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A Fuzzy Synthetic Evaluation Approach for Knowledge Management Assessment in Iraqi Governmental Companies

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ABSTRACT

Management has emerged as one of the pillars of this field. Given that the construction sector is one of the main pillars and levers of the economy, the application of this process plays a significant and broad role. Through this research, we studied aspects of knowledge management in the construction sector in Iraq, examining aspects in terms of knowledge creation, organization, and distribution, as well as the process of knowledge application. This was conducted in four government-owned companies in Iraq and we used a questionnaire as a means of gathering information, which included 44 specialists. We concluded that the strengths of these government-owned companies lie in the area of knowledge application as well as the process of knowledge creation and distribution. The weaknesses that pose a challenge to them are the process of knowledge distribution. We came up with recommendations to enhance these strengths and address weaknesses through the use of a fuzzy synthetic assessment.

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1. INTRODUCTION

As countries around the world move toward developing and relying on knowledge in all aspects of life, knowledge management is one of the most prominent modern concepts that has gained increasing importance. With the growth of the information age, especially in the construction sector, knowledge management has entered this field to solve challenges and complexities. This has created an urgent need for effective knowledge management strategies to overcome these challenges, such as resource management, team coordination, quality assurance, and other aspects that enhance efficiency and performance. Given Iraq's position in this world and the importance of the construction sector, it also faces numerous challenges, such as a shortage of trained personnel, a lack of financial resources, and political and economic fluctuations. Knowledge management may be the ideal solution for improving performance and productivity. Knowledge management is an effective tool that can help avoid these challenges, as it stimulates and improves communication between teams and knowledge exchange among individuals, among other benefits. In this research, we will examine and evaluate the extent to which the knowledge management process and its standards are applied within these government companies with the aim of avoiding and overcoming challenges, if any. Our research will include four Iraqi government companies These companies will be the ones to which we will distribute questionnaires.

2. LITERATURE REVIEW

Knowledge management is fundamental to organizational practice, as it relies on the development, storage, retrieval, and dissemination of information and expertise, ultimately improving business performance. [1] This includes strategic motivation and the interpretation of data and information using existing resources. [2] It is also characterized by the presence of several different strategies that rely on collecting and organizing knowledge from groups of individuals, including knowledge transformation processes and the creation of knowledge bases. [3]
The components of knowledge management include people, processes, technology, information, governance, and strategy. [4] Speaking of the structure of knowledge management, the components of knowledge, knowledge

management processes, information technology, and organizational aspects. [5] The decisive role is played by software systems in supporting various knowledge management activities. Tools can be classified based on their capabilities and functions. [6] Organizational culture, organizational structure, management support, support for supporters, knowledge strategy design, performance evaluation, training, and technologies are the main enabling factors for knowledge management. [4]

One of the aspects that gives importance to the knowledge management process is generating value from intellectual assets and improving innovation [7]. Knowledge management systems in various sectors aim to facilitate the construction of knowledge and its dissemination and use, and information technology is often used to support this process [8]. The effective application of knowledge management requires alignment between organizational strategies and objectives to enhance competitiveness and innovation capabilities [9].

Speaking of the construction sector, the knowledge management process is a systematic approach to collecting, storing, and using information related to the company's operations, products, and stakeholders. It is important to leverage organizational knowledge and improve the decision-making process. [10] Through recent research, we can identify the main factors of knowledge management in the construction sector, which are the use, exploitation, and transfer of knowledge, as well as information technologies. [11] However, the process of applying this management in the construction field faces many challenges, including the need for a change in mentality. [10] Operational risks are more important than technological and human factors, but financial risks remain the most prominent. [12] The building information modeling process has emerged as an effective tool to enhance knowledge management in the construction sector, and this process has a positive impact on improving the knowledge management process and mitigating obstacles. [13]

The most prominent challenges facing the construction sector in Iraqi construction projects are poor planning, resource allocation, and a shortage of skilled labor. Together, these are key issues affecting project performance. [14] Customer satisfaction, project profitability, and quality are additional indicators for measuring performance during implementation. [15] Furthermore, procurement challenges include inconsistent procurement methods across government agencies and a lack of mandatory processes for determining bid evaluation criteria. [16] This necessitates improved planning, workforce development, and procurement practices, as well as increased awareness of innovative technologies to enhance the performance of Iraqi construction projects. Knowledge management practices have a significant positive impact on both innovation and organizational performance in various industries, including construction, as they enhance green technological innovation and sustainable performance in construction companies. [17] Green knowledge management also has a prominent role in increasing the capabilities of organizational green innovation in addition to green performance. [18] Through the construction sector, we notice a positive impact on organizational performance, as innovation is an intermediary. [19] From here, the importance of knowledge management in driving innovation and improving organizational performance and the need for companies to invest in knowledge management emerges.

Knowledge management practices and capabilities have been shown to positively impact project performance in construction companies through studies conducted in Iraq, where knowledge factors such as technology, processes and capabilities significantly impacted project and institutional performance [20].

3. METHOD

The questionnaire method was adopted to collect information by relying on a number of specialists in the questionnaire included the answers of 44 respondents working in the construction sector in Iraq by relying on four government companies: C1, C2, C3, and C4, as it is possible to reflect the reality of the construction sector in Iraq. This questionnaire used 40 questions distributed over four axes: Knowledge Creation, Knowledge Organisation, Knowledge Distribution, Knowledge Application. The questionnaire relied on applying the five-point Likert scale, and the questionnaire sample, which is 44 questionnaires, is a good sample compared to similar studies such as [21][22][23][24], where the number of responses was 42.

Statistical analysis methods adopted

The first part of the questionnaire included the demographic aspects of the respondents in several aspects, including four government companies in Iraq, namely. The demographic aspects that were focused on were (the age group of the respondents, the degree they hold, the scientific specialization, the field of work, in addition to the number of years of experience. These characteristics can reflect the image of the respondent in terms of his ability to evaluate and the extent of his ability to answer questions in a way that reflects reality.

Age of respondents

Table (1) Age of respondents

AGE(Years)	C1	C2	C3	C4	Total	Percentage%
24-30	1	1	4	3	9	20
31-37	6	6	6	6	24	55
More than 38	3	3	2	3	11	25
Total	10	10	12	12	44	100

From the table, we note that the proportion of young people among the respondents was highest in companies C3 and C4, a group characterized by enthusiasm and a desire to work. We also note that the proportion of middle-aged respondents was equal across the four companies, while the proportion of older respondents was lowest in company C3. The ratio of these values can be represented as follows:

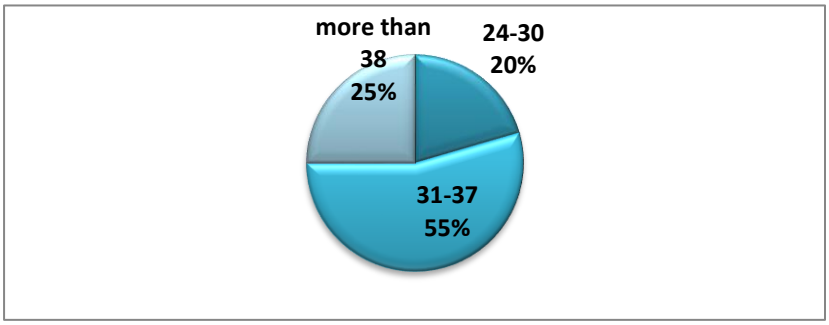

Fig 1. Age of respondents

Academic achievement:

Table (2) Academic achievement

Academic Achievement	C1	C2	C3	C4	Total	Percentage%
Bachelor	10	10	10	11	41	93
Master	0	0	2	1	3	7
Total	10	10	12	12	44	100

From the previous table, we can notice that most of the respondents in all companies hold a university degree, with two people holding a master's degree in company C3. We can represent the percentage of this through the following figure:

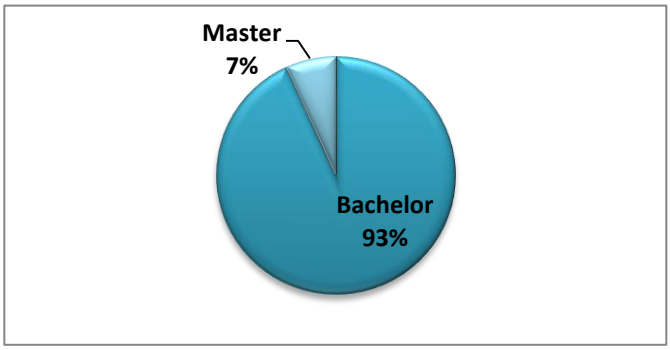

Fig 2. Academic achievement

Academic specialization of the respondents

Table (3) Academic specialization of the respondents

Project name	C1	C2	C3	C4	total	Percentage%
Civil Engineering	4	3	3	4	14	31.8
Electrical Engineering	3	1	5	4	13	29.5
Mechanical Engineering	2	3	2	2	9	20.5
Architect Engineering	1	3	2	0	6	6.8
Others	0	0	0	2	2	11.4
Total	10	10	12	12	44	100

From the previous table, we can notice that all companies had respondents with specializations in civil, mechanical and electronic engineering. However, Company C4 was the only company that did not have respondents with specializations in architecture. It had two with other degrees. We can represent the percentage of these specialists as follows:

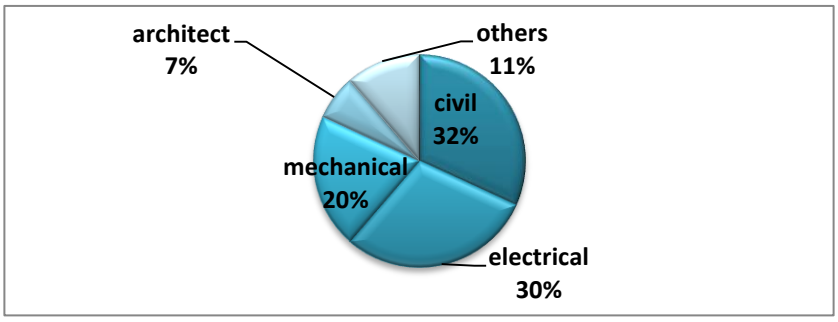

Fig 3. Academic specialization of the respondents

Work field of respondents

Table (4) Work field of respondents

Project name	C1	C2	C3	C4	total	Percentage%
Project Manager	2	0	1	0	3	6.8
Consultant	2	1	1	1	5	11.4
Designer	0	0	1	0	1	2.3
Supervising Engineer	4	2	4	7	17	38.6
Site Engineer	2	5	5	2	14	31.8
Others	0	2	0	2	4	9.1
Total	10	10	12	12	44	100

Regarding the field of work, we note from the table that C3 was the only company with a designer among the respondents, that the largest proportion of site engineers among the respondents was in companies C2 and C3, and that the largest proportion of supervising engineers among the respondents was in company C4. The proportions of these specializations can be represented as follows:

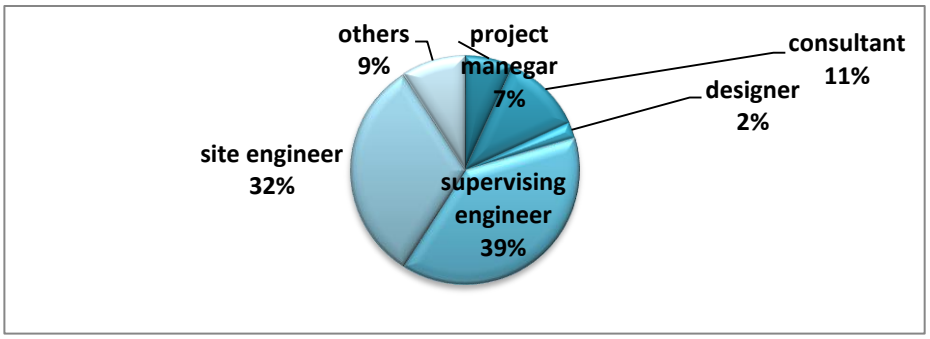

Fig 4. Work field of respondents

years of experience

Table (5) years of experience

AGE(Years)	C1	C2	C3	C4	Total	Percentage%
3-5	0	1	2	0	3	7
6-10	3	1	4	2	10	23
More than 10	7	8	6	10	31	70
Total	10	10	12	12	44	100

In terms of years of experience, we can notice that companies C2 and C3 are the only ones that have respondents with less experience, while in terms of the number of respondents with the most experience, it was in company C4, and we can represent the percentage of this through the following figure:

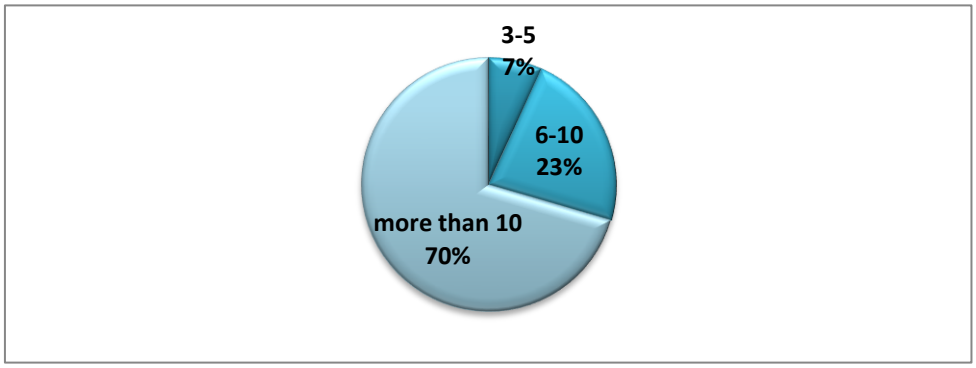

Fig 5 years of experience

From this description, we can see that these respondents were able to answer the questionnaire in a way that reflected reality, given the diversity of their specializations and experience, as well as the variety of projects they worked on.

According to Liu et al. (2013) [25] and Xu et al. (2010)[26], the procedure for conducting FSE modeling is as follows:

i. Determine a basic set of Indicators: $\Pi = \{f_1, f_2, f_3, \ldots, f_m\}$, where m is the number of criteria.
ii. Establish a set of grade alternatives: $E = \{e_1, e_2, e_3, \ldots, e_n\}$. This set of grade alternatives represents the measurement scale used in the study. In this case, a Five-point Likert scale was adopted, where e1 represents " low importance" and e5 represents " high importance."
iii. Establish the weightings for Indicators: The weightings (w) for each criterion can be computed from the mean scores. $W_i = \{w_1, w_2, \ldots, w_m\}$ where $(0 \leq w_1 \leq 1)$.
iv. Compute the fuzzy evaluation matrix for each Indicators: The matrix is expressed as $R = (r_{ij})_{m \times n}$, where r_{ij} is the degree to which alternative e satisfies Indicators f_m.
v. Determine the results for the evaluation: This is done by considering the weighting vector and the fuzzy evaluation matrix using the equation.

$$D = W_i^0 R_i$$

Where D: is the final evaluation matrix and ○ is a fuzzy composition operator

vi. Establish the final results by normalizing the final evaluation matrix using equation:

$$For\ each \sum_{i=1}^{7} D \times E$$

4. DATA ANALYSIS AND RESULTS

We conducted an analysis of the questions asked through the questionnaire within the four axes: knowledge creation, knowledge organization, knowledge distribution, and knowledge application. The mean and standard deviation were calculated and these factors were rearranged accordingly to obtain the final ranking shown in the table (6).

Table (6) Questions and Mean , Rank,Sd

No	**Knowledge Creation**	Mean	Sd	Rank
KC1	Has access to up-to-date tools and technologies for managing projects.	3.89	.618	3
KC2	Offers training programs to improve knowledge in project management.	3.93	.587	2
KC3	Regularly enhances project management methodologies.	3.55	.697	9
KC4	Creates methodologies informed by past experiences.	3.84	.608	4
KC5	Provides employees with opportunities to participate in project management communities.	3.66	.888	7
KC6	Encourages a culture of continuous learning and knowledge sharing.	3.82	.582	5
KC7	Supports employees in obtaining certified project management qualifications.	3.55	.697	9
KC8	Implements best practices in project management.	3.77	.642	6
KC9	Facilitates the sharing of project management knowledge among teams.	3.98	.590	1
KC10	Monitors and assesses the effects of training on employee performance.	3.61	.722	8
	Knowledge Organization			
KO1	Maintains clear policies for structuring project management knowledge.	3.73	.544	6
KO2	Offers a centralized platform for sharing knowledge	3.89	.538	2
KO3	Provides a unified system for storing project-related documents.	3.89	.655	2
KO4	Ensures convenient access to project information	3.82	.495	5
KO5	Records project knowledge using standardized formats.	3.27	.694	10
KO6	Supplies technological resources for organizing knowledge.	3.50	.591	8
KO7	Safeguards the security and confidentiality of project knowledge.	3.32	.518	9
KO8	Frequently assesses and revises knowledge management policies.	3.59	.622	7
KO9	Educates teams on the use of knowledge management tools.	3.8636	.59419	4
KO10	Evaluates the effectiveness of knowledge organization practices.	3.9318	.62497	1
	Knowledge Distribution			
KD1	Offers platforms for employees to exchange knowledge.	3.6136	.78402	4
KD2	Motivates employees to document and disseminate knowledge.	3.5227	.79207	5
KD3	Assesses the effectiveness of knowledge distribution efforts.	3.4318	.81833	8
KD4	Creates physical or virtual environments for knowledge exchange.	3.5227	.62835	5
KD5	Promotes the use of digital platforms for sharing knowledge.	3.7727	.56501	2
KD6	Ensures access to suitable resources for retrieving knowledge.	3.8409	.52576	1
KD7	Organizes training sessions and workshops to facilitate knowledge exchange.	3.7500	.57567	3
KD8	Records and disseminates valuable knowledge throughout the organization.	3.4545	.79107	7
KD9	Provides an electronic library containing project management resources.	3.0000	.83527	10
KD10	Offers incentives to promote knowledge sharing among employees.	3.3636	.78031	9
	Knowledge Application			
KA1	Knowledge and skills are utilized in actual projects	3.6818	.56126	9

KA2	Hires seasoned project managers.	3.9545	.52627	3
KA3	Implements structured planning processes prior to projects.	4.0000	.52827	2
KA4	Fosters a culture of innovation and experimentation.	3.5455	.62708	10
KA5	Utilizes contemporary tools and technologies, including specialized software.	3.7045	.66750	8
KA6	Consistently assesses how knowledge is applied in projects.	3.9091	.67577	5
KA7	Records successful instances of knowledge application.	3.8409	.64495	6
KA8	Obtains regular reviews and feedback on projects.	3.8409	.52576	6
KA9	Maintains well-defined risk management policies.	3.9318	.33395	4
KA10	Provides senior management with regular project updates.	4.0455	.52627	1

Table (2) Cronbach's Alpha

Reliability Statistics	
Cronbach's Alpha	N of Items
.908	40

Several tests were conducted on the questionnaire data, the most important of which was the internal consistency of the data using Cronbach's alpha model, whose value should range between 0 and 1, with an acceptable value greater than 0.70, which indicates the internal consistency and reliability of the data. In our questionnaire, the Cronbach's alpha value was 0.908, which indicates a high level of reliability and internal consistency for the adopted research tool.

FSE modelling:

Responses were categorized into five fuzzy linguistic variables: Very Low (VL), Low (L), Medium (M), High (H), and Very High (VH). Each response was assigned a corresponding membership value using predefined fuzzy logic functions.

The processes of analyzing the Reponses starts with, Weighting and Normalized values of Responses using the following equation.

$$W_i = \frac{M_i}{\sum M_{ii}}$$

Where, Wi is the weightings of a question or a field, Mi is the mean score value of a question or a field, and Mii is the summation of mean score values of all the questions for the governmental companies.

Table (6)

	VL	L	M	H	VH	Avg.
			Knowledge Creation			
KC1	0	0	0.25	0.613636	0.136364	0.103457
KC2	0	0.022727	0.136364	0.727273	0.113636	0.104521
KC3	0	0.068182	0.363636	0.522727	0.045455	0.094415
KC4	0	0	0.272727	0.613636	0.113636	0.102128
KC5	0.068182	0	0.204545	0.659091	0.068182	0.09734
KC6	0	0	0.272727	0.636364	0.090909	0.101596
KC7	0	0.068182	0.363636	0.522727	0.045455	0.094415
KC8	0	0.022727	0.272727	0.613636	0.090909	0.100266
KC9	0	0	0.181818	0.659091	0.159091	0.105851

KC10	0	0.068182	0.318182	0.545455	0.068182	0.096011
Knowledge Organization						
KO1	0	0	0.318182	0.636364	0.045455	0.101344
KO2	0	0	0.204545	0.704545	0.090909	0.105691
KO3	0	0	0.272727	0.568182	0.159091	0.105691
KO4	0	0	0.227273	0.727273	0.045455	0.103789
KO5	0	0.136364	0.454545	0.409091	0	0.088846
KO6	0	0.022727	0.477273	0.477273	0.022727	0.095095
KO7	0	0.022727	0.636364	0.340909	0	0.090204
KO8	0	0.022727	0.409091	0.522727	0.045455	0.09754
KO9	0	0.022727	0.181818	0.704545	0.090909	0.104974
KO10	0	0	0.227273	0.613636	0.159091	0.106827
KO1	0	0	0.318182	0.636364	0.045455	0.101344
KO2	0	0	0.204545	0.704545	0.090909	0.105691
KO3	0	0	0.272727	0.568182	0.159091	0.105691
KO4	0	0	0.227273	0.727273	0.045455	0.103789
KO5	0	0.136364	0.454545	0.409091	0	0.088846
KO6	0	0.022727	0.477273	0.477273	0.022727	0.095095
KO7	0	0.022727	0.636364	0.340909	0	0.090204
KO8	0	0.022727	0.409091	0.522727	0.045455	0.09754
KO9	0	0.022727	0.181818	0.704545	0.090909	0.104974
KO10	0	0	0.227273	0.613636	0.159091	0.106827
KO1	0	0	0.318182	0.636364	0.045455	0.101344
Knowledge Distribution						
KD1	0	0.090909	0.295455	0.522727	0.090909	0.102456
KD2	0	0.113636	0.318182	0.5	0.068182	0.099879
KD3	0	0.159091	0.295455	0.5	0.045455	0.097301
KD4	0	0.045455	0.409091	0.522727	0.022727	0.099879
KD5	0	0	0.295455	0.636364	0.068182	0.106967
KD6	0	0	0.227273	0.704545	0.068182	0.1089
KD7	0	0.045455	0.181818	0.75	0.022727	0.106323
KD8	0.022727	0.090909	0.318182	0.545455	0.022727	0.097946
KD9	0	0.295455	0.454545	0.204545	0.045455	0.085058
KD10	0	0.113636	0.477273	0.340909	0.068182	0.095368
Knowledge Application						
KA1	0	0	0.363636	0.590909	0.045455	0.095744
KA2	0	0.022727	0.090909	0.795455	0.090909	0.102836
KA3	0	0	0.136364	0.727273	0.136364	0.104019
KA4	0	0.022727	0.454545	0.477273	0.045455	0.0922

KA5	0	0.068182	0.204545	0.681818	0.045455	0.096335
KA6	0	0.022727	0.204545	0.613636	0.159091	0.101655
KA7	0	0.022727	0.227273	0.636364	0.113636	0.099882
KA8	0	0.022727	0.159091	0.772727	0.045455	0.099882
KA9	0	0	0.090909	0.886364	0.022727	0.102246
KA10	0	0.022727	0.045455	0.795455	0.136364	0.105202

The membership function of a question is derived from the evaluation by the experts given the grades for selection, where 1 = Very Low, 2= Low, 3 = Moderate, 4= High and 5= Very high.

Next, is to estimate the membership value, fuzzy membership values were assigned for each VL, L, M, H, VH category, as shown in the following matrix, so every respond can get such value. The membership values estimated for Q1 in KC,

$$MF_{Q1} = \frac{0.00}{VL-2-} + \frac{0.00}{L-2-} + \frac{0.25}{M-3-} + \frac{0.61364}{H-4-} + \frac{0.13636}{VH-5-}$$

Moving forward the value for each response, and the average estimated to estimate the membership values for each knowledge management area.

$$D = W_i * R$$

Where Wi is the weighting for all the questions under each field, and R represents the function matrix for each field.

For the first field Knowledge Creation, the Membership function can be defined by targeting each question in this field as this calculation to be done as a two matrixes multiplication, the calculation based on the following weights and function matrix.

(0.10348 0.10452 0.09441 0.10213 0.09734 0.10159 0.09441 0.10027 0.10585 0.09601) ×

0	0	0.25	0.613636	0.136364
0	0.02273	0.136363636	0.727273	0.113636
0	0.06818	0.363636364	0.522727	0.045455
0	0	0.272727273	0.613636	0.113636
0.068182	0	0.204545455	0.659091	0.068182
0	0	0.272727273	0.636364	0.090909
0	0.06818	0.363636364	0.522727	0.045455
0	0.02273	0.272727273	0.613636	0.090909
0	0	0.181818182	0.659091	0.159091
0	0.06818	0.318181818	0.545455	0.068182

DKC = (0.00664 0.02408 0.26139 0.61335 0.09455)

Calculating in this way, the membership functions for the remaining KMFGs are computed using the same approach. After determining the membership function of each KMA, the criticality (index) for each field Index for each $KMA = \sum_{l=1}^{5} D \times E$

D_{KC}=	0.00664	0.02408	0.26139	0.61335	0.09455	×	1	2	3	4	5	**=3.765**
D_{KO}=	0	0.02093	0.33272	0.57747	0.06888	×	1	2	3	4	5	**=3.694**
D_{Kd}=	0.00223	0.09039	0.32269	0.53223	0.05255	×	1	2	3	4	5	**=3.543**
D_{KA}=	0	0.02024	0.19342	0.70114	0.08518	×	1	2	3	4	5	**=3.8513**

5. DISCUSSION OF RESULTS

By discussing the survey results through the average values for each criterion, we find that for the knowledge creation criterion, the highest-rated criterion in terms of average response values, ranked first, was KC9, which relates to sharing project management-related knowledge among teams and individuals within the company. This was followed by training programs to enhance project management knowledge, KC2.

For the knowledge organization criterion, the first criterion was KO10, which relates to the presence of mechanisms to measure and evaluate the effectiveness of the knowledge management system within the company. This was followed by KO2, which relates to the availability of a centralized system for communicating and sharing knowledge related to project management.

For the knowledge distribution criterion, the first criterion was KD6, which relates to directing employees to appropriate resources and tools to access the necessary information and knowledge. This was followed by KD5, which relates to encouraging employees to use social media and digital platforms to share knowledge and experiences.

Finally, for the knowledge application criterion, the most prominent criterion was KA10, which relates to regularly exchanging reports and information related to the project with senior management. This was followed by KA3, which relates to the company's reliance on comprehensive planning processes before starting the project.

Through A Fuzzy Synthetic Evaluation, we can observe that the values were ranked according to the following criteria:

Knowledge Application Criterion: This value, 3.8513, is considered a high value. This value indicates that government companies have good knowledge application policies and methods and demonstrates the use of acquired knowledge in actual projects.

Knowledge Creation Criterion: These companies have good policies and procedures for organizing knowledge, modern tools and technologies, and effective training programs.

Knowledge Organization Criterion: 3.694. This number indicates that these government companies have effective knowledge organization policies and centralized information storage systems, making it easy to access.

Knowledge Distribution Criterion: 3.543, which is lower than the previous criteria, indicates some challenges in knowledge distribution and a lack of mechanisms that encourage knowledge sharing.

Therefore, it can be concluded that:

These companies' strengths are:

Knowledge Application: A significant increase in the use of acquired knowledge, which supports the achievement of objectives.

Knowledge Creation and Organization: The companies are strong in both areas, providing a good foundation for improving organizational performance.

Weaknesses:

Knowledge Distribution: This aspect poses a challenge for these companies, as the lower score indicates a need to improve the mechanisms used.

6. CONCLUSION

Through this research, we sought to evaluate knowledge management in four public sector companies in Iraq (C1,C2,C3,C4). Using the Fuzzy Synthetic Evaluation technique, we identified strengths in knowledge application, creation, and organization, which companies must enhance, and weaknesses in knowledge distribution, which companies must address. We concluded the following recommendations:

- Policies and mechanisms should be strengthened to facilitate knowledge sharing among employees, such as creating interactive knowledge-sharing platforms.
- Organizing workshops and seminars to exchange ideas and experiences.
- Continued support should be given to the application of acquired knowledge through providing ongoing training.
- Promoting a culture of innovation and experimentation in projects.
- By addressing these aspects, government companies can improve performance efficiency and increase the effectiveness of their services.

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