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INVESTIGATION IN THE BARRIERS FACING THE APPLICATIONS OF LEAN MANAGEMENT IN CONSTRUCTION PROJECTS IN KRG-IRAQ

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Abstract:

The construction industry has suffered from low production and improvement, as well as a high level of waste, and the same is true for Kurdistan-Iraq. Many methods have been used to solve these problems and improve project performance, one of them is Lean management, which has shown a lot of benefits and improvement in the overall performance of the industry. This research investigates the application of Lean management and identifies the barriers to the application of this system, which will aid in improving the application of lean management in this region. The questionnaire method was used for this purpose and was designed to be filled out by all engineers. According to the findings, the top three barriers to Lean management implementation in Kurdistan-Iraq are a lack of training (0.0985), unskilled workers and a low level of labor education (0.0811), and limited usage of off-site construction techniques (0.0717).

Keywords: *Lean Management; Construction Projects; Barriers; Kurdistan-Iraq*

1. Introduction

The construction industry is one of the industries which have a tremendous impact on every country's economic progress, it significantly adds to a country's total workforce and income generation. At the same time, the construction sector is notorious for poor performance and safety, as well as low-quality outputs and a high level of waste [1]. The building sector is seen as a major danger to sustainable development due to its severe environmental effect. Reduced negative effect motivates construction teams to adopt new green techniques and processes. One way utilized in the construction sector to reach sustainability is the lean strategy. Lean management concepts have been proved in studies all over the world to have a huge potential beneficial influence on the building process and the sector in general when used.

Lean is a managerial phrase that refers to a high-performance and effective strategy to achieving primary goals as quickly and effectively as possible. Lean is a corporate concept as well as a way of life. Its goal is to increase client value generation by eliminating all types of waste, guaranteeing quality products, shortening timelines, and lowering prices [2]. The phrase "lean" refers to a high-performance machine with no wastage, everything going fine, and constant efficiency [3]. Lean is a collection of concepts, attitudes, techniques, and procedures that may be used individually or in groups. When lean principles are applied as a management technique, they are carried out on a continual basis and could evolve into a long-term strategy for guiding organizations to be basic, straightforward, and well-managed. Toyota was the first to publicize the Lean concepts. Toyota developed an emphasis on waste elimination and expanded to become the world's biggest automobile business by using seven waste-reduction concepts.

Lean ideas have gradually made significant inroads into the construction business due to their approach to waste elimination and providing value with less effort and time. The most significant economic impact of construction nowadays is the way the entire process is handled, rather than the cost of people and resources. The construction process is comprised of several activities that bring little value to the result. These non-value-added activities (e.g., waiting time, double handling, material hunting, etc.) are incredibly wasteful, according to Hines and Rich, and should be avoided totally. Applying lean management in construction projects has multiple barriers because of the different natures of the construction industry and manufacturing, Construction projects, unlike manufacturing, have various natures and each project is unique, so many parties joined the project, but these obstacles may be transitory by pursuing improvement and absorbing to the greatest extent needed from individuals who have done it before. Several studies have been undertaken in various locations throughout the world to assess the difficulties associated with employing the lean management style [4, 5, 6].

In this study, we investigate the current state of lean management applications and identify barriers to the application of this approach in Kurdistan-Iraq construction projects, which assist in identifying the challenges that must be addressed to improve lean management application in construction projects.

2. Literature Review

Ohno's efforts and labor were principally responsible for the invention of what is now called the Toyota Production System, which was based on Henry Ford's flow-based manufacturing management and incorporated the benefits of both handmade and processing conditions. Toyota's manufacturing system has four objectives: customer satisfaction, zero storage, zero waste, and perfectionism. To achieve such goals, two important tactics were employed. The first was to minimize inventory and so lower it, and the second was to adopt the pull-type production approach. These solutions met two critical Toyota production system objectives: zero waste and manufacturing efficiency. Waste is classified into three types in the Toyota Production System (TPS) and lean nowadays: Muda is the first of them, a conventional waste with seven categories (transportation, waiting, overproduction, defect, overprocessing, motion, and inventory), while the second is Mura. It denotes irregularity or variation. Muri, which means overburdening, refers to asking too much of persons and organizational procedures [3].

Alternatively, Koskela [7] is credited with developing the transformation-flow-value creation way of production, termed as the TFV theory of production, which might result in greater productivity when used in construction [7]. To eliminate waste, he argued for construction products to be understood as a combination of conversion and flow processes, whereas conventional building thinking concentrated only on conversion activities while ignoring flow and value considerations [8, 9].

As a result, Womack and Jones [10] described the lean thinking processes and developed the following five lean management principles:

1. Determine Customer Value: It is vital to meet the required criteria and give the desired value to the end customer.
2. Map the Value Stream: This illustrates the end-to-end process that provides value to the customer, requiring the removal of any non-added value procedures.
3. Make the flow of products: Maintain the workflow by achieving the ideal job sequence.
4. Adopt a pull logistic: This includes creating in response to the wants of the consumer.
5. Attempt to achieve excellence in all operations: Try to achieve perfection at all times through continuous improvement and the use of suitable processes [10].

Evidence of lean thinking application has indicated the existence of various benefits to using lean principles in the construction industry. These benefits are as follows: greater productivity, better dependability, better quality, greater consumer satisfaction, improved consistency, shorter timelines, less waste, lower cost, improved design constructability, and higher reliability [11].

Adopting the lean idea in building projects and implementing lean practices on actual work sites presents a number of challenges. As a result, there is a need to exchange knowledge about how other organizations utilize lean tools, as well as emphasize the benefits and challenges associated with adopting lean techniques in the construction sector [12]. To implement the lean principles in a construction company, it is suggested that the firm needs to understand and identify sequences (barriers) that may hinder correct application. Several studies have been conducted throughout the world to identify the hurdles to using lean solutions to reduce/eliminate construction waste [13, 14, 15, 16].

It was found that process duration decreased by 15.57% by implementing Last Planner System (Lean tool) [17]. In different research, a model was created using lean principles during design stage to find its effect on project cycle time, reduced cycle times were achieved by 40% more than in the prior process scenario [18].

3. Methodology

The survey questionnaire was equipped and planned with detailed that were simple to understand research question to construct an effortlessly filled questionnaires for the participants, and it was shared to experienced professionals who already have handled projects in the Kurdistan-Iraq construction sector in both sectors (public and private), taking ideas from all engineers with various positions and different period of working experience, with the goal of reaching the conclusion.

3.1 Data Collection

The questionnaire was sent to 100 engineers in three governorates (Erbil, Duhok, and Sulaymaniyah); 85 were returned, and 17 were eliminated because of inconsistent and inaccurate responses. As a result, there were 68 acceptable questionnaires in all. The questionnaire was distributed through interviews as well as online publishing.

3.2 The Questionnaire Design

The questionnaire is divided into three sections:

Part 1 (Personal information): This section comprises the respondent's personal details (work sector, gender, qualification, job title, Experience, Educational level, and Governorate).

Part 2 (Current Situation of Application of Lean Management): in this part respondents were asked about their current knowledge of lean management and management methods companies currently use, their expectations, and the potential of the application of lean management.

Part 3 (Barriers facing the application of lean management in construction projects): This identifies the barriers facing lean management application in construction projects, this part was designed to be analyzed by Fuzzy AHP.

3.3 Data Analysis

3.3.1 Fuzzy Analytical Hierarchy Process AHP

Saaty developed the Analytical Hierarchy Process (AHP), it is a basic decision-making technique, it allows for choice uncertainty and provides a method for enhancing accuracy [19]. The AHP technique does not account for mapping-related uncertainty [20]. A fuzzy was created to handle uncertainty since the fuzzy notion is an excellent tool for explaining ambiguity, because human judgments are significant elements in prioritizing barriers, the Fuzzy AHP approach is the best fit for this research study. The procedure of Fuzzy AHP is shown in figure (1), and figure (2) shows the hierarchy structure model for barriers facing the application of Lean management in construction projects.

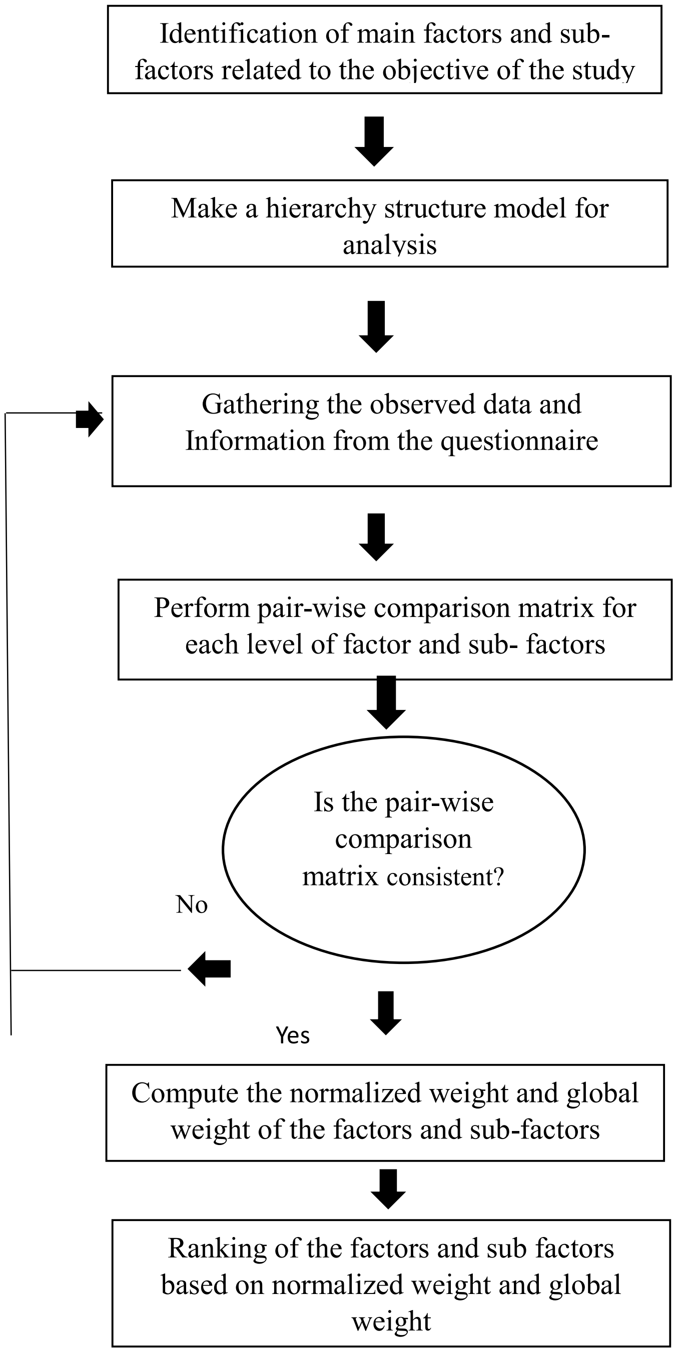

Figure 1: Flowchart of fuzzy AHP procedure.

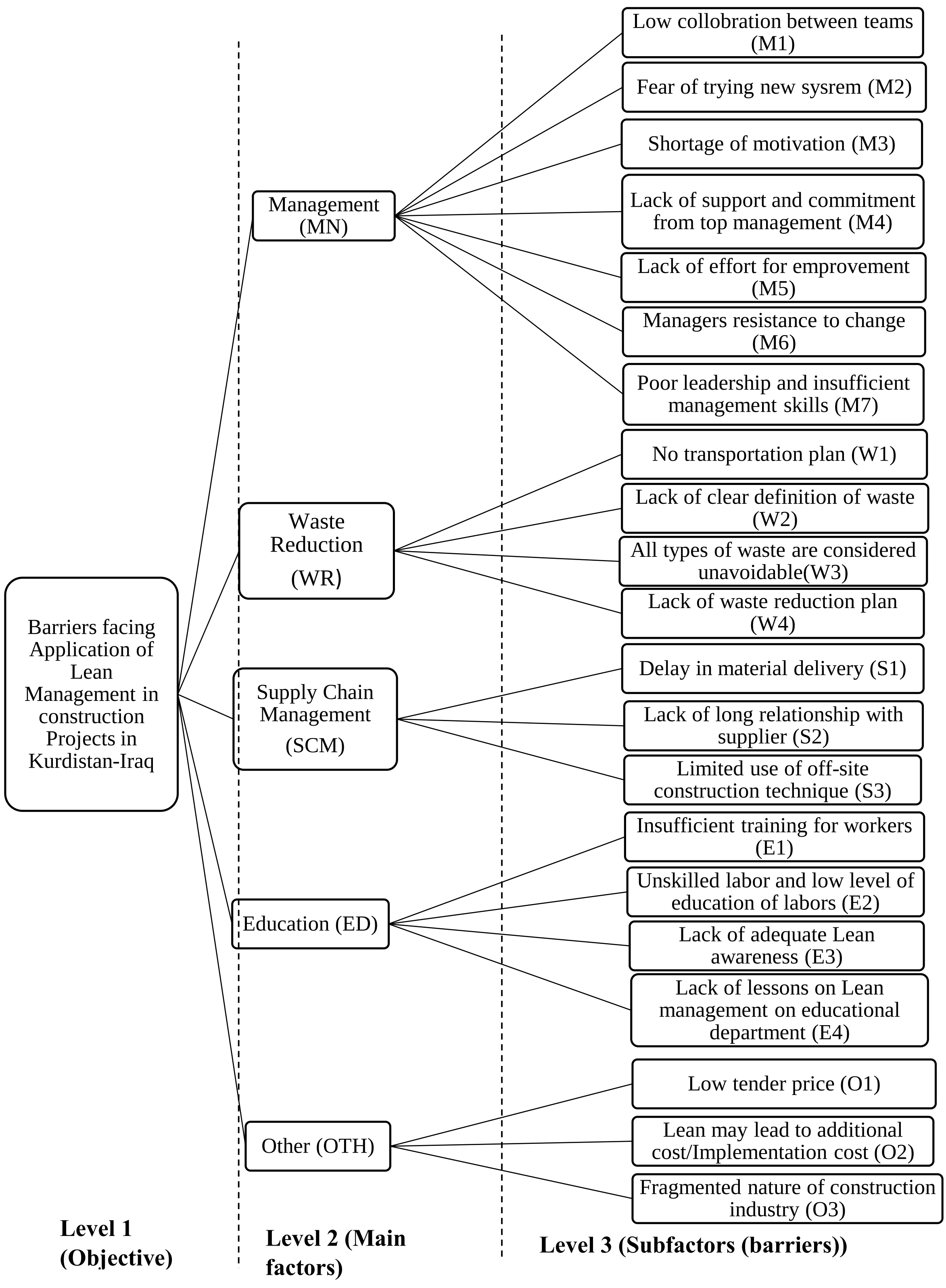

Figure 2: Hierarchy structure model for barriers facing the application of Lean management in construction projects.

3.3.3 Evaluation of Fuzzy Pairwise Comparison

When the hierarchy is constructed, the pairwise comparison assessment begins. The elements within the same level in the hierarchy are examined to the elements on the following (higher) level. Pairwise comparisons are performed using linguistic terms. Based on a variant of Chen's definition, five linguistic notions are used to construct fuzzy comparison matrices [19]. those five phonetic variables are defined by fuzzy numbers or membership functions. Each pair element's fuzzy relative importance is represented by the fuzzy comparison matrix. Buckley's approach flips the order of the fuzzy number and considers the negative decision element as an opposite.

3.3.4 Fuzzy Weight

The geometric mean values are computed after building fuzzified pairwise comparison matrices with fuzzy integers [21]

The geometric mean values are computed after building fuzzified pairwise comparison matrices with fuzzy integers [21]

The following formula yields a fuzzy geometric mean value

(1) $$\tilde{r} = [\widetilde{a_{i1}} \otimes \ldots \otimes \widetilde{a_{in}}]^{1/n}$$

n = Total number of criteria

ãin = Pairwise comparison across I and n

Following that, equation (2) is utilized to compute the fuzzy weight.

(2) $$\widetilde{w}_i = \tilde{r}_i \otimes \left(\sum_{i=1}^{n} \tilde{r}_i\right)^{-1}, i = 1,2, \ldots, n$$

I = the row number in each comparison table.

n= the number of criteria/options in each comparison table.

The Center of Area technique is used to defuzzify and normalize fuzzy weights.

The following is the Center of Area formula:

(3) $$w_i = \frac{l_i+m_i+u_i}{3}, \quad i = 1,2, \ldots, n$$

3.3.5 Consistency Test

The consistency ratio (CR) measures how consistent judgments are. If the CR is more than 0.1, the responses are not acceptable and are judged to be fully unpredictable judgments; the judgments should be evaluated or participants should provide their answers again.

The equation (4) is used to calculate CR [22].

(4) $$C.R. = \frac{C.I.}{R.I.}$$

R.I. is a random consistency index that varies with the length of the pairwise comparison matrix table (1).

Table 1: Average Random of Consistency Index (R.I) [23].

Number of items n	1-2	3	4	5	6	7	8	9
Random Consistency Index	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

C.I. is the consistency index, and it is calculated using Equation (5) [23].

(5) $$C.I = \frac{\lambda_{MAX} - n}{n-1}$$

Where λmax is the comparison matrix's biggest eigenvalue and n is the matrix's size [24].

(6) $$\lambda max = \left| n + det \begin{vmatrix} m_{11} & m_{12} & \dots & \dots & m_{1j} \\ m_{21} & m_{22} & \dots & \dots & m_{2j} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ m_{ij} & m_{ij} & \dots & \dots & m_{ij} \end{vmatrix} \right|$$

Where: λ max = lambda –max (Eigen value)

n = Number of matrix comparison sizes of each i and j row

det = Determinant of the matrix

mij = The middle number of TFNs of each i and j row of matrix comparison

4. Results and Discussion

4.1 Respondent Information

The personal information of the 68 respondents is shown in table (2).

Table 2: Respondent Information

Categories	Types	Frequency	Percentage
Gender	Female	14	20.6
	Male	54	79.4
Qualification	BSc	44	64.7
	diploma	1	1.5
	MSc	11	16.2
	PhD	12	17.6
Year of experience	1-5	9	13.2
	10-15	13	19.1
	15-20	13	19.1
	5-10	13	19.1
	more than 20	20	29.4
Working sector	Pubic	20	29.4
	Private	33	48.5
	Both	15	22.1

Education	Architecture	6	8.8
	civil engineer	23	33.8
	IT Engineer	3	4.4
	mechanic engineer	14	20.6
	Others	22	32.4
Job title	Planning Engineer	5	7.4
	procurement engineer	2	2.9
	project manager	18	26.5
	site engineer	11	16.2
	supervisor	14	20.6
	Teaching staff	11	16.2
	Other	7	10.3
Governorate	Duhok	10	14.7
	Erbil	24	35.3
	Sulaymaniyah	34	50.0

According to the above data, 79.4% of respondents are male and 20.6% are female; the proportion of respondents with a BSc Diploma, MSc, Ph.D., and postgraduate students is 64.7%, 1.5%, 16.2%, 17.6%, and 0%, respectively. The majority of responders (29.4%) have more than 20 years of experience, and we have an equal amount of (5-10, 10-15, 15-20) and years of experience (19.1%). The proportion of individuals employed by the government was 29.4%, while the proportion of individuals employed in the private industry was 48.5%, with 22.1% working in both sectors. The majority of respondents (26.5%) and supervisors (20.6%) work in the Sulaymaniyah governorate (50%).

4.2 Current Situation Of Application Of Lean Management In Kurdistan-Iraq.

The respondents were given seven distinct questions on the present state of lean management implementation in Kurdistan-Iraq:

From the data obtained, the level of knowledge of lean management in the construction sector is low, only 34% of respondents have knowledge about Lean management and 66% of them don’t have knowledge about it.

After a discussion with the respondent about Lean management when respondents were asked if they have the potential to work with this method 60% answered with Yes.

While only 31% of the respondents are satisfied with the current management method of their company but the expectation of the improvement of the application of Lean management in Kurdistan-Iraq is still not known as 60% of the respondent answered, 22% of the respondent don’t expect any improvement and only 18% think that application of lean will improve soon.

4.3 Fuzzy AHP Analysis For Identifying The Main Barriers Facing The Implementation Of Lean Management In Kurdistan-Iraq.

4.3.1 Comparative Matrix

To create pair-wise comparison matrices for the main factor and sub-factors of the barriers to Lean management implementation in the construction sector, the opinions of the 68 respondents were combined by calculating the geometric mean for each value (lower, medium, and upper), as shown in Tables (3) to Tables (8).

Table 3: Comparison matrix of Main factors.

Main factors	Management (MN)			Waste Reduction (WR)			Supply Chain Management (SCM)			Education (ED)			Others (OTH)		
	L	m	u	L	m	u	l	m	u	l	m	u	l	m	u
MN	1.00	1.00	1.00	3.28	3.82	4.35	1.71	1.94	2.33	0.62	0.71	0.81	2.48	2.97	3.49
WR	0.23	0.26	0.30	1.00	1.00	1.00	0.65	0.77	0.92	0.47	0.55	0.64	2.25	2.66	3.06
SCM	0.43	0.51	0.59	1.09	1.29	1.53	1.00	1.00	1.00	0.55	0.64	0.76	2.01	2.42	2.83
ED	1.24	1.41	1.61	1.57	1.83	2.12	1.32	1.55	1.81	1.00	1.00	1.00	3.22	3.71	4.19
OTH	0.29	0.34	0.40	0.33	0.38	0.45	0.35	0.41	0.50	0.24	0.27	0.31	1.00	1.00	1.00

Table 4: Comparison matrix of subfactors of Management (MN).

MN subfactors	M1			M2			M3			M4			M5			M6			M7		
	L	m	u	L	m	u	l	M	u	l	m	u	l	m	U	l	m	u	l	m	u
M1	1.00	1.00	1.00	0.72	0.90	1.00	0.62	0.70	0.79	0.66	0.76	0.87	1.07	1.24	1.44	0.60	0.70	0.83	0.44	0.51	0.61
M2	1.00	1.11	1.39	1.00	1.00	1.00	1.48	1.77	2.07	0.52	0.61	0.74	0.48	0.57	0.67	0.40	0.47	0.56	0.58	0.68	0.81
M3	1.27	1.43	1.61	0.48	0.57	0.68	1.00	1.00	1.00	0.53	0.60	0.70	0.65	0.76	0.90	0.49	0.57	0.68	0.49	0.57	0.68
M4	1.14	1.32	1.51	1.35	1.63	1.93	1.44	1.66	1.89	1.00	1.00	1.00	1.75	2.10	2.49	1.03	1.18	1.33	1.14	1.37	1.62
M5	0.69	0.81	0.94	1.48	1.77	2.07	1.11	1.32	1.54	0.40	0.48	0.57	1.00	1.00	1.00	0.62	0.73	0.88	0.82	0.94	1.08
M5	1.21	1.42	1.68	1.78	2.15	2.52	1.47	1.75	2.03	0.75	0.85	0.97	1.14	1.37	1.62	1.00	1.00	1.00	0.69	0.76	0.86
M7	1.63	1.96	2.29	1.23	1.46	1.72	1.48	1.76	2.06	0.62	0.73	0.88	0.92	1.06	1.21	1.16	1.31	1.46	1.00	1.00	1.00

Table 5: Comparison matrix of subfactors of Waste Reduction (WR).

WR subfactors	W1			W2			W3			W4		
	l	m	u	L	m	u	l	m	u	l	m	u
W1	1.00	1.00	1.00	0.58	0.69	0.83	0.51	0.62	0.76	0.32	0.38	0.46
W2	1.21	1.44	1.72	1.00	1.00	1.00	1.37	1.73	2.09	1.10	1.36	1.57
W3	1.32	1.62	1.97	0.48	0.58	0.73	1.00	1.00	1.00	0.68	0.76	0.86
W4	2.19	2.63	3.08	0.64	0.73	0.91	1.16	1.31	1.47	1.00	1.00	1.00

Table 6: Comparison matrix of sub-factors of Supply Chain Management (SCM).

SCM subfactors	S1			S2			S3		
	l	M	U	l	m	u	l	M	u
S1	1.00	1.00	1.00	0.91	1.04	1.19	0.57	0.68	0.82
S2	0.84	0.96	1.10	1.00	1.00	1.00	0.68	0.79	0.92
S3	1.21	1.46	1.74	1.08	1.27	1.48	1.00	1.00	1.00

Table 7: Comparison matrix of sub-factors of Education (ED).

ED subfactors	E1			E2			E3			E4		
	l	m	U	l	m	u	l	M	u	l	M	u
E1	1.00	1.00	1.00	1.76	2.05	2.34	1.91	2.21	2.52	0.64	0.72	0.83
E2	0.43	0.49	0.57	1.00	1.00	1.00	1.66	1.98	2.33	1.29	1.59	1.92
E3	0.40	0.45	0.52	0.43	0.51	0.60	1.00	1.00	1.00	0.88	0.97	1.07
E4	1.20	1.38	1.57	0.52	0.63	0.77	0.93	1.03	1.14	1.00	1.00	1.00

Table 8: Comparison matrix of subfactors of Others (OTH).

OTH subfactors	O1			O2			O3		
	l	M	u	l	m	U	l	M	u
O1	1.00	1.00	1.00	2.07	2.44	2.85	1.21	1.44	1.71
O2	0.35	0.41	0.48	1.00	1.00	1.00	0.61	0.70	0.81
O3	0.59	0.70	0.83	1.24	1.43	1.63	1.00	1.00	1.00

4.3.2 Consistency Test

The matrix's consistency must be tested using the lambda-max approach equation (6). The consistency index (CI) was then determined using equation (5), and the consistency ratio (CR) was derived using equation (4) and the RI table (1). After analyzing the Consistency Ratio for the main factor and subfactors Comparison matrices all CR values is below 0.1 so the matrices are consistent which means the data is reliable, as shown in table (9).

Example: for main factors, the matrix size was 5*5, therefore n=5.

$$\lambda \max = \left| 5 + \det \left| \begin{matrix} 1 & 3.82 & 1.94 & 0.71 & 2.97 \\ 0.26 & 1 & 0.77 & 0.55 & 2.66 \\ 0.51 & 1.29 & 1 & 0.64 & 2.42 \\ 1.41 & 1.83 & 1.55 & 1 & 3.71 \end{matrix} \right| \right|$$

λ max = 5.17

Consistency Index CI=λ max−n /n−1 = 5.17−5/5−1 = 0.043

Relative Index (RI) =0.9 in the Table (3) for (n = 5)

Consistency Ratio CR = $CI/\ RI$ = 0.043/ 0.9 = 0.047 < 0.1ok the matrix is consistent

Table 9: Consistency test for Main factor and Subfactor matrices.

Comparison matrix of:	CR
Main factors	0.047
Management	0.0248
Waste reduction	0.0308
Supply chain management	0.002
Education	0.095
Others	0.0059

4.3.3 Finding the Rank Of The Factors And Subfactors (Barriers)

Using eq (1) fuzzy geometric-mean are calculated after those Fuzzy weights are found using equation (2), then fuzzified using equation (3) and normalized. which is shown in table (10).

Example: main factor (management) geometric mean:

r˜management = $((1\times3.28\times1.71\times0.62\times1.4\times2,48)^{1/6},(1\times3.82\times1.94\times0.71\times1.61\times2.97)^{1/6},(1\times4.35\times2.33\times0.81\times1.82\times3.49)^{1/6})$

r˜ management = (1.52,1.71,1.93)

fuzzy weight: w ˜management= (1.52,1.71,1.93) × (1/5.94, 1/6.73. 1/7.62) = (0.1989, 0.2542, 0.3255)

defuzzification = (0.1989, 0.2542, 0.3255) /3= 0.2595

normalization= 0.2595/1.02= 0.2542

Table 10: Geometric mean, Fuzzy Weights, Defuzzification, Normalization, and the Rank of Barriers facing the Application the Lean Management.

Main factors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
MN	1.540	1.733	1.955	0.307	0.306	0.306	0.3064	0.3064	1nd
WR	0.693	0.783	0.886	0.138	0.138	0.139	0.1384	0.1384	4th
SCM	0.877	1.007	1.139	0.175	0.177	0.178	0.1770	0.1770	3rd
ED	1.525	1.714	1.917	0.304	0.303	0.300	0.3023	0.3023	2st
OTH	0.379	0.427	0.488	0.076	0.075	0.076	0.0758	0.0758	5th
MN subfactors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
M1	0.801	0.906	0.678	0.121	0.112	0.096	0.1098	0.1096	6th
M2	0.804	0.941	0.682	0.121	0.116	0.097	0.1116	0.1114	5th
M3	0.736	0.847	0.603	0.111	0.105	0.085	0.1006	0.1005	7th
M4	1.427	1.622	1.283	0.215	0.201	0.182	0.1994	0.1991	1st
M5	0.933	1.072	0.847	0.141	0.138	0.120	0.1313	0.1311	4th
M6	1.250	1.421	1.097	0.189	0.176	0.156	0.1734	0.1732	3rd

M7	1.101	1.263	1.436	0.166	0.156	0.203	0.1754	0.1751	2nd
WR subfactors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
W1	0.557	0.635	0.731	0.117	0.152	0.200	0.1564	0.1529	4th
W2	1.163	1.358	1.541	0.245	0.326	0.422	0.3305	0.3231	1st
W3	0.810	0.920	1.053	0.170	0.220	0.288	0.2263	0.2212	3rd
W4	1.128	1.261	1.425	0.237	0.302	0.389	0.3098	0.3028	2nd
SCM subfactors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
S1	0.804	0.893	0.994	0.238	0.295	0.365	0.2992	0.2947	3rd
S2	0.827	0.911	1.006	0.245	0.300	0.369	0.3049	0.3003	2nd
S3	1.096	1.229	1.372	0.325	0.405	0.503	0.4111	0.4049	1st
ED subfactors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
E1	1.210	1.344	1.489	0.263	0.326	0.404	0.3312	0.3259	1st
E2	0.978	1.113	1.262	0.213	0.270	0.342	0.2751	0.2707	2nd
E3	0.622	0.687	0.762	0.135	0.167	0.207	0.1697	0.1669	4th
E4	0.875	0.973	1.084	0.190	0.236	0.294	0.2403	0.2364	3rd
OTH subfactors	Geometric-mean			Fuzzy Weight			Defuzzification	Normalization	Rank
	l	m	U	l	m	u			
O1	1.358	1.519	1.695	0.385	0.478	0.594	0.4855	0.4783	1st
O2	0.600	0.660	0.732	0.170	0.208	0.256	0.2113	0.2082	3rd
O3	0.897	0.997	1.103	0.254	0.314	0.386	0.3182	0.3135	2nd

As presented in table (10), among the main factors Management is ranked as the first one, so that means managerial factors in Kurdistan-Iraq is the biggest barrier facing the application of lean management, Education comes second, third is Supply Chain Management, fourth is waste Reduction, the fifth is Other factor which contains the barriers that are not included in above factors.

The most crucial sub-factor concerning Management factor for the application of Lean management is Lack of support and commitment from top management, the second significant sub-factor was Poor leadership and insufficient management skills, while Managers resistance to change turned out to come in the third rank, and Lack of effort for improvement is the fourth rank. Then the fear of trying new systems, a low collaboration between teams, and a Shortage of motivation were given the minimum consideration having fifth, sixth, and seventh rank respectively.

For the waste Reduction factor as can be seen from Table (10), the Lack of a clear definition of waste was the most valuable sub-factor for implementation of the Lean management. Subsequently, the second more considerable sub-factor was the Lack of a waste reduction plan. The third sub-factor was all types of waste considered unavoidable. The last one was No transportation plan.

Limited use of off-site construction techniques is considered as a critical sub-factor referring to supply chain management factor, followed by lack of long-term relationship with supplier and delay in materials delivery as the second and third most principal sub-factors.

Insufficient training for workers took a higher position among the sub-factor of education factor, and unskilled labor and low level of education of labors took the second position. While No lessons about Lean management in educational departments, and Lack of adequate lean awareness and understanding are considered the third and fourth barriers regarding education factors facing the implementation of Lean management.

With respect to Other factor, the highest crucial sub-factor was the low tender price, whereas the fragmented nature of the construction industry became second. The last sub-factor, Lean may lead to additional cost, was a less significant sub-factor when compared to the other sub-factors.

Global weight is gained to perform an overall ranking for sub-criteria. Global weight is the priority weight for the highest hierarchical level – the aim or objective. The global weight of the sub-factors is calculated by multiplying the main factor's normalized weight by the sub-factor's normalized weight (Drake, 1998). Table (11) and Figure (3) shows the overall weight of the sub-factors.

Table 11: Global Weight and Ranking of Subfactors.

Main Factor	main factor Weight	Sub-factor	Global Weight	Rank
Management	0.3064	Low collaboration between teams	0.0336	16
		Fear of trying new systems	0.0341	15
		Shortage of motivation	0.0308	17
		Lack of support and commitment from top management	0.0610	5
		Lack of effort for improvement	0.0402	13
		Manager's Resistance to change	0.0531	8
		Poor leadership and insufficient management skills	0.0537	6
Waste reduction	0.1384	No transportation plan	0.0212	20
		Lack of clear definition of waste	0.0447	11
		All types of waste are considered unavoidable	0.0306	18
		Lack of waste reduction plan	0.0419	12
Supply Chain Management	0.1770	Delays in materials delivery	0.0522	9
		Lack of long-term relationships with suppliers	0.0532	7
		Limited use of off-site construction techniques	0.0717	3
Education	0.3023	Insufficient training for workers	0.0985	1
		Unskilled labor and low level of education of labor	0.0818	2
		Lack of adequate lean awareness and understanding	0.0505	10

		No lessons about lean construction in educational departments	0.0715	4
Other	0.0758	Low tender price	0.0363	14
		Lean may lead to additional cost/Implementation cost	0.0158	21
		Fragmented nature of the construction industry/so many parties joined the project	0.0238	19

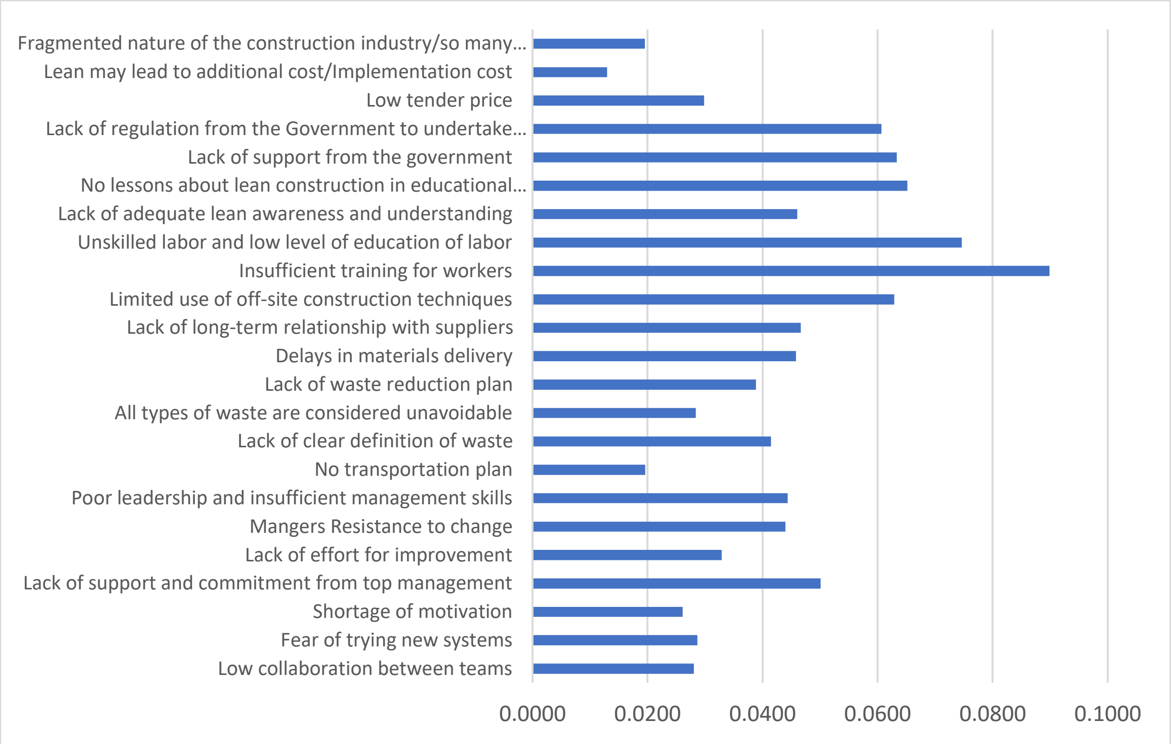

Figure 3: Global Weight of all sub-factors (barriers) facing the Application of Lean management.

The list of top ten barriers facing the application of Lean management based on Fuzzy AHP indicates that 'Insufficient training for workers' (0.0985) is the most important factor among the 21 barriers and it is the highest ranked one followed by 'Unskilled labor and low level of education of labor' (0.0811), and 'Limited use of off-site construction techniques' (0.0717). The fourth-biggest factor is 'No lessons about lean construction in educational departments '(0.0715), followed by, 'Lack of support and commitment from top management' (0.0610), 'Poor leadership and insufficient management skills '(0.0537), 'Lack of long-term relationship with suppliers' (0.0532), 'Managers Resistance to change' (0.0531), 'Delays in materials delivery' (0.0522) and 'Lack of adequate lean awareness and understanding' (0.0505).

5. Conclusion

From the data obtained, we get to know that engineers in Kurdistan-Iraq are not satisfied with the current management method used by companies, they are aware of its flaws and, starting to get familiar with Lean management also have the potential to work with it, at the same time they don't know if the application of Lean management will improve soon as only 18% of engineers expect improvement in

Lean management application. We also investigated the barriers facing Lean management application in construction projects in this region, it turns out that the top five barriers are:1. Insufficient training for workers (0.0985). 2. Unskilled labor and low level of education of labor (0.0811). 3. Limited use of off-site construction techniques (0.0717). 4. No lessons about lean construction in educational departments (0.0715). 5. Lack of support and commitment from top management (0.0610). From the top five barriers we get to know that three of the top five are from Education which means a lack of good and strong curriculum is needed in educational departments and also sufficient training in workplaces will have a big impact on the application of new and Lean management system in Kurdistan-Iraq.

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