An Investigation of Lean Application Challenges in Construction Projects by Root Cause Analysis

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Received: 16 August 2025 | Revised: 4 September 2025, 23 September 2025, 7 October 2025, and 14 October 2025 | Accepted: 18 October 2025

 DOI: https://doi.org/10.48084/etasr.14111

ABSTRACT

The construction industry has increasingly embraced lean construction methodologies to improve productivity, minimize waste, and enhance stakeholder value. Despite this growing trend, several challenges hinder the successful adoption of Lean Principles in developing countries. Within the Kurdistan Region of Iraq, the implementation of lean construction remains constrained by multiple barriers that have not been systematically examined. In this study, the challenges associated with lean construction adoption are explored through the application of Root Cause Analysis (RCA) techniques, including fishbone diagrams, Pareto charts, and the "5 Whys" method. RCA provides a structured and analytical approach for identifying the fundamental causes of systemic issues and determining their relative significance. The identified challenges are classified into five main categories: organizational, cultural and human attitudes, technical, governmental and regulatory, and financial. A total of forty-one challenges were recorded, among which twenty-eight were recognized as key obstacles to lean implementation. Moreover, an innovative methodological approach is introduced by focusing on the underlying causes rather than superficial manifestations of lean construction barriers in developing contexts. The findings offer valuable insights for policymakers, project managers, and industry stakeholders, enabling the formulation of targeted strategies that address systemic obstacles, promote organizational transformation, and establish a conducive environment for the effective implementation of lean practices.

Keywords-lean construction; Root Cause Analysis (RCA); pareto analysis; fishbone diagram; 5-Whys

I. INTRODUCTION

The construction industry, similar to other industrial sectors, strives to enhance performance, minimize resource waste, reduce costs, and mitigate adverse environmental impacts. To achieve these objectives, the Lean Construction approach has been increasingly adopted and implemented [1, 2], although, the construction sector continues to face numerous challenges that hinder its effective realization.

Authors in [3] revealed that most studies across different countries have identified similar barriers to Lean project implementation, including deficiencies in organizational culture, human attitudes, and insufficient communication among employers, suppliers, designers, and other stakeholders. In Morocco, the primary obstacles to Lean implementation were inadequate funding, limited skilled labor, and a general lack of awareness regarding Lean methodologies [4]. In [5], twenty-seven barriers were identified in Turkey, the most critical of which were the absence of governmental support, limited expertise, unclear understanding of Lean requirements, and insufficient information sharing and integrated change control mechanisms.

Design-related issues also contradict the fundamental objectives of Lean implementation. One of the core principles of Lean is the waste minimization through improved time and work efficiency, which often conflicts with design-construction inconsistencies that result in rework and project delays [6]. Within the Jordanian construction sector, incomplete or inaccurate designs and the limited application of design-and-build procurement methods were considered major obstacles to Lean adoption [7].

Across many countries, the adoption of Lean practices has also been constrained by challenges associated with material procurement and delivery systems, irrespective of a nation's level of economic development. Authors in [8] pointed to the persistence of traditional material procurement methods in Germany, while in Uganda, supply chain uncertainty, inadequate planning, and weak long-term relationships with suppliers were also reported as major impediments within the construction industry [9].

Although nations, such as the United States and China, have successfully integrated Lean principles into numerous projects, certain technical challenges persist, such as the absence of comprehensive performance measurement systems and the high workforce turnover rates [3]. Moreover, inadequate soft skills and limited knowledge of Lean techniques among civil engineering graduates have further exacerbated implementation barriers [10].

In the Kurdistan Region, there is limited research on the obstacles associated with Lean Construction implementation. Authors in [11] examined the application of Lean concepts and the Last Planner System (LPS), identifying key factors restricting their utilization, while in [12] the Analytic Hierarchy Process (AHP) was applied to evaluate and rank Lean-related challenges based on their significance. Additionally, authors in [13, 14] analyzed Lean practices within the manufacturing sector in the Kurdistan Region, outlining both the potential benefits and the challenges inhibiting their effective execution.

Research in the Kurdistan Region has primarily relied on traditional problem-solving techniques, with no evidence of the systematic application of RCA methods for identifying and classifying the Lean Construction challenges.

The present research provides a novel contribution by applying RCA techniques to examine Lean Construction challenges in the Kurdistan Region. It aims to address the gaps identified in previous research by investigating and ranking major Lean Construction barriers in the Kurdistan Region using the Relative Importance Index (RII) method. Furthermore, it seeks to uncover the underlying causes of these challenges through RCA, thereby establishing a robust framework to support the mitigation of Lean implementation barriers throughout the project life cycle.

II. METHODOLOGY – QUESTIONNAIRE DESIGN

Google Scholar was utilized as the main database for retrieving scholarly articles relevant with the primary barriers affecting the adoption of Lean principles within the global construction industry. To ensure the main study's feasibility and reliability, a pilot study was carried out that simulated all key research procedures and verified the inclusion and exclusion criteria of the respondents [15]. The main challenges identified from the literature review were presented in person to a group of experienced civil engineers occupying various professional positions, including project managers, site engineers, office engineers, and an initial draft questionnaire was developed for the pilot phase. According to [16], a pilot study may be designed as either an internal component of the main research or as an external standalone study. In this research, an internal pilot study approach was employed.

A total of sixty Lean-related challenges were classified into five principal categories: organizational, technical, cultural and human attitudes, governmental and regulatory, and financial. These items were reviewed and refined by a panel of seven experts, specialized in construction management, material management, and environmental management, representing both academic and industry backgrounds in civil engineering (Figure 1).

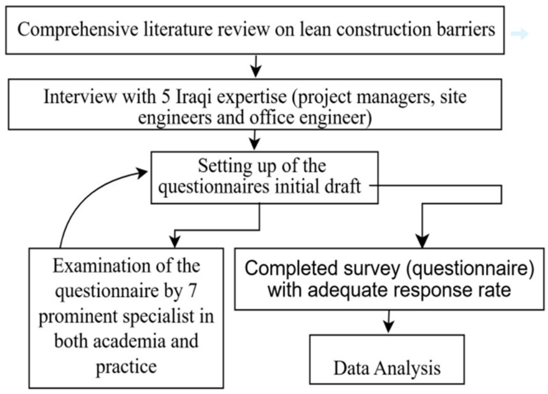

Fig. 1. Study outline.

To ensure that the questionnaire components accurately represented the intended constructs, Lawshe's Content Validity Ratio (CVR) was applied through:

$$CVR = \frac{n_e - \frac{N}{2}}{\frac{N}{2}} \quad (1)$$

where n_e is the number of experts who rated the challenge as "essential" or "appropriate" for inclusion and the total number of experts in this study N=7.

Based on Lawshe's table and the number of participating experts, a minimum CVR value of 0.99 was adopted as the acceptance threshold [17]. Following the experts' evaluation and CVR results, forty-one challenges were retained for inclusion in the main questionnaire, representing those most compatible with the construction context of the Kurdistan Region. Integrating pilot data into the main study had a positive impact, as it shortened the overall research duration and optimized participant engagement.

For the final questionnaire, a five-point Likert scale was employed to assess the perceived significance of Lean Construction barriers, where: 1=Strongly Does Not Impact, 2=Does Not Impact, 3=Neutral Impact, 4=Significant Impact, and 5=Strongly Significant Impact.

The internal consistency and reliability of the questionnaire were evaluated using one of the most widely applied reliability indicators, the Cronbach's Alpha (α). The value obtained was 0.90, indicating excellent internal consistency, as it was greater than 0.70, which is generally considered acceptable [18].

The research was conducted across four provinces of the Kurdistan Region: Erbil, Sulaymaniyah, Duhok, and Kirkuk. The minimum required sample size was determined using the Krejcie and Morgan table for a population of 40,000, which proposes a sample of 380 participants [19]. The final valid sample consisted of 385 respondents, satisfying the required threshold. A simple random probabilistic sampling technique was applied to ensure representativeness.

More than 420 questionnaires were distributed among engineers specializing in various fields. Of these, 385 were returned and deemed valid, while the remaining responses were excluded due to incomplete or inconsistent answers. The questionnaire comprised three sections: A cover letter describing the purpose of the study, demographic information of respondents, and items related to Lean practices and Lean Construction challenges.

Among the respondents, 327 participants reported not adopting Lean principles in their current projects and were asked to rate the barriers preventing adoption. The questionnaires were distributed both manually and electronically, with particular attention given to ensuring that participants clearly understood the content and terminology.

All collected data were carefully organized, verified, and prepared for subsequent statistical analysis.

III. DATA ANALYSIS

RCA techniques were employed to investigate the underlying factors impeding the adoption of Lean Construction within the building sector. Five primary categories of barriers were identified: organizational, financial, technical, cultural and human attitudes, and governmental and regulatory obstacles. Each category includes several sub-causes that collectively provide an understanding of the challenges faced in implementing Lean principles. To explore these root causes, several analytical tools were employed, including fishbone diagrams, Pareto charts, and the 5-Why analysis. These methods can enhance creative cognition and systematically identify the underlying causes of complex issues [20].

A. Fishbone Diagram

The Fishbone Diagram, also known as the Ishikawa Diagram or Cause-and-Effect Diagram, was developed by Professor Kaoru Ishikawa in the 1960s as part of the quality management process at the Kawasaki Shipyards [21]. It remains one of the seven fundamental quality control tools used to visually organize and analyze the causes contributing to a specific problem. The diagram's structure resembles a fish skeleton, with the central "spine" representing the problem and the "bones" representing possible causes [20]. Through this method, the relationships between seemingly unrelated factors can be visualized and systematically analyzed. Each main category and its sub-causes are organized in a hierarchical structure, allowing the identification of the contributing factors and their interconnections [22].

The construction of a fishbone diagram facilitates the identification of areas where data should be collected and serves as an effective tool for recognizing root causes through a structured and visual process. Figure 2 illustrates the developed Ishikawa diagram for the five main and associated sub-challenges related to Lean Construction implementation.

B. Pareto Diagram

The Pareto Diagram, or Pareto Analysis, originated from the work of the Italian economist Vilfredo Pareto in the 19th century [20]. It is a bar chart-based tool that follows the 80–20 principle, which states that approximately 80% of problems are often caused by 20% of the most significant factors [22].

In this research, the Pareto chart was utilized to rank and classify the causes hindering Lean Construction adoption into the five principal groups. A supporting table was developed to list all challenges along with their corresponding impact percentages, arranged in descending order. The cumulative percentage of these impacts was plotted on a secondary line graph, where the x-axis represented the causes and the y-axis represented the cumulative values. The bar chart and cumulative line were then combined on the same figure. A horizontal line was drawn at the 80% level on the y-axis, intersecting the cumulative curve. From this intersection, a vertical line was extended down to the x-axis to distinguish the major challenges (on the left) from the minor ones (on the right).

This visualization method allows decision makers to effectively identify the few critical causes that must be addressed to solve most problems and, more specifically, address the 20% of root causes that are responsible for approximately 80% of the challenges.

C. 5-Why Analysis

The 5-Why Analysis method was developed by Sakichi Toyoda, founder of Toyota Industries, and has since become an integral component of the Toyota Production System (TPS) [23]. The technique is widely applied in Lean production and problem-solving due to its strong capability to trace complex and intertwined causes back to their root origins. While it can be used independently, the 5-Why method is often combined with other analytical tools, such as the Fishbone Diagram or Pareto Chart, to enhance the diagnostic accuracy. The approach follows an iterative questioning process that supports a logical and systematic investigation of cause-and-effect relationships, ensuring that efforts are directed toward addressing fundamental rather than superficial issues:

1. Define the problem: Clearly identify the issue under investigation. In the current study, the highest-ranked barriers from each category were defined as the key issues affecting Lean Construction implementation.

2. Ask "Why?" to determine the initial cause of the problem.

3. Repeat the "Why?" question iteratively, typically five times, to probe deeper into the underlying causes.
4. Stop when the true root cause has been reached, that is, when further questioning no longer yields new insights.
5. Implement corrective actions based on the identified root cause to prevent recurrence of the problem.

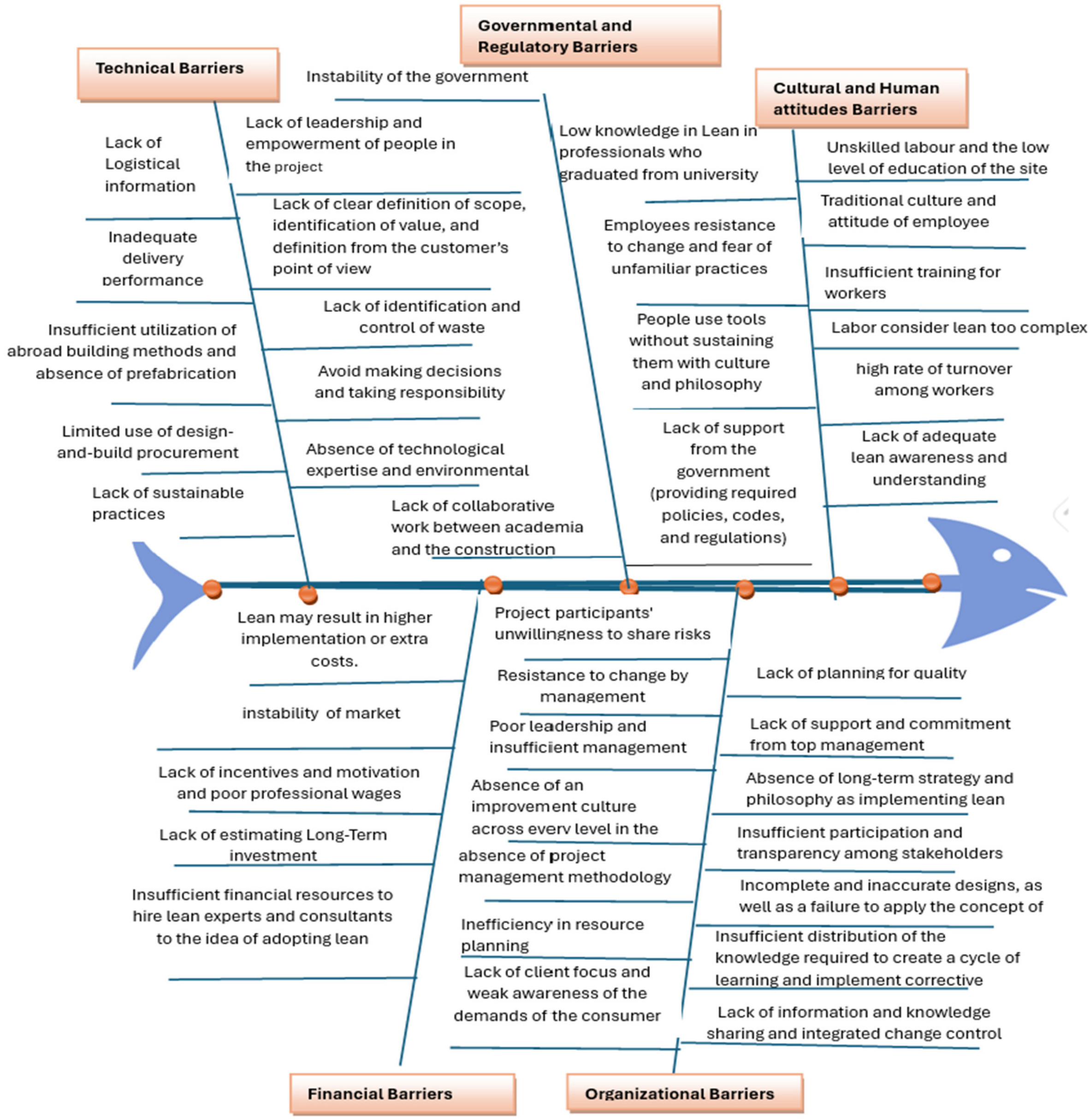

Fig. 2. Ishikawa diagram for the five main and sub-challenges for implementing Lean Construction.

IV. RESULTS AND DISCUSSION

The collected data were quantitatively analyzed using statistical techniques similar to those adopted in [24], and the impact degree and arithmetic mean of each challenge were observed (Table I). Based on the RII, the main and sub-challenges that hinder the implementation of Lean Construction were ranked. RCA was applied to identify the key contributors at both the main and sub-category levels (Figure 2). The Pareto chart of Figure 3 is based on weighted mean, relative importance, and the ranking of the main challenges (Table II). The Governmental and Regulatory challenges ranked first among the main categories, with an RII of 22.29%, followed by Financial challenges with an RII value of 21.91%. The lowestranked category was Cultural and Human Attitudes, with an RII of 16.39%. The intersection of the cumulative frequency curve with the 80% reference line indicates that Governmental and Regulatory, Financial, and Technical challenges constitute the most critical barriers requiring immediate attention.

TABLE I. IMPACT DEGREE AND ARITHMETICAL MEAN FOR LEAN CONSTRUCTION CHALLENGES

Challenges	Symbol	Frequency					Arithmetic mean
		10	30	50	70	90	
Organizational Challenges (C1)							
Lack of client focus and weak awareness of the demands of the consumer	C1-1	25	76	96	80	50	53.30
Resistance to change by management	C1-2	41	125	59	82	20	44.80
Absence of commitment and support from top management	C1-3	3	16	74	136	98	68.96
Insufficient participation and transparency among stakeholders	C1-4	5	42	126	115	39	58.62
Absence of project management methodology	C1-5	1	11	38	135	142	74.83
Incomplete and inaccurate designs, as well as a failure to apply the concept of design constructability	C1-6	1	20	95	162	49	64.56
Project participants' unwillingness to share risks	C1-7	11	46	127	108	35	56.73
Absence of long-term strategy and philosophy while implementing Lean	C1-8	9	38	70	148	62	63.21
Lack of planning for quality	C1-9	2	17	101	158	49	64.37
Poor leadership and insufficient management skills	C1-10	2	17	87	168	53	65.47
Lack of information and knowledge sharing, and integrated change control	C1-11	3	56	136	98	34	56.36
Insufficient distribution of the knowledge required to create a cycle of learning and implement corrective actions	C1-12	5	68	145	77	32	53.85
Absence of an improvement culture across every level in the company	C1-13	8	18	127	142	32	60.52
Inefficiency in resource planning	C1-14	6	20	115	143	43	62.05
Cultural and Human Attitudes (C2)							
Employees' resistance to change and fear of unfamiliar practices	C2-1	30	126	70	75	26	46.39
Unskilled labor and the low level of education of the site foreman	C2-2	5	23	70	75	26	36.18
Insufficient training for workers	C2-3	6	45	99	137	40	59.79
Labor is considering lean too complex	C2-4	115	82	50	59	21	37.09
High rate of turnover among workers	C2-5	6	19	49	142	111	70.37
Low knowledge of Lean among professionals who are university graduates	C2-6	17	89	110	79	32	51.22
Traditional culture and attitude of employees	C2-7	6	35	153	105	28	56.97
People use tools without sustaining them with culture and philosophy	C2-8	28	125	80	77	17	45.72
Lack of adequate lean awareness and understanding	C2-9	3	40	114	132	38	59.91
Technical Challenges (C3)							
Inadequate delivery performance	C3-1	3	39	166	92	27	56.18
Lack of leadership and empowerment of people in the project	C3-2	1	11	96	186	33	64.62
Insufficient utilization of abroad building methods and absence of prefabrication	C3-3	1	20	94	139	73	66.09
Lack of identification and control of waste	C3-4	3	10	49	97	168	75.50
Limited use of design-and-build procurement	C3-5	4	22	121	139	41	61.68
Lack of Logistical information	C3-6	5	25	90	123	84	65.66
Lack of clear definition of scope, identification of value, and definition from the customer's point of view	C3-7	2	33	131	115	46	60.40
Absence of technological expertise and environmental efforts	C3-8	3	52	123	114	35	57.71
Lack of sustainable practices	C3-9	3	15	79	158	72	67.19
Avoiding making decisions and taking responsibility	C3-10	20	80	52	94	81	58.32
Governmental and Regulatory Challenges (C4)							
Government instability	C4-1	5	15	49	139	119	71.53
Lack of support from the government (providing required policies, codes, and regulations)	C4-2	2	35	112	120	58	62.05
Lack of collaborative work between academia and the construction industry	C4-3	6	13	28	100	180	76.61
Financial challenges (C5)							
Lean may result in higher implementation or extra costs	C5-1	3	22	76	118	108	68.72
Insufficient financial resources to hire Lean experts and consultants	C5-2	5	9	67	152	94	69.63
Lack of incentives and motivation, and poor professional wages	C5-3	3	13	37	134	140	74.16
Lack of estimating long-term investment	C5-4	6	11	67	132	111	70.24
Instability of the market	C5-5	7	38	103	115	64	61.68

A. Organizational Challenges

Fourteen organizational challenges were identified through the fishbone (Figure 4). The absence of project management methodology ranked as the most significant barrier with RII=8.83%, followed by lack of commitment and support from top management, with an RII value of 8.14%, and poor leadership and insufficient management skills with RII=7.72% (Table III). The Pareto analysis (Figure 5) shows that seven additional barriers are particularly influential and should be prioritized: Insufficient participation and transparency among stakeholders, unwillingness of project participants to share risks, incomplete and inaccurate designs, inefficient resource planning, poor quality planning, lack of an improvement culture, and absence of a long-term strategy for lean implementation.

TABLE II. WEIGHTED MEAN RELATIVE IMPORTANCE AND RANKING OF THE MAIN CHALLENGES

Symbols	Arithmetic mean	Average weights	RII%	Rank
Organizational challenges (C1)				
C1-1	53.30	60.55	19.26	4
C1-2	44.80			
C1-3	68.96			
C1-4	58.62			
C1-5	74.83			
C1-6	64.56			
C1-7	56.73			
C1-8	63.21			
C1-9	64.37			
C1-10	65.47			
C1-11	56.36			
C1-12	53.85			
C1-13	60.52			
C1-14	62.05			
Cultural and human attitudes (C2)				
C2-1	46.39	51.52	16.39	5
C2-2	36.18			
C2-3	59.79			
C2-4	37.09			
C2-5	70.37			
C2-6	51.22			
C2-7	56.97			
C2-8	45.72			
C2-9	59.91			
Technical challenges (C3)				
C3-1	56.18	63.33	20.15	3
C3-2	64.62			
C3-3	66.09			
C3-4	75.50			
C3-5	61.68			
C3-6	65.66			
C3-7	60.40			
C3-8	57.71			
C3-9	67.19			
C3-10	58.32			
Governmental and regulatory challenges (C4)				
C4-1	71.53	70.06	22.29	1
C4-2	62.05			
C4-3	76.61			
Financial challenges (C5)				
C5-1	68.72	68.89	21.91	2
C5-2	69.63			
C5-3	74.16			
C5-4	70.24			
C5-5	61.68			

B. Cultural and Human Attitude Challenges

Cultural and Human Attitude Challenges ranked fifth overall, with RII=16.39%, comprising nine significant sub-challenges (Figure 6). The high rate of worker turnover was identified as the top barrier, with RII=15.18%, followed by lack of Lean awareness and understanding, with RII=12.92%, and insufficient worker training, with RII=12.89% (Table IV). The Pareto chart (Figure 7) indicates that additional factors, like traditional work culture, low lean knowledge among recent graduates, and employee resistance to change, are key contributors that must be addressed to overcome human-related barriers.

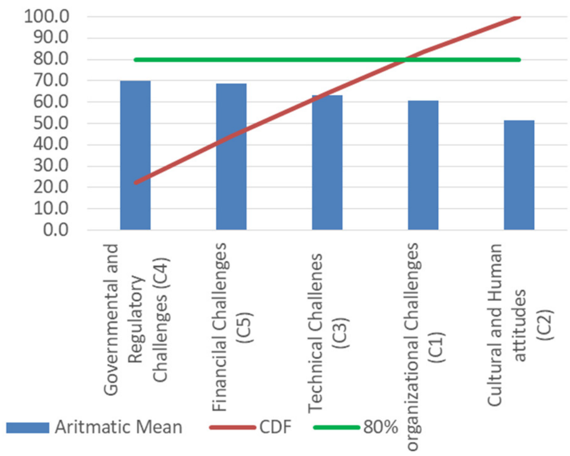

Fig. 3. Pareto chart for the main challenges' categories.

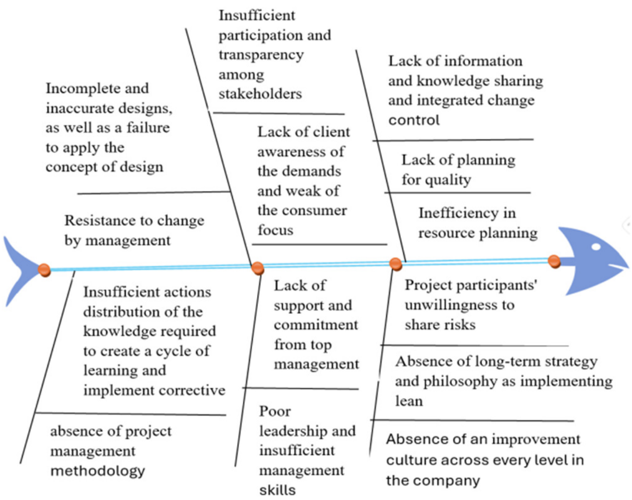

Fig. 4. Fishbone diagram for organizational challenges.

TABLE III. ARITHMETICAL MEAN, RELATIVE IMPORTANCE, AND RANKING FOR ORGANIZATIONAL CHALLENGES

Main challenge	Sub challenge	Arithmetic mean	RII%	Rank
C1	C1-1	53.30	6.29	13
	C1-2	44.80	5.29	14
	C1-3	68.96	8.14	2
	C1-4	58.62	6.92	9
	C1-5	74.83	8.83	1
	C1-6	64.56	7.62	4
	C1-7	56.73	6.69	10
	C1-8	63.21	7.46	6
	C1-9	64.37	7.59	5
	C1-10	65.47	7.72	3
	C1-11	56.36	6.65	11
	C1-12	53.85	6.35	12
	C1-13	60.52	7.14	8
	C1-14	62.05	7.32	7

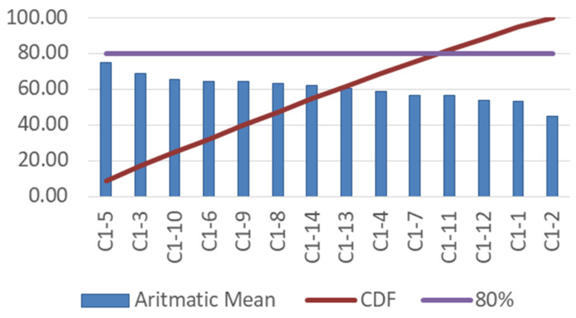

Fig. 5. Pareto chart for organizational challenges' group.

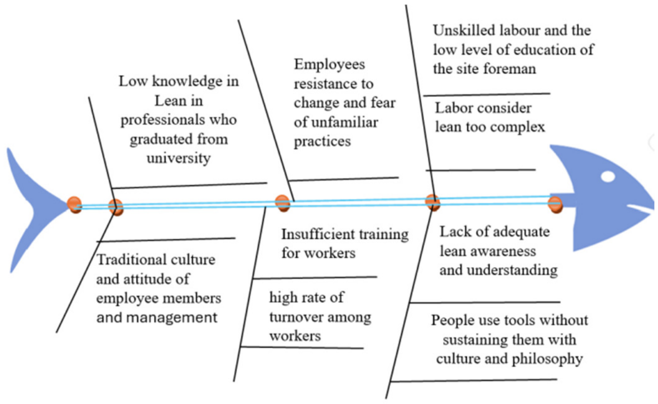

Fig. 6. Fishbone diagram for cultural and human attitudes' challenges.

TABLE IV. ARITHMETICAL MEAN, RELATIVE IMPORTANCE, AND RANKING FOR CULTURAL AND HUMAN ATTITUDES' CHALLENGES

Main challenge	Sub challenge	Arithmetic mean	RII%	Rank
C2	C2-1	46.39	10.01	6
	C2-2	36.18	7.80	9
	C2-3	59.79	12.89	3
	C2-4	37.09	8.00	8
	C2-5	70.37	15.18	1
	C2-6	51.22	11.05	5
	C2-7	56.97	12.29	4
	C2-8	45.72	9.86	7
	C2-9	59.91	12.92	2

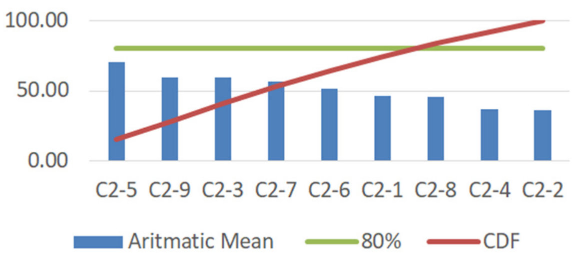

Fig. 7. Pareto chart for cultural and human attitude group challenges.

C. Technical Challenges

Among the main technical barriers identified (Figure 8), the lack of waste identification and control obtained the highest RII, with a value of 11.92%, directly opposing one of the Lean Construction's core principles, the waste elimination. Other major barriers include the lack of sustainable practices, with RII=10.61% and the limited use of modern building methods, such as prefabrication, with RII=10.43% (Table V).

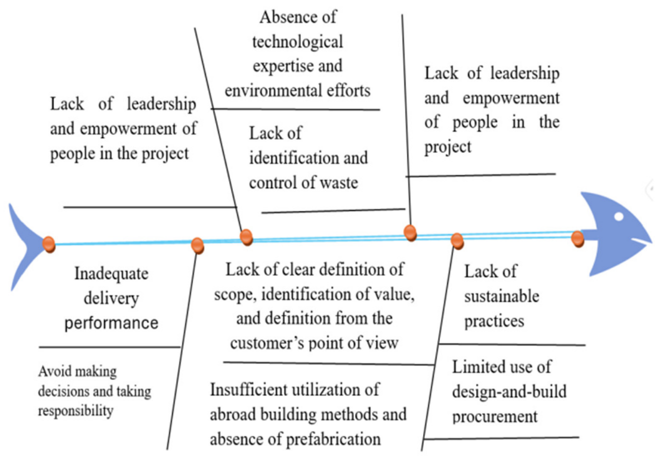

Fig. 8. Fishbone diagram for technical challenges.

TABLE V. ARITHMETICAL MEAN, RELATIVE IMPORTANCE, AND RANKING FOR TECHNICAL CHALLENGES

Main challenge	Sub challenge	Arithmetic mean	RII%	Rank
C3	C3-1	56.18	8.87	10
	C3-2	64.62	10.20	5
	C3-3	66.09	10.43	3
	C3-4	75.50	11.92	1
	C3-5	61.68	9.74	6
	C3-6	65.66	10.37	4
	C3-7	60.40	9.54	7
	C3-8	57.71	9.11	9
	C3-9	67.19	10.61	2
	C3-10	58.32	9.21	8

The Pareto chart (Figure 9) further emphasizes five key issues: lack of logistical information, insufficient leadership and empowerment, limited use of design-build procurement, unclear project scope and value definition, and avoidance of responsibility. Addressing these issues would alleviate most technical challenges affecting the Lean adoption.

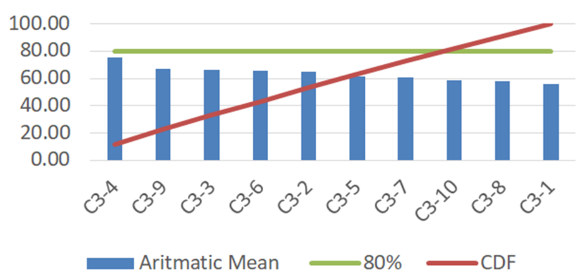

Fig. 9. Pareto chart for technical group challenges.

D. Governmental and Regulatory Challenges

Governmental and Regulatory Challenges ranked as the most significant overall. The Ishikawa diagram (Figure 10) identifies three main barriers: lack of collaboration between the academia and the construction industry, with RII=36.45%, governmental instability, with RII=34.03%, and lack of supportive policies, codes, and regulations, with RII=29.52% (Table VI).

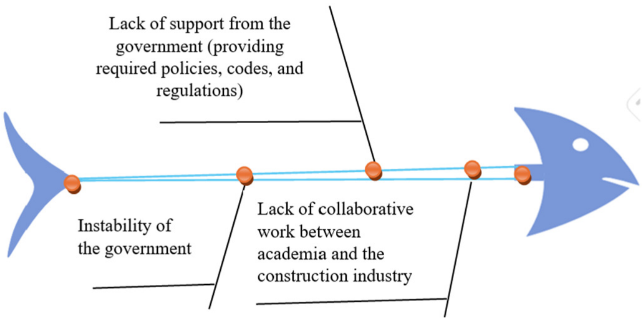

Fig. 10. Fishbone diagram for governmental and regulatory challenges.

TABLE VI. ARITHMETICAL MEAN, RELATIVE IMPORTANCE, AND RANKING FOR GOVERNMENTAL AND REGULATORY CHALLENGES

Main challenge	Sub challenge	Arithmetic mean	RII%	Rank
C4	C4-1	71.53	34.03	2
	C4-2	62.05	29.52	3
	C4-3	76.61	36.45	1

The respondents emphasized that research and academic outputs often remain theoretical, with limited industry application due to weak institutional linkages. The Kurdistan Regional Government (KRG), though semi-autonomous, relies heavily on Iraqi national laws and policies that do not align with Lean Construction frameworks. The intersection of the 80% line with the cumulative curve (Figure 11) confirms that C4-3 and C4-1 are the most critical factors to be addressed for regional improvement.

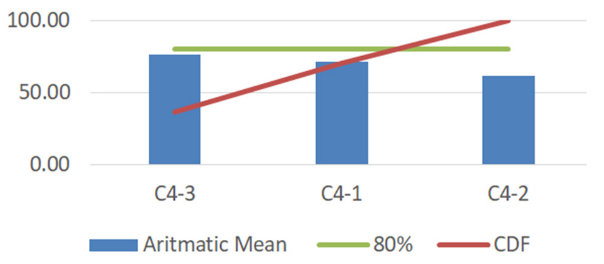

Fig. 11. Pareto chart for governmental and regulatory group challenges.

E. Financial Challenges

Financial challenges ranked second overall (Figure 3). The Ishikawa diagram (Figure 12) shows that the lack of incentives and poor professional wages are the most significant financial barriers, with RII=21.53% (Table VII). The traditional focus on cost, time, and quality discourages innovation and Lean implementation when financial rewards and recognition are absent. Lack of long-term investment ranked second, with RII=20.39%, reflecting stakeholders' hesitation to invest without tangible cost savings or evidence of successful Lean projects. Additional financial barriers include insufficient funds to hire lean consultants and the perception of high implementation costs. Market instability driven by inflation, fluctuating material prices, and uncertain workloads, further amplifies these issues. The Pareto chart (Figure 13) highlights that addressing these top causes could resolve 80% of financial-related barriers.

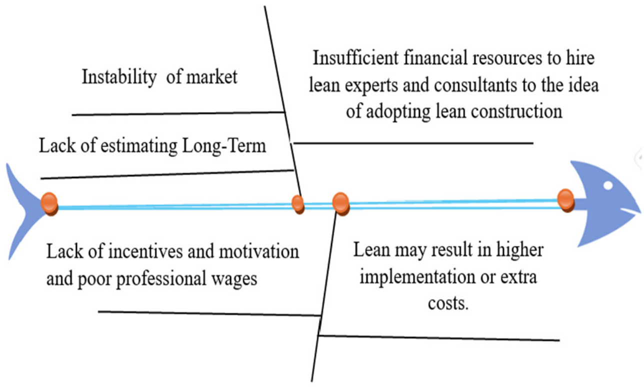

Fig. 12. Fishbone diagram for financial challenges.

TABLE VII. ARITHMETICAL MEAN, RELATIVE IMPORTANCE, AND RANKING FOR FINANCIAL CHALLENGES

Main challenge	Sub challenge	Arithmetic mean	RII%	Rank
C5	C5-1	68.72	19.95	4
	C5-2	69.63	20.22	3
	C5-3	74.16	21.53	1
	C5-4	70.24	20.39	2
	C5-5	61.68	17.91	5

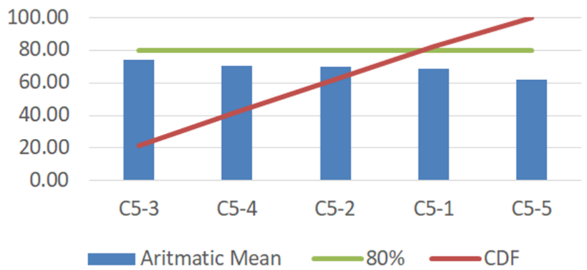

Fig. 13. Pareto chart for financial group challenges.

F. 5-Whys

This study is the first to apply RCA techniques to identify Lean Construction challenges in the Kurdistan Region. The 5-Whys method was used after determining 28 significant challenges out of a total of 41 (Table VIII). The key root causes include:

- Organizational Barriers: Lack of successful Lean implementation examples and limited exposure to standardized project management methods.
- Cultural and Human Barriers: Absence of daily on-site planning, leading to worker dissatisfaction, rework, and resistance to change.
- Technical Barriers: Lean principles are not formally embedded in project management policies or engineering education.
- Governmental Barriers: Lack of innovation prioritization and weak academia–industry collaboration due to outdated regulations.
- Financial Barriers: Absence of incentive programs and rigid administrative structures that resist change.

These findings highlight that overcoming Lean Construction barriers in the Kurdistan Region requires a systemic transformation that includes educational reform, stronger industry, together with government collaboration, and the institutionalization of Lean principles within project management and construction policies.

TABLE VIII. ROOT CAUSES' ANALYSIS OF 28 SIGNIFICANT CHALLENGES

1st Why?	2nd Why?	3rd Why?	4th Why?	5th Why?	Root of the challenges
Main challenge: Not implementing Lean Construction in Kurdistan region's construction industry					
Identify 14 Organizational barriers	Absence of project management methodology	Project team is not trained or required to follow standardized frameworks, like WBS, schedule baseline, risk registry, etc.	Governmental agencies promote the use of modern project management methods	Decision makers' lack of awareness	Limited exposure, few success stories, and no incentive to adopt the best practice
Identify 9 Cultural and Human attitudes barriers	High turnover among workers	Workers are dissatisfied with working conditions	There is a constant rework, unclear daily tasks, and pressure due to last-minute changes		No daily planning system on site
Identify 10 Technical barriers	Lack of identification and control of waste	The project team does not use tools or systems to control or eliminate waste	There is no training in Lean principles or waste identification, like value stream mapping	Lean Construction is not embedded in the project management standard, engineering practices, or construction education	Governmental institutions and ministries do not adopt Lean as a formal part of policy and contract
Identify 3 Governmental and Regulatory barriers	Lack of collaboration between academia and the construction industry	Academic research is disconnected from the real project needs and industry challenges	There is no structured platform or governmental policy to promote research internships and knowledge transfer		Government planning agency and ministry have not prioritized innovation or industry-academia collaboration
Identifying 5 Financial barriers	Lack of incentives and motivation, and poor professional wages	Professional wages are low and do not reward extra effort or innovative ideas	The governmental institutions have a fixed salary scale without a performance-based reward	Financial regulations do not include incentive programs for Lean application due to their high initial cost	Administrative culture resists change

V. CONCLUSIONS

The current study identified and analyzed the principal barriers impeding the implementation of Lean Construction in the Kurdistan Region of Iraq. Root Cause Analysis (RCA) techniques were employed to diagnose, categorize, and prioritize these challenges according to their Relative Importance Index (RII). Based on the fishbone diagram, a total of forty-one barriers were initially identified, twenty-eight of which were recognized as major challenges through the Pareto analysis.

The findings revealed that ten significant barriers belonged to the Organizational category, followed by nine related to the Cultural and Human attitudes. Seven challenges were classified under the Technical group, while the Governmental and Regulatory category emerged as the most influential group. The two dominant challenges in this group were identified as the lack of collaboration between academia and the construction industry, and insufficient governmental support in providing the required policies, codes, and regulations. Furthermore, the root causes underlying most financial challenges were linked to an administrative culture resistant to change. The principal root causes identified across all categories included the limited exposure to Lean practices, absence of success stories or incentives for best-practice adoption, lack of daily planning systems on-site, exclusion of Lean principles from formal project policies and contracts, and minimal prioritization of innovation and academia–industry collaboration by governmental institutions.

Unlike prior studies, this research provides empirical evidence from the Kurdistan Region, offering a systematic RCA-based approach to uncovering the underlying causes of Lean implementation barriers. The findings contribute to both theory and practice by emphasizing the importance of addressing systemic issues rather than surface-level obstacles. Although regionally focused, the results have a broader applicability to developing economies with similar construction environments. The application of RCA not only deepens the understanding of the Lean barriers but also presents a replicable framework that can be adapted in other regional contexts. By examining Lean implementation in a developing construction market, the study distinguishes between universal and context-specific factors, thereby providing transferable insights for other developing nations. Moreover, it strengthens the international discourse on Lean–sustainability integration by linking Lean barriers with efficiency and environmental performance outcomes.

The study was limited to the Kurdistan Region, located in northern Iraq. Future research could extend this analysis to central and southern Iraqi cities, where differing construction practices, budgets, and governance systems may yield additional insights. Addressing Lean implementation barriers requires continuous collaboration among policymakers, academia, and industry stakeholders. Practical actions, such as training programs, awareness workshops, and pilot Lean projects, are proposed to test and evaluate potential solutions. Further research may employ advanced analytical methods, such as Structural Equation Modeling (SEM), to explore the causal relationships between the Lean barriers, root causes, and project performance. Additionally, integrating Lean principles with sustainability frameworks could reveal new opportunities for reducing waste, conserving energy, and improving productivity. Finally, a longitudinal replication of this study is proposed to monitor the evolution of Lean adoption as the Kurdistan construction industry matures.

DATA AVAILABILITY

The datasets created and/or analyzed during the current study are available from the corresponding author on reasonable request.

ACKNOWLEDGMENT

The authors express their sincere appreciation to the Civil Engineering Department, College of Engineering, Salahaddin University, Kurdistan Region, Iraq, for providing the facilities and support necessary to accomplish this research. This work was financially supported by the Postgraduate Research Grant (PGRG) No. SU.G/2023/HIR/MOHE/ENG/39 (12-53-9).

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