project-Manager-Related Factors	
34-Project manager's experience	[57–59]
35-Project manager skills	[34,57,59]
36-Coordination between all participants	[34,37,48]
37-Commitment to meet quality, cost, and time objectives	[16,28,32,46]
38-Project manager's early and continued involvement in project	[10,18,34]
39-Project manager's adaptability to changes in project plan	[57,59]
40-Project manager's ability to delegate authority	[57,59]

A questionnaire was developed based on the CSFs gathered and the CSFs are evaluated by professionals in the construction industry. By this way, significant success factors were captured through RII and AHP. The contrary or competing points of view will be captured by the ranking of CSFs through the questionnaire. This questionnaire was used to get the RII rankings, which later established the basis for the AHP analysis.

This work leads to the collection and study of the project success factors with the integrated AHP. This study tried to overcome the assessment of project critical success factors by AHP. This research is distinct from the others in the literature because it takes into consideration the impact of project stakeholders on project performance.

3. Methodology

This research mixes qualitative and quantitative research methods. This method is based on KBT (Knowledge-Based Theory) and it has three steps: (1) identification of factors that affect project success, (2) survey, and (3) RII and AHP analyses. KBT is embedded and carried through multiple entities

including organizational identities, systems, and employees with the tool of the literature review and a questionnaire. A questionnaire was designed for the business professionals' opinions of the CSFs. The first section of the questionnaire includes questions on respondents' background. Categorizing respondents on the basis of their type of organization would also give an idea of the understanding of CSFs by each category. The 40 factors listed in this section have been grouped into seven groups based on literature review, with different success factors in each category. The weighting scale was designed and consisted of 1 to 9 ratings, where 1 was the project's no significant impact on project success and 9 was the project's highest impact on project success.

In order to measure the significance of different factors, the relative importance index formula was used. Then, the ranking values obtained from RII were used for the AHP analysis. This is a new way of use of AHP by transferring values from RII to AHP. Due to its great flexibility and broad applicability, AHP has been extensively implemented for the last 20 years [60]. The study by [61] reviewed 77 AHP-based papers published in eight peer-reviewed journals in order to better identify and delineate AHP implementation areas and problem-solving decision-making within the field of construction management. The study revealed that AHP is versatile and can be used either as a stand-alone tool or in combination with other tools to solve problems in building decision-making. Several authors have used AHP for the coordination and review of complex decisions [62–64]. This study tried to overcome the decision-making of assessment of project critical success factors by AHP. The methodology can be seen in Figure 1 below.

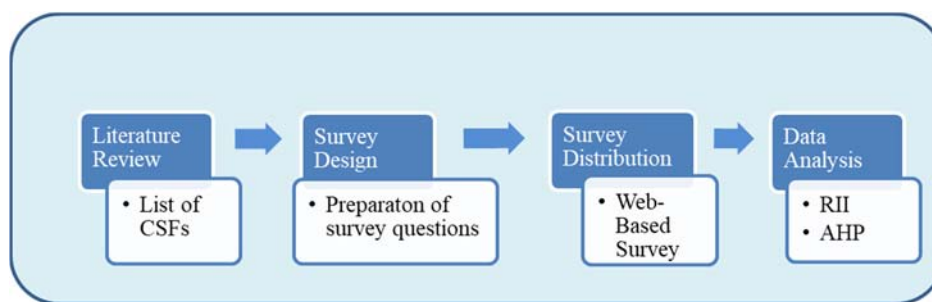


Figure 1. Research methodology. RII: Relative Importance Index; AHP: Analytical Hierarchy Process.

A total of 148 complete surveys were collected. Relative importance index and Analytical Hierarchy Process were used as statistical tools to rank CSFs. Recommendations were given to industry professionals to achieve better project success based on the rankings received.

4. Data Characteristics

The questionnaire was designed using an online tool to help organize, distribute, collect responses, and categorize the collected data. The data were collected from construction professionals worldwide with the help of the website SurveyMonkey. The emails of the respondents were gathered from the network of the research team and the literature review. The questionnaire was sent to 250 participants. 201 responses were received. Only 148 respondents fully completed the survey, and these fully completed responses were considered for analysis. Owners make up 52% of the responses with 77 respondents. Contractors, supervision consultants, and Project Management Consultants (PMC) make up 19%, 18%, and 9% of the responses, respectively and 85% of the respondents work with an organization that has more than 300 employees, whereas only 9% of the respondents work with an organization that has less than 100 employees. Most of the responses come from project management team members, 61% (91 responses). Moreover, 19% and 11% of the respondents are from design/engineering and project control departments, respectively. The rest of the data were from finance and contracts departments. Participants who are project managers make up 41%. Site engineers and operational/general managers make up 11% and 8% of the data, respectively.

5. Data Analysis

The main goal for all stakeholders in any construction project is to effectively complete the project. This paper mainly aims at defining, examining, and evaluating the CSFs that can affect the performance of any project. The list of 40 factors was established in the same area by analyzing the literature of relevant articles, cases, and studies. The evaluation was carried out through a survey filled out by experts from the construction industry. The questionnaire asked participants to define the effect of each factor on performance of a project on the basis of a 9-point scale. The effect of each factor on project performance was asked to be determined by the experts from the construction industry. After collection of data from construction industry professionals, RII and AHP were carried out, respectively. The outputs of these analyses are presented in the coming sections.

5.1. Relative Importance Index (RII)

Researchers used the RII to rate factors [16,65,66]. The RII is shown as:

$$RII (\%) = \frac{\sum W}{(A * N)} * 100 \quad (0 \leq RII \leq 100) \quad (1)$$

Where:

W: the weight given to each attribute by the respondents differs between 1 and 9

A: the maximum weight (nine for this study)

N: the total number of participants

As example, the RII value for the 1st factor, which is project location, was calculated as follows:

$$\sum W = 421, \quad A = 9, \quad N = 77 \quad (2)$$

$$RII (\%) = \frac{\sum W}{(A * N)} = \frac{421}{9 * 77} * 100 = 60.75 \quad (3)$$

Table 2. below shows RII values calculated based on the responses from the industry professionals.

Table 2. RII (%) factors for CSFs.

Factor Number	RII Value (%)
1	60.75
2	64.09
3	82.85
4	84.77
5	80.41
6	71.25
7	60.88
8	64.46
9	76.34
10	78.60
11	75.62
12	76.97
13	79.51
14	73.74
15	83.19
16	85.67

Table 2. Cont.

Factor Number	RII Value (%)
17	75.48
18	78.02
19	78.71
20	78.04
21	74.36
22	80.15
23	84.58
24	80.89
25	73.69
26	79.00
27	77.49
28	79.76
29	78.36
30	81.79
31	79.90
32	80.90
33	84.12
34	83.08
35	82.67
36	83.44
37	83.01
38	79.34
39	79.02
40	80.91

From Table 2, it can be observed that the top most significant CSFs according to RII are: (1) Decision-making effectiveness (project-management-related); (2) Project's adequate funds/resources (project-related); (3) Top management support (project-management-related); (4) Availability of experienced managers and skillful workforce (contractor-related); (5) Coordination between all participants (project-manager-related).

5.2. AHP Analysis

AHP's first step was to establish a hierarchical structure for the analysis. The hierarchical structure can be seen in Figure 2. The first level are the CSFs in the study. The second level includes seven categories as listed earlier.

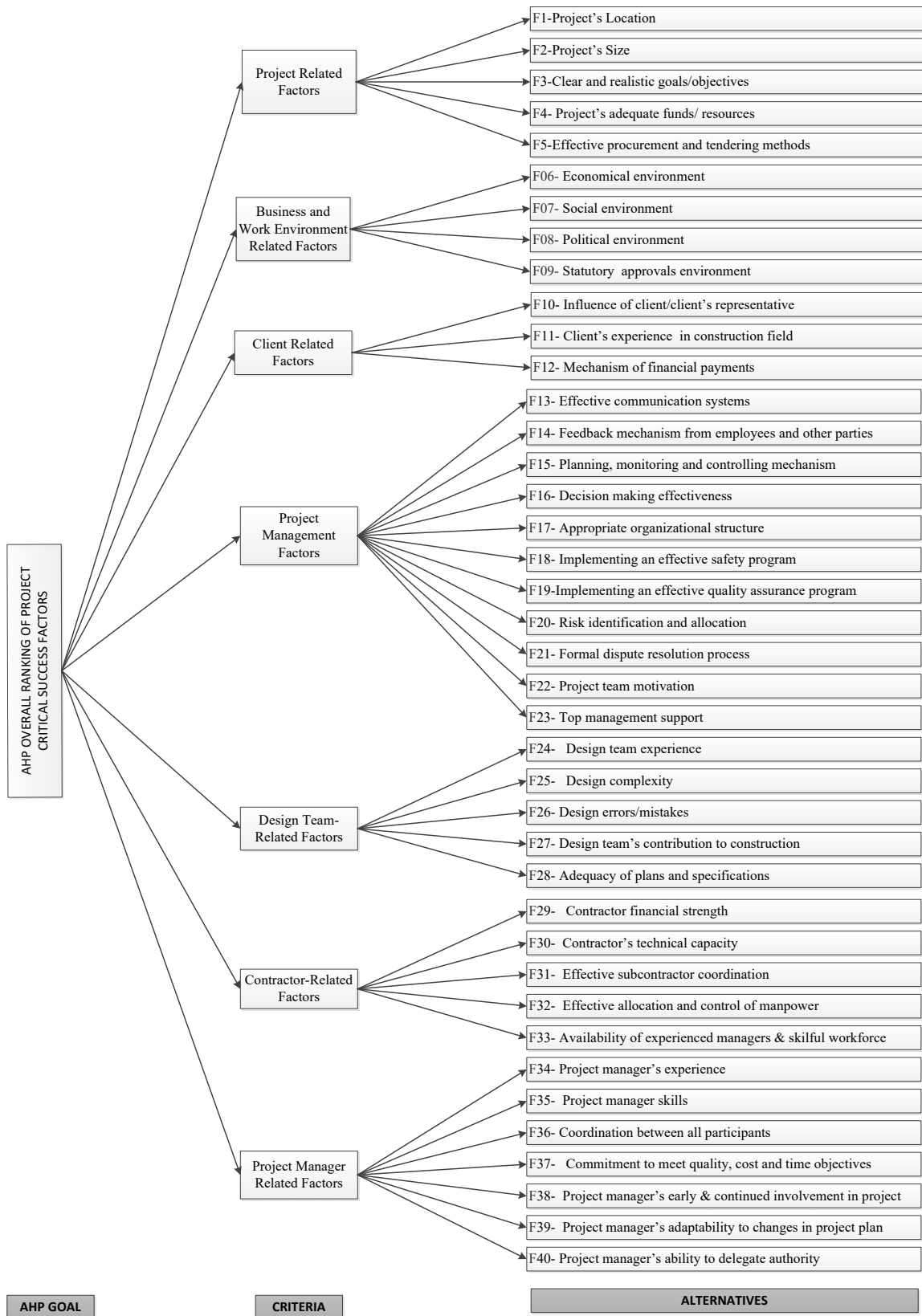


Figure 2. AHP hierarchy figure of criteria and alternatives for project success factors.

The next step in AHP was to produce matrices of comparison on a pair basis that are a very important part of the AHP research. The data collected include levels provided to each factor by each

participant based on the literature's suggested 9-point scale. Then, for use in a pair-wise comparison procedure, the average values were determined.

To determine the commitment of each organization to the success of the project, a pair-wise matrix was developed. The data collected include levels provided to each factor by each participant based on the literature's suggested 9-point scale (Table 3). Then, for use in a pair-wise comparison, the average values were determined.

Table 3. Pair-wise comparison matrix for organizations.

Interested Party	Owner	Design Consultant	Supervision Consultant	PMC	Contractor
Owner	1	2	4	9	9
Design Consultant	1/2	1	3	9	8
Supervision Consultant	1/4	1/3	1	6	5
PMC	1/9	1/9	1/6	1	1/2
Contractor	1/9	1/8	1/5	2	1

PMC: Project Management Consultant.

The next step was to divide each value in every column by the total sum of each column to find the normalized weight. Consequently, average value of each row was calculated and this value becomes the priority weight. Normalized weights and priority weights are shown in Table 4.

Table 4. Normalized and priority weights for organizations.

Interested Party	Owner	Design Consultant	Supervision Consultant	PMC	Contractor	Priority Weight
Owner	0.51	0.56	0.48	0.33	0.38	0.45
Design Consultant	0.25	0.28	0.36	0.33	0.34	0.31
Supervision Consultant	0.13	0.09	0.12	0.22	0.21	0.15
PMC	0.06	0.03	0.02	0.04	0.02	0.035
Contractor	0.06	0.04	0.02	0.07	0.04	0.052
Sum	1.00	1.00	1.00	1.00	1.00	1.00

The consistency ratio for the pairwise comparison was also compared and calculated to be 0.03. This value is less than 0.1 and is acceptable.

The subsequent move is to replicate the same between seven groups and each success factor listed under each of the seven groups. This requires developing many matrices. As a sample, Tables 5 and 6 list normalized weights and priority weights matrices for owner and project-related factors for the owner for illustrative purposes.

Table 5. Normalized and priority weights for seven groups (Owner).

Owner	PRF	BRF	CLRF	PMRF	DTRF	CORF	PMRF	PW
PRF	0.05	0.08	0.04	0.03	0.04	0.06	0.04	0.050
BRF	0.02	0.03	0.02	0.02	0.02	0.04	0.03	0.023
CLRF	0.10	0.13	0.08	0.05	0.07	0.09	0.07	0.084
PMRF	0.15	0.15	0.16	0.10	0.07	0.12	0.07	0.118
DTRF	0.15	0.18	0.16	0.20	0.13	0.12	0.11	0.150
CORF	0.30	0.23	0.31	0.30	0.40	0.37	0.45	0.337
PMRF	0.25	0.21	0.24	0.30	0.27	0.19	0.22	0.238

Table 6. Normalized and priority weights for project-related factors (Owner).

Project- Related Factors	Project's Location	Project's Size	Clear and Realistic Goals/ Objectives	Project's Adequate Funds/ Resources	Effective Procurement and Tendering Methods	Priority Weight
Project's Location	0.036	0.022	0.030	0.050	0.027	0.033
Project's Size	0.071	0.044	0.038	0.056	0.031	0.048
Clear and realistic goals/objectives	0.321	0.311	0.266	0.224	0.377	0.300
Project's adequate funds/resources	0.321	0.356	0.533	0.447	0.377	0.407
Effective procurement and tendering methods	0.250	0.267	0.133	0.224	0.188	0.212

Where: PRF, BRF, CLRF, PMRF, DTRF, CORF, PMRF and PW are project-related factors, business- and work-environment-related factors, client-related factors, project-management-related factors, design-team-related factors, contractor-related factors and project-manager-related factors and priority weight, respectively.

The cumulative weight of each performance metric was calculated by multiplying the corresponding weight of each criteria (this weight is calculated for each organization separately. As a sample, the calculation for owner is shown in Table 6) within its organization and the weight of each organization type. This will lead to the finalized AHP weights for each CSF as listed in Table 7.

Table 7. Overall AHP ranking for CSFs.

Critical Success Factor	Overall Score	Rank
Statutory approvals environment	0.592	1
Influence of client/client's representative	0.493	2
Availability of experienced managers and skillful workforce	0.422	3
Mechanism of financial payments	0.396	4
Project's adequate funds/resources	0.369	5
Design team experience	0.338	6
Clear and realistic goals/objectives	0.299	7
Adequacy of plans and specifications	0.275	8
Project manager's experience	0.272	9
Economical environment	0.252	10
Effective procurement and tendering methods	0.242	11
Decision-making effectiveness	0.241	12
Design errors/mistakes	0.219	13
Coordination between all participants	0.201	14
Contractor's technical capacity	0.198	15
Project manager skills	0.189	16
Contractor financial strength	0.170	17
Top management support	0.166	18
Commitment to meet quality, cost, and time objectives	0.153	19
Planning, monitoring, and controlling mechanism	0.128	20
Design team's contribution to construction (constructability review, value engineering, etc.)	0.113	21

Table 7. Cont.

Critical Success Factor	Overall Score	Rank
Client's experience in the construction field	0.112	22
Effective subcontractor coordination	0.110	23
Political environment	0.107	24
Effective allocation and control of manpower	0.100	25
Project manager's ability to delegate authority	0.096	26
Implementing an effective safety program	0.091	27
Implementing an effective quality assurance program	0.078	28
Project manager's adaptability to changes in project plan	0.073	29
Project team motivation	0.070	30
Effective communication systems	0.068	31
Project's Size	0.057	32
Design complexity	0.054	33
Risk identification and allocation	0.052	34
Social environment	0.049	35
Project manager's early and continued involvement in project	0.043	36
Feedback mechanism from employees and other parties	0.038	37
Appropriate organizational structure	0.035	38
Project's Location	0.033	39
Formal dispute resolution process	0.028	40

6. Discussion of Results and Recommendations to Industry Based on Results

Based on the participants' responses, variables were rated using AHP. The overall score for each factor is presented in Table 7. Further detail for each criteria for the AHP review will be discussed in the section below for the list of top five variables. Figures 3–7 below show the most significant CSFs for client, PMC, supervision consultant, design consultant and contractor, respectively.



Figure 3. CSFs (AHP) for owner.

It is found that the most significant CSF is based on the influence of the owner with a score of 0.76. This is anticipated as the client being the largest player in the project. The statutory approval environment (0.66) is the second most important element. The availability of experienced managers and skilled workforce became the third most significant factor. The project's adequate funds/resources and design errors/mistakes are considered as the next significant, with scores of, respectively, 0.41 and 0.39.

At the planning stage, the owner should use a very professional designer. This will ensure accurate project cost estimates and minimal design errors and/or changes. Moreover, a complex framework to promote the issuance of appropriate approvals is recommended for the relevant governmental authorities. This can be achieved by good interagency cooperation.

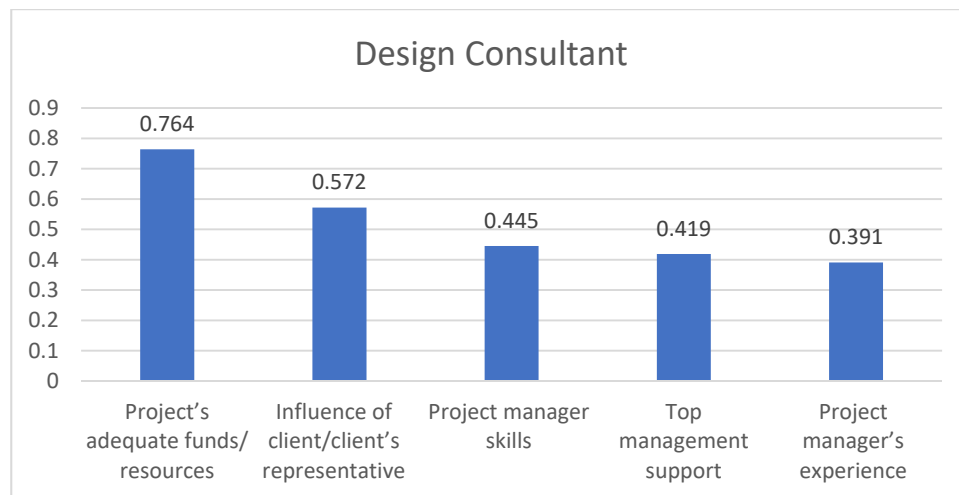


Figure 4. CSFs (AHP) for design consultant.

As design consultants, the findings of the ranking indicate that the main concerns of the designers were about the sufficient funding/resources of the project besides the legislative approvals. Such two variables, respectively, had ratings of 0.76 and 0.57. The third, fourth, and fifth critical factors include the competence of project managers (0.445), top management support (0.419), and project manager experience (0.391). The designers found that one of the significant CSFs was the top management support. In order to increase efficiency and motivation, top management must provide additional resources to their employees. In addition, training support will improve the design team's performance.

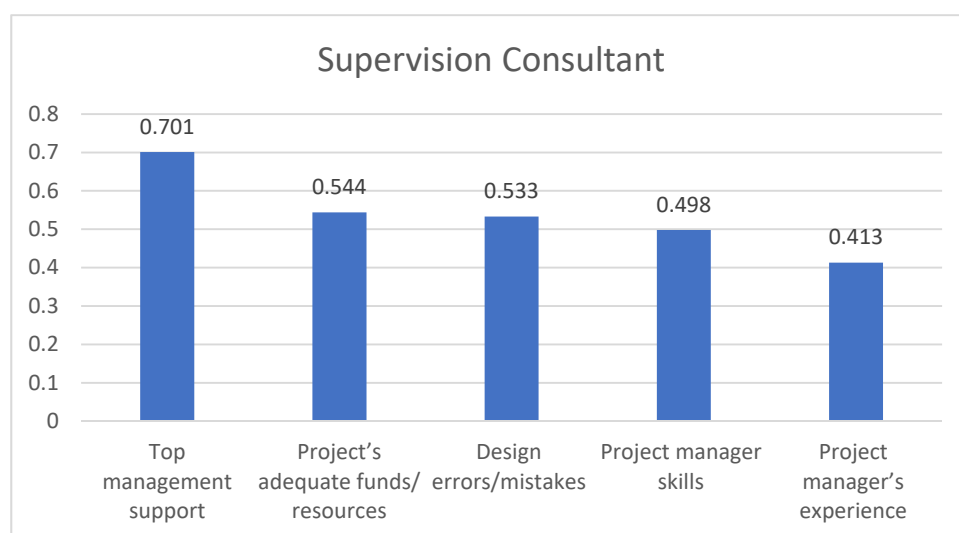


Figure 5. CSFs (AHP) for supervision consultant.

The highest scored factor for the supervision consultants is the top management support (0.701). During the construction phase, the supervision consultant needs full support to make the necessary decisions. Consequently, project adequate funds (0.544) is the second important factor. The consultant assumed in the third position that reducing design error/errors would impact project performance (0.533). The remaining two variables are project manager skills (0.5) and project manager's experience (0.413).

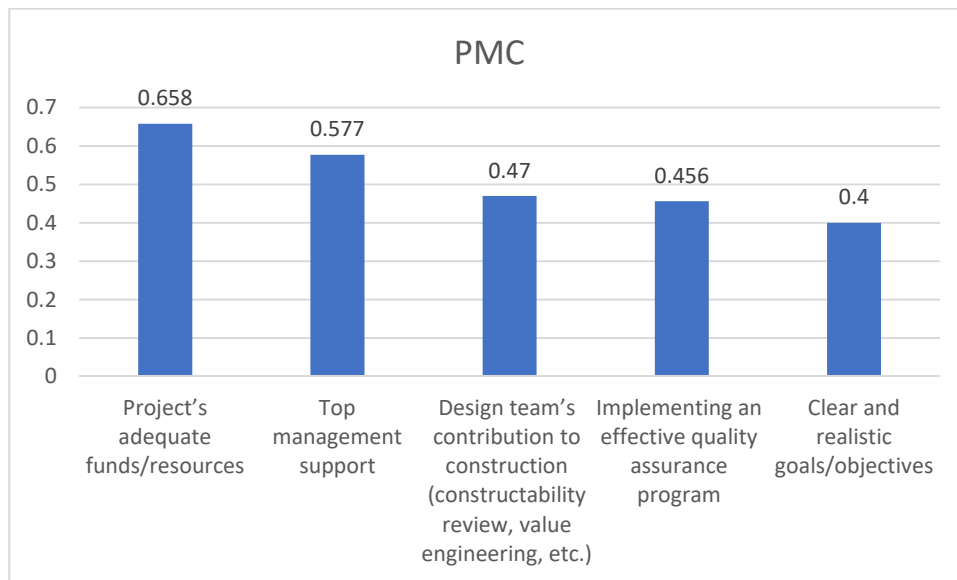


Figure 6. CSFs (AHP) for supervision PMC.

The PMC considered the project's adequate funds, top management support, and the design team's contribution to construction to be the most significant factors with scores of 0.658, 0.557, and 0.47, respectively. Notwithstanding these reasons, the PMC claimed that in project performance the successful quality assurance system is very critical (0.456). The fifth critical factor with a score of 0.4 is the clear and realistic goals/objectives. This aspect ensures that modifications, disagreements, and disputes are reduced during project lifetime.

Most of the PMC's CSFs have to do with project funds, top management funding, and design team involvement. The quality assurance program was also considered by the PMC to be one of the critical factors. Such standards include project documentation for management of material, production, and workforce.

The top two important factors, according to the contractor's responses in Figure 6, are top management support (0.701) and client/client representative influence (0.606).

Respondents stressed that the process for organizing, tracking, and managing is a significant factor (0.594). The last two most important factors are, respectively, clear and realistic goals/objectives (0.401) and the commitment of the design team to construction (0.399). The clear and practical goals/objectives were identified as being a top CSF for contractors. Changes in construction projects is one of the causes of failure for any project. For disputes mitigation, the client must devote sufficient time for planning before construction. Contractors are also advised during the bid to carefully review the specifics of the project documents.

This study categorized project success factors into categories and quantified the effect of each category on project performance and success considering all project stakeholders. This study differs from others by quantifying the effect of project stakeholders on project success.

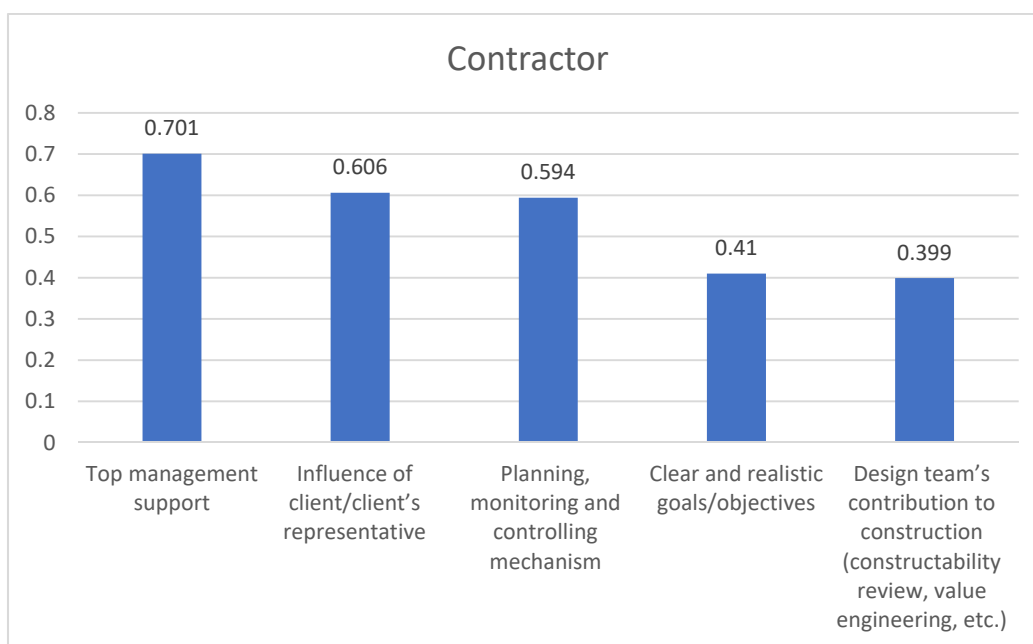


Figure 7. CSFs (AHP) for supervision contractor.

7. Conclusions

This paper aimed at assessing and prioritizing CSFs in the construction industry. A list of 40 CSFs was generated by reviewing literature and related studies to achieve this aim. Under seven major groups, the variables were grouped. Construction industry professionals evaluated the impact level of each factor through a questionnaire. From 148 different construction experts from various types of organizations, responses were received. Employing the Relative Importance Index (RII) and traditional Analytic Hierarchy Process (AHP) method with Saaty random index, the CSFs were prioritized according to seven categories, namely, project-related factors, company- and work-related factors, client-related factors, project-management-related factors, design-team-related factors, contractor-related factors, project-manager-related factors, taking into account the effect of all stakeholders on project efficiency and progress.

The results indicate that the majority of the significant factors were about financial problems (Mechanism of financial payments, project's adequate funds/resources), administrative aspects (Influence of client/client's representative, availability of experienced managers and skillful workforce), and the authorities' approval mechanisms (statutory approvals environment).

8. Recommendations for Future Study

Combining two or more multiple-criteria decision-making or other methods (i.e., fuzzy AHP, etc.) for validation and ranking of alternatives will gain more robust results.

9. Data Availability

Data and models generated or used during the study are available from the corresponding author by request.

Author Contributions: Conceptualization, M.G. and M.A.; Methodology, M.G. and M.A.; Software, M.A.; Validation, M.G. and M.A.; Formal analysis, M.G. and M.A.; Investigation, M.G. and M.A.; Resources, M.A.; Data curation, M.A.; Writing—original draft preparation, M.G. and M.A.; Writing—review and editing, M.G. and M.A.; Visualization, M.A.; Supervision, M.G.; Project administration, M.G. All authors have read and agreed to the published version of the manuscript.

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Abbreviations

CSFs	Critical Success Factors
RII	Relative Importance Index
AHP	Analytic Hierarchy Process
KBT	Knowledge-Based Theory
PMC	Project Management Consultant
PRF	Project-Related Factors
BRF	Business- and Work-Environment-Related Factors
CLRF	Client-Related Factors
PMRF	Project-Management-Related Factors
DTRF	Design-Team-Related Factors
CORF	Contractor-Related Factors
PMRF	Project-Manager-Related Factors
PW	Priority Weight

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