Tikrit Journal of Engineering Sciences (2022) 29 (1): 36-45
http://doi.org/10.25130/tjes.29.1.4

IRAQI Academic Scientific Journals

ISSN: 1813-162X (Print); 2312-7589 (Online)

Tikrit Journal of Engineering Sciences

available online at: http://www.tj-es.com

TJES Tikrit Journal of Engineering Sciences

College of Engineering

Specify the Priorities of Indicators for Measuring the Performance Success of Construction Projects

Nawras Faris Ali *, ***Maysoon Abdullah Mansor***

Civil Eng. Department/ College of Eng./ Tikrit University /Tikrit/Iraq

Keywords:

Indicators for measuring the performance, the performance of construction projects

ARTICLE INFO

Article history:

Received	15 Nov. 2021
Accepted	05 Jan. 2022
Available online	05 Feb. 2022

©2022 COLLEGE OF ENGINEERING, TIKRIT UNIVERSITY. THIS IS AN OPEN ACCESS ARTICLE UNDER THE CC BY LICENSE http://creativecommons.org/licenses/by/4.0/

Citation: Ali NF, Mansor MA. Specify the Priorities of Indicators for Measuring the Performance Success of Construction Projects. Tikrit Journal of Engineering Sciences 2022; 29(1): 36- 45. http://doi.org/10.25130/tjes.29.1.4

A B S T R A C T

The construction industry in Iraq faces many challenges, the most important of which is the lack of a performance measurement system for construction projects, thus showing the need to understand and identify performance areas that affect the performance of projects. Indicators were collected from literature review. The Delphi technique was used in three rounds, the first is an open questionnaire and the second is to assess the importance of the indicators through the weighted average and the application of the Pareto principle to choose the most important indicators from the second round. The third round is a pairwise comparisons questionnaire and analyzed by the process of hierarchical analysis using Expert choice program. The most important indicators that are used to measure the success of the performance of construction projects (learning from the best practices and experiences of others) by obtaining (4.29) followed by (the organization's liquidity) by obtaining the importance (4.24) and the third indicator (the planned construction time) by obtaining (4.24). The indicators prioritize and set in a framework to help project managers and stakeholders remove weaknesses and take the necessary measures in a timely manner to reach a high-performing, successful facility therefore, it is preferable to pay attention to the importance of performance measurement for construction projects.

*Corresponding Author: Nawras.f.ali42491@st.tu.edu.iq, Civil Eng. Department/ College of Eng./ Tikrit University /Tikrit/Iraq

أولويات مؤشرات قياس أداء المشاريع الإنشائية

نورس فارس علي كلية الهندسة /جامعة تكريت
ميسون عبد الله منصور كلية الهندسة /جامعة تكريت

الخلاصة

تواجه صناعة البناء في العراق العديد من التحديات ، من أهمها عدم وجود نظام قياس الأداء لمشاريع البناء ، مما يظهر الحاجة إلى فهم وتحديد مجالات الأداء التي تؤثر على أداء المشاريع. تم جمع المؤشرات من مراجعة الأدبيات. تم استخدام تقنية دلفي في ثلاث جولات ، الأولى عبارة عن استبيان مفتوح والثانية لتقييم أهمية المؤشرات من خلال المتوسط المرجح وتطبيق مبدأ باريتو لاختيار أهم المؤشرات من الجولة الثانية. الجولة الثالثة عبارة عن استبيان مقارنات زوجية ويتم تحليله من خلال عملية التحليل الهرمي باستخدام برنامج اختيار الخبراء. أهم المؤشرات التي تستخدم لقياس مدى نجاح أداء المشاريع الإنشائية (التعلم من أفضل ممارسات وتجارب الآخرين) بحصوله على أهمية (4.29) متبوعًا بـ (السيولة المالية للشركة او المنظمة) بالحصول على الأهمية (4.24) والثالث مؤشر (وقت البناء المخطط له) بالحصول على أهمية (4.24). ترتيب المؤشرات حسب الأولوية ووضعها في إطار عمل يساعد مديري المشاريع وأصحاب المصلحة على إزالة نقاط الضعف واتخاذ التدابير اللازمة في الوقت المناسب للوصول إلى منشأة عالية الأداء وناجحة ولهذا يفضل الانتباه الى أهمية قياس الأداء للمشاريع الانشائية.

الكلمات الدالة: مؤشرات قياس الأداء للمشاريع، قياس أداء المشاريع الانشائية

1.Introduction

The construction industry's high competitiveness and rapid changes push executives to constantly improve the performance of their projects[1]. Construction is regarded as one of the most inefficient industries. primarily due to a lack of materials and poor craftsmanship. Changes in the project during execution, a lack of project information. As a result of a shortage of equipment [2], performance enhancement is the primary goal. By streamlining project delivery, the construction sector can alleviate some of its concerns process[3]. As a result, performance management has been included in the curriculum. Construction company management systems. [4].

According to (Doyeong Kim,2021) performance measurement is the essence of continuous improvement. The application of the performance measurement process leads to identifying weaknesses and strengths in performance[5], and thus determining the best practices that lead to successful and distinguished performance if implemented. [6].

According to (Mahmoud, Abubakar,2020) The KPIs were further categorized into 9 categories that include planning, design and procurement. Construction safety policy, construction safety personnel, communication & maintenance of effective safety behavior, management effort and support, safety training and orientation, administration of safety processes, accident reporting and investigation, rewards and sanctions for project stakeholders [7].

According to (Karston, Thomas,2018) The study showed that key Performance Indicators (KPIs) are measurable values that demonstrate the general health of the industry and provide a basis from which to work collaboratively in order to lift industry performance overall, and thereby bring about economic and social benefits to the industry and broader community[8].

The need to develop a system for measuring performance in the construction industry is very important because of the complex administrative work that involves the implementation of several simultaneous projects and the control of many input resources. Despite this, the majority of construction companies still depend in measuring performance on financial profit [9].

Researchers have recommended (Lee, Tomas,Richard) that measurement is one of the first steps of any improvement process, and when data is delivered in the early stages of the project, processes that can be improved can be identified directly. So that you can shorten the cost and time of the project [10]. The construction industry in Iraq faces many challenges, the most important of which is the lack of a performance measurement system for construction projects, thus showing the need to understand and identify performance areas that affect the performance of projects. The aim of the research is to create an integrated framework for measuring the success of project performance by identifying the most important indicators that can be used to measure the success of performance. After prioritizing indicators by completing Delphi technology rounds and performing a hierarchical analysis process. The category has the highest weight is cost by obtaining percentage is 29.9%, the category that in second place is time with percentage is 19.7% and the third place is quality with obtaining 15.3%. Government agencies should pay attention to these indicators, which greatly help in measuring the success of the performance of construction projects.

2- Search objective

The research aims to create an integrated framework for measuring the success of project performance by identifying the most important indicators that can be used to measure the success of performance. An integrated framework for measuring the success of construction project performance was created after prioritizing indicators by completing Delphi technology rounds and performing a hierarchical analysis process.

3-Methodology

This research methodology includes the following:

1-Theoretical study phase: Gathering indicators from previous research and studies, Review of literature and the Internet, as well as of related theoretical topics on the subject of success indicators for the performance of construction projects.
2-Application study phase: includes this phase the following stages
a- Field survey: including the three Delphi Rounds:
a.1 An open questionnaire : was conducted which is a direct interview with expert engineers to add information about the research topic. The based on the information collected from the literature review and an open questionnaire , 17 categories and 129 sub-indicators were summarized.
a.2 A closed questionnaire : was on a five-point Likert scale. The results of the questionnaire were construction projects. analyzed the relative importance of the indicators was found using the weighted average. Some indicators that were medium and low were deleted importance. Then the Pareto principle was applied to the indicators that got a degree of importance (important, very important).
a.3 Pair comparisons questionnaire: the third round of Delphi pairwise comparisons questionnaire and its analysis hierarchical analysis (AHP) using Expert choice program to find priorities for sub-indicators and categories to create an integrated framework. The weights of these indicators and categories were also found to be used in finding the value of the performance index.
b- Establishing an integrated framework to measure the success of the performance of

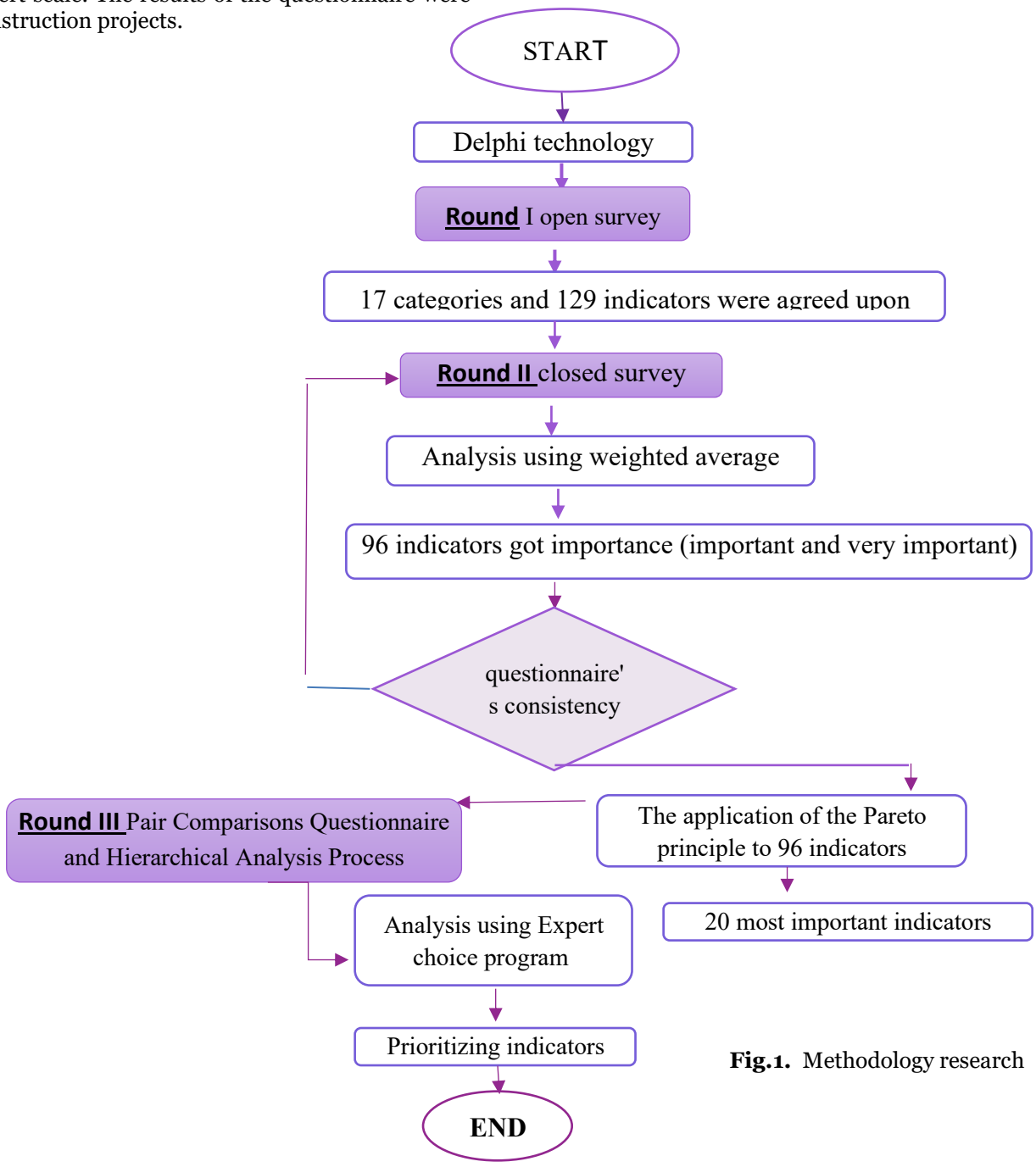


Fig.1. Methodology research

3.1 Delphi technology :

The Delphi method is a qualitative methodology for research using the survey tool to give experts with answers. The approach of Delphi can be employed, according to Scholl et al [11], when little information on a subject is accessible.

Delphi technology be in three rounds:

3.1.1- Round I: An open questionnaire

An open questionnaire was conducted, which is a direct interview with the expert engineers to answer some of the researcher's questions, as well as to add information on the subject of the research, clarify some indicators that were not clear, and delete some indicators that are not understood or have the same meaning for another indicator taken. Some categories have also been merged with indicators for other categories because there are no sub-indicators for them.

The key performance indicators for the current research.The indicators collected from the literature review are 17 categories. These categories include 129 indicators.

3.1.2-Round II: An closed questionnaire

A five-points Likert questionnaire was used and distributed to find the importance of indicators that measure the success of project performance from experts in the construction process.

Excel program (Excel 2016**)** used to find the weighted average Eq (1) [12] of the indicators to find their importance of (Likert Scale point five).

$$\mathbf{WA} = \frac{\boldsymbol{\Sigma(fr * d)}}{\boldsymbol{(n)}} \qquad \ldots (1)$$

3.1.3 Pareto Principle

The Pareto Principle says that 80% of the results come from 20% of the causes (Kevin Kruse,2016) [13] .

The Pareto Principle can be applied in a wide range of areas such as manufacturing, management, and human resources. For instance, the efforts of 20% of a corporation's staff could drive 80% of the firm's profits[14].

The Pareto principle was applied in this study to the indicators that resulted from the second round. 20% of the most important indicators were taken and the result was 19, and again 20% of the total number of indicators was taken and the result was 19.2, the method that gave the highest value was relied upon.

Table (1) presents the indicators that resulted from the application of the Pareto principle, which represents 20% of the indicators that have an importance equivalent to 80% importance on the success of the construction projects performance. It also shows the ranking of indicators in order of importance and shows the categories to which these indicators are affiliated it also shows the level of importance obtained by each indicator.

Table 1

The twenty most important indicators to measure the success of the performance of construction projects

No	Influential indicators	WA	Rank	Categories	level of importance
1	Learning from best practice and experience of others	4.29	1	innovation and learning	very important
2	Liquidity of organization	4.24	2	Cost	very important
3	Planned time for construction	4.24	3	Time	very important
4	jobsite management planning.	4.24	4	Planning and design	very important
5	Bribe	4.24	5	Government policies	very important
6	Specifications of the materials used	4.18	6	Quality	Important
7	Procurement Cost of Material, Labour and Equipment	4.18	7	Cost	Important
8	Past Experience of Engineer/Supervisor	4.12	8	Time	Important
9	Technical background	4.12	9	Productivity	Important

No	Influential indicators	WA	Rank	Categories	level of importance
10	Leadership skills for project manager	4.12	10	Team Compatibility and Integration	Important
11	pre-construction planning	4.12	11	Planning and design	Important
12	delays and disputes	4.12	12	Contract and risk management	Important
13	ease payment	4.12	13	Contract and risk management	Important
14	Unavailability of competent staff	4.06	14	Quality	Important
15	Construction methods	4.06	15	Quality	Important
16	Training programs		16	innovation and learning	Important
17	team efficiency	4.06	17	Team Compatibility and Integration	Important
18	Sequencing of work according to schedule	4.06	18	Productivity	Important
19	Legal Documentation and amendments	4.06	19	Government policies	Important
20	Poor planning and supervision	4	20	Productivity	Important

3.1.4 Round III: Pairwise Comparisons Questionnaire and Hierarchical Analysis Process (AHP)

The pairwise comparisons questionnaire was conducted on the indicators obtained after applying the Pareto principle to the second round [15]. the pairwise comparisons questionnaire to find the priorities for these indicators.

Expert choice program version 11 used to analyze the pairwise comparisons questionnaire in the hierarchical analysis process (AHP) and to find priorities for indicators and categories, as well as to find weights of indicators to be used in calculating the value of the performance index. It is specifically designed for multi-criteria decision-making[16].

A- Hierarchical structure

Passing the data entry in the expert selection program specially prepared for this purpose, the hierarchy that was adopted in the hierarchical analysis process was built for the categories and sub-indicators so that the values of the frequencies (geometric mean) are entered into the program in the same order[17].

The researcher built the problem pyramid, starting with defining the goal, which is to prioritize the indicators which measures the success of the performance of construction projects in order to achieve an integrated framework for measuring the performance of construction projects through identifying the categories (cost, time, quality, productivity ...) as well as sub-indicators . Then preparing the pairwise comparison tables for the criteria based on the process of hierarchical analysis. Fig. (2) shows the steps of the hierarchical analysis process .

B-Geometric Mean

The geometric mean was used to calculate the frequencies of the two respondents in the pairwise comparisons questionnaire and before entering the data into the expert choice program through the geometric mean formula Eq (2) and its details [18]:

$$G= \sqrt[\Sigma fi]{(X1^{f1})(x2^{f2})(x3^{f3})(xn^{fn})} \quad \dots (2)$$

Where:

fi: respondents number for each weights

n: ∑fi: the all-respondent sum

Xn: weights of each respondents' number

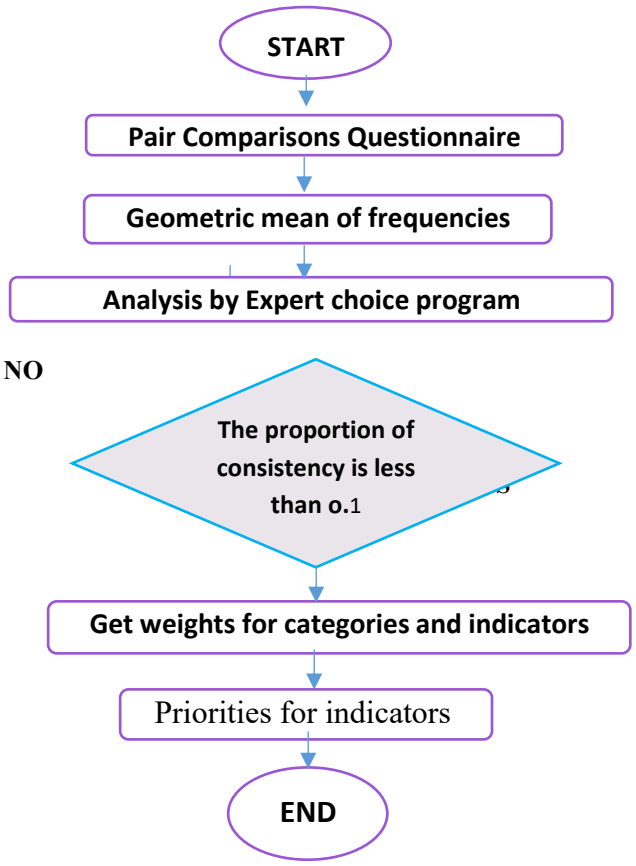


Fig . 2 . The hierarchical analysis process steps

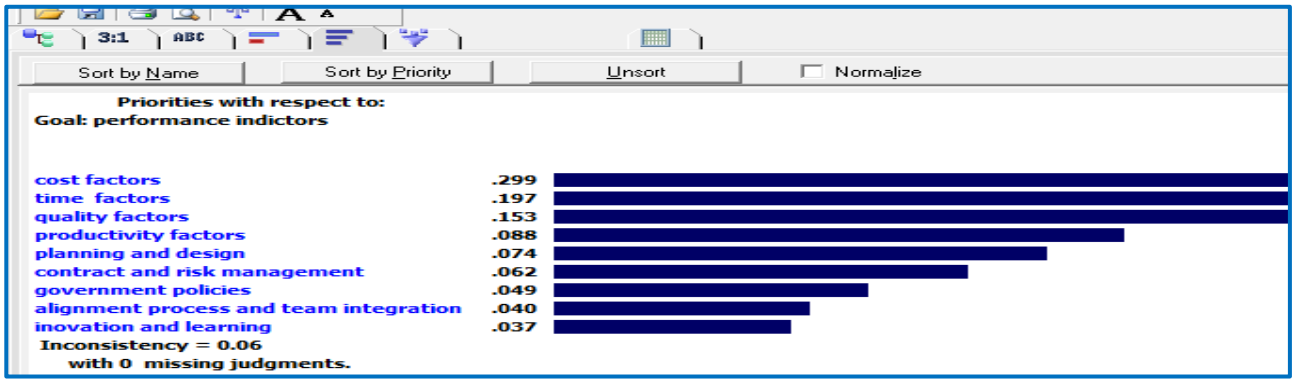
4-The Results and Discussion

The results of the analysis of pairwise 4.1comparisons

The results of the pairwise comparisons questionnaire include two parts: the first part is the results of paired comparisons for the categories and the second part is the results of the paired comparisons for the indicators. Note that the discrepancy did not exceed the permissible percentage of 10% for all comparisons [19].

4.1.1-Pairwise comparisons for categories

The category has the highest weight is cost by obtaining percentage is 29.9%, the category that in second place is time with percentage is 19.7% and the third place is quality with obtaining 15.3%. Inconsistency 0.06 permissible percentage. As shown in Fig. (3).



4.1.2-Pairwise comparisons for indictors

Fig. (4) shows a summary of the relative importance of the indicators in the expert choice program :

Liquidity of organization is 20.5% procurement cost of material and equipment is 6.2%, planned time for construction is 13.5%, past experience of engineer (supervisor) is 5.5% , specifications of the materials used is 10.5%, unavailability of

competent staff is 5.5%, construction methods is 2.2%, technical background is 6% , poor planning and supervision is 3.1%, sequencing of work according to schedule is 1.4% , jobsite management planning is 5.1%, pre-construction planning is 2.6%, delay and disputes is 4.2%, payment is 1.3%, bribe 3.4%legal documentation and amendments is 1.3% ,team efficiency is 2.8%,leadership skill for project manage is 1.5%, learning from best Patrice and experience of other is 2.5% and training programs is 1%. Inconsistency overall is 0.07.

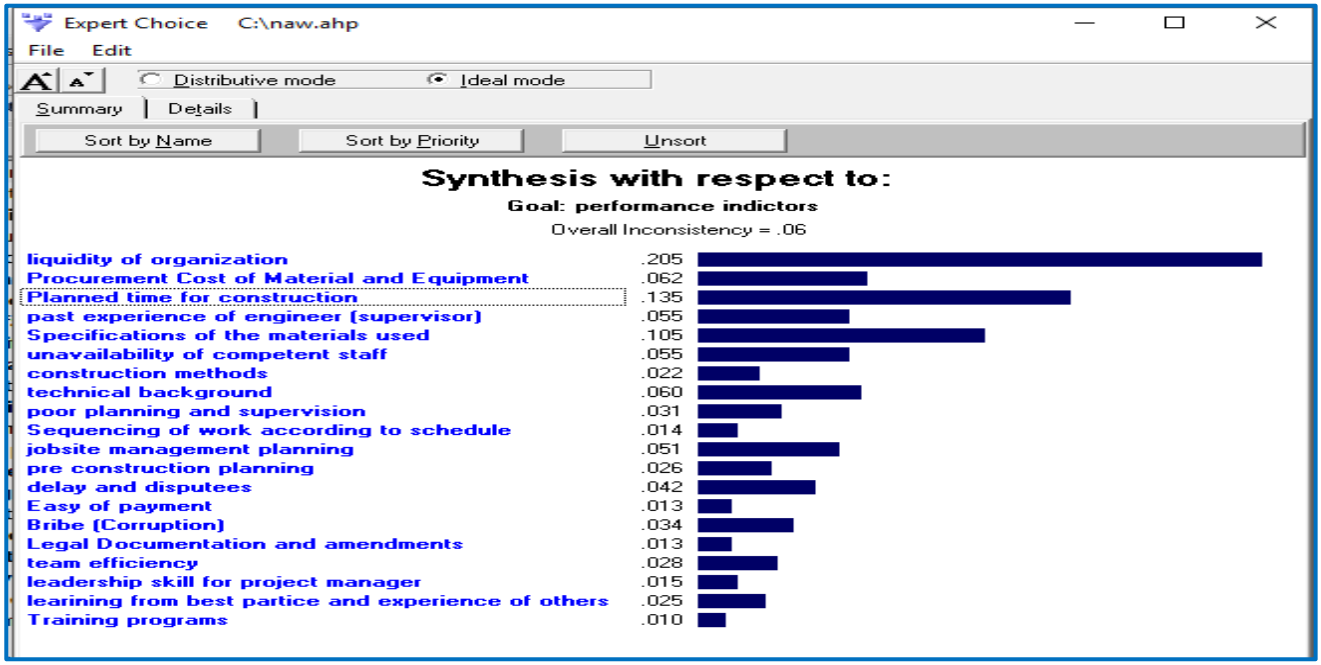


Fig .4. Pairwise comparisons for indicators

4.2 Arranging Indicators and Categories According to the Priorities

Arranging indicators and categories as shown in table (2) according to the priorities obtained from the hierarchical analysis process from expert choice program as shown in Fig. (5).

Table 2.

Ranking categories and indicator**s**

No	Category and indicators
1	**Cost category**
1.1	Liquidity of organization
1.2	Procurement Cost of Material and Equipment
2	**Time category**
2.1	Planned time for construction
2.2	Past experience of engineer(supervisor)
3	**Quality category**
3.1	Specifications of the materials used
3.2	Unavailability of competent staff
3.3	Construction methods
4	**Productivity category**
4.1	Technical background
4.2	Poor planning and supervision
4.3	Sequencing of work according to schedule
5	**Planning and design category**
5.1	Jobsite management planning

5.2	Pre-construction planning
6	**Contract and risk management category**
6.1	Delay and disputes
6.2	Easy Payment
7	**Government policies category**
7.1	Bribe
7.2	Legal Documentation and amendments
8	**Alignment process and team integration category**
8.1	Team efficiency
8.2	Leadership skill for project manager
9	**Innovation and learning category**
9.1	Learning from best Partice and experience of others
9.2	Training programs

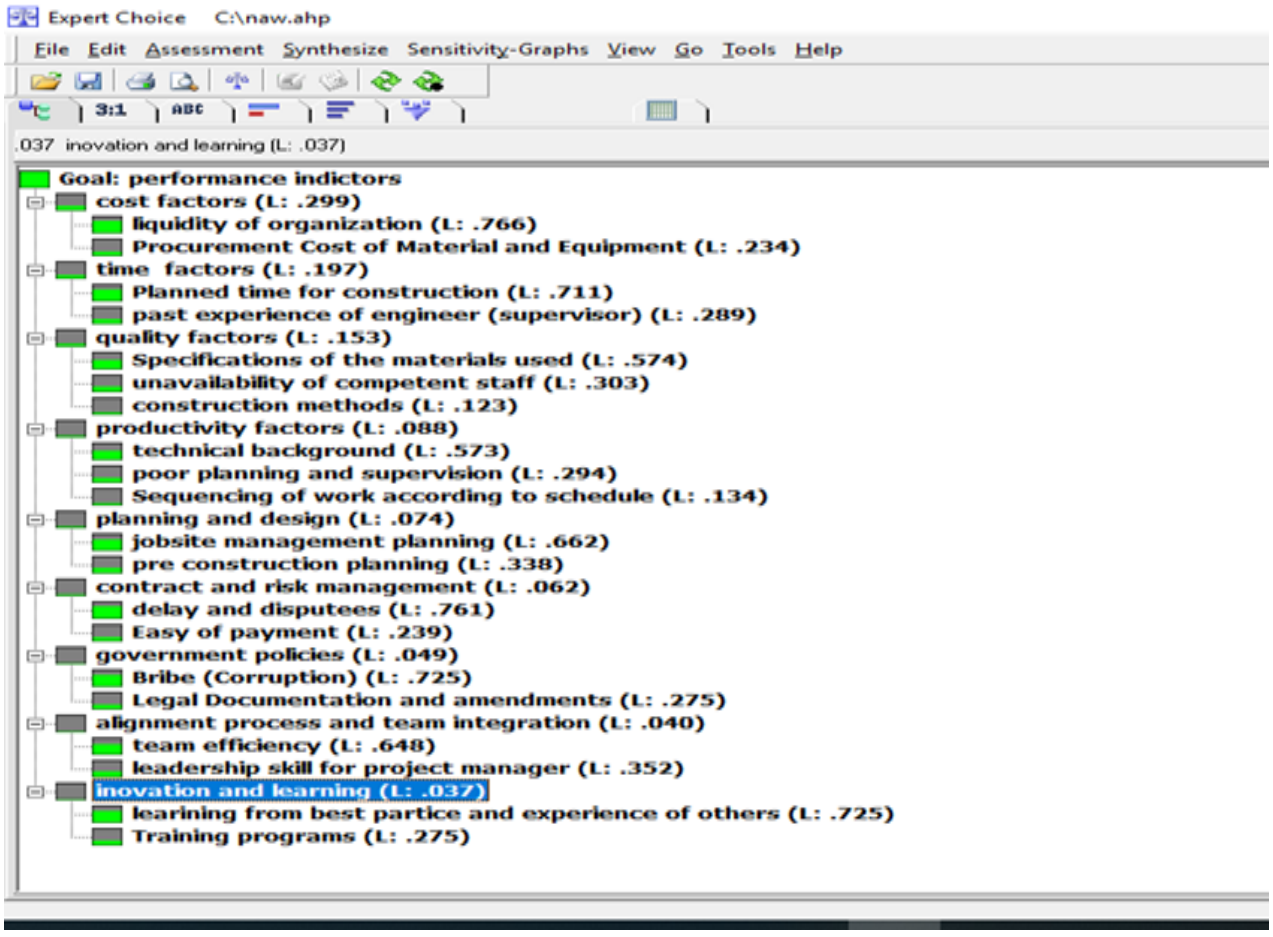


Fig .5. Arranged in order of priority in the hierarchical analysis proces***s***

5- Conclusion

1-The hierarchical analysis process is a multi-criteria decision-making tool that can deal with multiple criteria: In this study, 29 criteria were reached, including 9 major criteria categories and 20 sub-indicators sub-criteria.

2-Finding an priorities for indicators to measuring the performance of construction projects is a solution to many big problems, which are the absence of information related to performance and consequently poor control and control over project

performance, which leads to delays, errors and increased costs.

3-Real-time follow-up of performance enables prediction and prevention of problems or solving problems as they occur, which helps in managing, controlling and controlling the cost, time and quality of the project.

6-Recommendations

1-Government agencies should pay attention to these indicators, which greatly help in measuring the success of the performance of construction projects.

2-Holding training courses to help understand the indicators that measure the success of the performance of construction projects and know their importance and the method of calculating performance by identifying these indicators. In addition to courses to teach the use of programs used in multi-criteria decision-making, such as the expert choice program.

References

[1] Zimmer, B.T. Project management: A methodology for success. “Hospital Materiel Management Quarterly,” pp.83-89, Hamilton Exhibits [Zimmer Biomet 2016]

[2] Mahmoud AS, Ahmad MH, Yatim YM, Dodo YA. Key performance indicators (KPIS) to promote building developers safety performance in the construction industry. J Ind Eng Manag. 2020;13(2):371-401. doi:10.3926/jiem.3099

[3] Monika Meshram. Project Performance Indicators for Measuring Construction Performance in Mumbai. Int J Eng Res. 2020;V9(06):911-914. doi:10.17577/ijertv9is060635

[4] Ingle PV, Mahesh G. Assigning weights for modified project Quarter Back Rating based construction project performance model. Int J Math Eng Manag Sci. 2019;4(4):895-904. doi:10.33889/IJMEMS.2019.4.4-071

[5] Naguib MN. An Integrated Framework to Quantify the Impact of Competency factors on Project Performance By. Published online 2020:1-215.

[6] Mansor MA. Economic and social sustainability for Iraqi middle provinces. Adv Sci Technol Eng Syst. 2018;3(5):447-453. doi:10.25046/aj030551

[7] Dziekoński K, Ibrahim OHMF, Mahamadu AM, Manu P. Framework of performance measurement practices in construction companies in Egypt. Eng Manag Prod Serv. 2018;10(2):7-14. doi:10.2478/emj-2018-0007

[8] Silva GASK, Warnakulasooriya BNF. Criteria for Construction Project Success: A Literature Review. SSRN Electron J. Published online 2017:697-717. doi:10.2139/ssrn.2910305

[9] Sonson S, Kulatunga U, Pathirage C. Performance measurement and management in construction : a conceptual framework. 13th Int Postgrad Res Conf. Published online 2017:516-528. http://usir.salford.ac.uk/43860/

[10] Ismail S, Hussaini M. Contractor ’ s Performance for Construction Project : A Review Cont ractor ’ s Performance for Construction Project : A Review. 2017;(December).

[11] Bekr GA. Factors affecting performance of construction projects in unstable political and economic situations. ARPN J Eng Appl Sci. 2017;12 (19):5384-5395.

[12] Bello WA. Project Performance Diagnostics: A model for Assessing Construction Project Performance in Nigeria. Published online 2017:385. http://usir.salford.ac.uk/id/eprint/44793/

[13] Parmar M, Jaydev Bhavsar P, Jayeshkumar Pitroda D. Identification of Factors Influencing the Cost of Residential Construction Project Work in South Gujarat Region Using S . I . Method. 2016;(3):2395-4396. https://www.researchgate.net/profile/Dr_Jayeshkumar_Pitroda/publication/303608333

[14] Paper C, Shah GS, Vishvakarma B, et al. Assessment of Parameters Influencing the Performance of Construction in ... 2016;(April).

[15] Zidane YJ-T, Andersen B, Johansen A, Ahmad S. “Need for Speed”: Framework for Measuring Construction Project Pace – Case of Road Project. Procedia - Soc Behav Sci. 2016;226(1877):12-19. doi:10.1016/j.sbspro.2016.06.156

[16] Ramlee N, Tammy NJ, Raja Mohd Noor RNH, et al. Critical success factors for construction project. AIP Conf Proc. 2016;1774(October 2016). doi:10.1063/1.4965067

[17] View SR. Developing Sustainable Urban Planning Indicators Framework for Iraqi Cities by Using Content Analysis and Delphi Method. 2015;(May 2017).

[18] Sibiya M, Aigbavboa C, Thwala W. Construction Projects' Key Performance Indicators: A Case of the South African Construction Industry. ICCREM 2015 - Environ Sustain Build - Proc 2015 Int Conf Constr Real Estate Manag. Published online 2015:954-960. doi:10.1061/9780784479377.111

[19] Nyangwara PO, Datche E. Factors Affecting the Performance of Construction Projects : A Survey of Construction Projects in the Coastal Region of Kenya. Int J Sci Res Publ. 2015;5(10):1-43. www.ijsrp.org