Evaluation of Lean Construction Practices for Enhanced Project Delivery in Faridabad District, Delhi NCR

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ABSTRACT

This study evaluates the adoption and effectiveness of lean construction practices in improving project delivery within Faridabad District, Delhi NCR. Utilizing a structured, data-driven methodology, the research gathered insights from key stakeholders Property Surveyors, Clients, Civil Engineers, and Project Managers to assess the perception, prioritization, and implementation of lean principles. Results highlight widespread recognition of lean's benefits, particularly in reducing waste, promoting sustainability, and enhancing workflow. However, stakeholder-specific priorities underscore the need for role-based strategy alignment. Barriers such as resistance to change, inadequate training, and rigid organizational structures were also identified, indicating the necessity of cultural and operational transformation for successful lean adoption.

Key Words: *Lean Construction, Stakeholder Perception, Project Delivery Efficiency.*

1. INTRODUCTION

Lean Construction

Lean construction is a management philosophy that focuses on reducing waste, promoting ongoing improvement, and enhancing value delivered to clients. Originating from the Toyota Production System (TPS) principles, it transforms conventional construction methods by prioritizing efficiency gains through improved planning, coordination, and communication among all parties involved in a project. Unlike conventional construction methods that often rely on rigid scheduling and hierarchical project management, lean construction advocates for a more integrated and flexible approach that aligns all activities with the end goal of value creation. Key lean techniques include:

i) Just-in-Time (JIT) delivery of materials to minimize inventory costs.
ii) Last Planner System (LPS) to improve short-term planning reliability.
iii) Pull Planning to ensure that work is only undertaken when the necessary inputs are available.
iv) Value Stream Mapping to visualize and eliminate non-value-adding steps.

Figure 1: Lean Construction

Lean construction enables a shift from reactive problem-solving to proactive process control, ultimately reducing delays, rework, and cost overruns while enhancing collaboration, safety, and quality. The image illustrates the core principles of Lean Construction, emphasizing the eight primary forms of waste that the methodology seeks to eliminate in construction workflows. These wastes are crucial targets for optimization to enhance project efficiency, reduce costs, and improve overall value delivery. The Spanish terms represented in the graphic translate as follows

Sobreproducción (Overproduction) – Producing more than needed or earlier than required.
Retraso (Delays) – Time lost due to waiting for materials, approvals, or equipment.
Talento No Usado (Underutilized Talent) – Failing to leverage workers' skills and knowledge.
Transportación (Transportation) – Unnecessary movement of materials or equipment.
Sobre Procesos (Over-processing) – Doing more work than necessary or redundant steps.
Movimiento (Unnecessary Motion) – Excessive movement by workers due to poor layout or planning.
Sobre Inventario (Overstocking) – Holding more materials or supplies than currently needed.
Defectos (Defects) – Errors or reworks that reduce quality and increase costs.

At the centre lies Lean Construction, promoting continuous improvement and value-driven processes. This visual encapsulates the core philosophy of lean: to minimize waste in all its forms and ensure that every step contributes meaningfully to the project outcome. Through targeting these inefficiencies, lean construction facilitates better workflow, resource use, and stakeholder satisfaction in projects especially crucial in large-scale endeavours.

2. RESEARCH METHODOLOGY

This chapter presents the research methodology used to assess the implementation and effects of lean construction practices on project execution in the Faridabad District of Delhi NCR. A mixed-methods approach—incorporating both quantitative and qualitative techniques—was employed to gain comprehensive insights into the application, benefits, and challenges of lean construction. The section further details the research framework, participant selection process, tools for data gathering, analytical methods, and ethical protocols followed throughout the study.

Research Design: The study employs a descriptive and analytical research design. As a cross-sectional investigation, it captures the current state of lean construction practices at a specific moment. Data for the research was gathered from both primary sources—such as structured questionnaires and interviews—and secondary sources, including academic publications, institutional documents, and case studies.

Study Area: The study is conducted in Faridabad District, a key industrial hub in the Delhi NCR (National Capital Region) of India. The region has experienced significant infrastructure development in recent decades, with a high density of ongoing residential, commercial, and public infrastructure projects. Faridabad was chosen due to its urban setting, access to skilled professionals, and growing construction demands.

Population and Sample: The **target population** includes professionals directly involved in construction projects within the district, namely:

- Civil Engineers
- Project Managers
- Property Surveyors / Estate Managers
- Clients / Developers

A sample size of 105 respondents was determined using a purposive and stratified sampling technique to ensure adequate representation from each professional group.

Sampling Technique

Purposive Sampling: Purposive sampling was used to select specific construction projects based on their relevance, scale, and documentation accessibility. Projects selected included residential buildings, road works, and public infrastructure works.

Stratified Sampling: The respondents were stratified into professional categories. From each category, participants were randomly selected to ensure proportionate representation. This stratified approach helped in capturing diverse perspectives across disciplines.

Data Collection Instruments

To ensure the robustness of the data, the following instruments were used:

- **Structured Questionnaire**: A 5-point Likert scale was used to rate the importance and impact of various lean construction factors. The questionnaire was segmented into demographic details, knowledge of lean principles, implementation challenges, and perceived benefits.
- **Interviews**: Semi-structured interviews were conducted with a subset of respondents to collect qualitative insights and validate the survey findings.
- **Document Analysis**: Reports, tender documents, and progress charts from selected projects were analysed to correlate the self-reported data with project performance indicators.

Data Analysis Techniques

Two main statistical methods were used:

Relative Importance Index (RII)

The RII method was used to rank factors influencing lean construction adoption and benefits. RII is calculated as:

$$RII = \frac{\sum W}{A \times N}$$

Where,

W = weight given to each factor by respondents (1 to 5)
A = highest weight (i.e., 5)
N = total number of respondents

Spearman's Rank Correlation Coefficient

This non-parametric measure was employed to determine the degree of agreement between respondent groups (e.g., between clients and engineers). It is calculated as:

$$\rho = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Where d = difference between ranks of variables, and n = number of variables.

Graphical Representation

Bar graphs and matrix plots were generated using MS Excel and Python to visually interpret the RII rankings and correlation outputs.

Validity and Reliability

To enhance **validity**, the questionnaire was pre-tested with five industry professionals and adjusted for clarity and relevance. **Reliability** was ensured through the use of standardized tools and consistency in the administration process. Cronbach's alpha was also calculated and found to be above 0.7 for internal consistency.

Research Objectives

- To evaluate the adoption level and awareness of lean construction principles among construction professionals in Faridabad District.
- To identify the challenges and barriers hindering the effective implementation of lean construction practices in large-scale construction projects.
- To analyse the impact of lean construction practices on key project performance indicators such as cost control, waste reduction, sustainability, and client satisfaction.

Limitations of the Study

- The cross-sectional nature of the study limits long-term analysis.
- The findings may not be generalized to other districts without contextual adaptation.
- Availability of data and willingness of respondents varied across projects.

3. DATA ANALYSIS AND RESULT

This Chapter presents a comprehensive analysis of the data collected for evaluating lean construction practices in improving project delivery within Faridabad District, Delhi, NCR. This chapter synthesizes the responses of 105 participants across diverse professional backgrounds, including Property Surveyors, Clients, Civil Engineers, and Project Managers. The demographic distribution confirms a balanced mix

in terms of gender, age, years of experience, and educational qualifications, ensuring a well-rounded representation of the construction industry. The analysis adopts the Relative Importance Index (RII) methodology to rank critical parameters influencing lean construction. The chapter explores multiple dimensions, including prevailing trends, core principles, implementation challenges, and measurable impacts of lean practices. Key findings reveal widespread support for sustainability, waste reduction, and local material usage, while also exposing gaps such as limited technological adoption and low prioritization of decentralized decision-making. Further, the data highlights contrasting views across professions Civil Engineers stress flow optimization, Project Managers emphasize oversight and variability control, and Clients focus on satisfaction and sustainability. These insights not only underline the complexity of implementing lean practices but also point toward actionable areas for policy and professional development. Overall, this section provides valuable empirical evidence, laying a robust foundation for drawing meaningful conclusions and recommending practical interventions in the subsequent section.

Respondents	**Person: 1**	**Property surveyor/estate**	**Person: 3**	**Clients**	**Person: 5**	**Civil Engineer**	**Person: 7**	**Project Manager**	**Person: 9**	**Total**	**Person: 11**
details		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sex	M	20	64.52	14	58.33	15	62.5	17	65.38	66	62.86
F	11	35.48	10	41.67	9	37.5	9	34.62	39	37.14	
Total	31	100	24	100	24	100	26	100	105	100	
Age	20–35	8	25.81	11	45.8	12	50	9	34.62	40	38.1
36–45	19	61.29	10	41.67	10	41.67	13	50	52	49.52	
46–60	3	9.68	2	8.33	1	4.17	3	11.54	9	8.57	
>60	1	3.23	1	4.17	1	4.17	1	3.85	4	3.81	
Total	31	100	24	100	24	100	26	100	105	100	
Years of experience	0–10	12	38.71	18	75	16	66.67	17	65.38	63	60
11–20.	15	48.39	6	25	7	29.17	6	23.08	34	32.38	
21–30	3	9.68	0	0	1	4.17	2	7.69	6	5.71	
>30	1	3.23	0	0	0	0	1	3.85	2	1.9	
Total	31	100	24	100	24	100	26	100	105	100	
Level of education	Diploma	8	25.81	11	45.83	4	21.05	7	26.92	30	28.57
BSc.	16	51.61	10	41.67	14	73.68	15	57.69	55	52.38	
MSc.	5	16.13	1	4.17	6	31.58	3	11.54	15	14.29	
PhD	2	6.45	2	8.33	0	0	1	3.85	5	4.76	
Total	31	100	24	100	24	100	26	100	105	100	

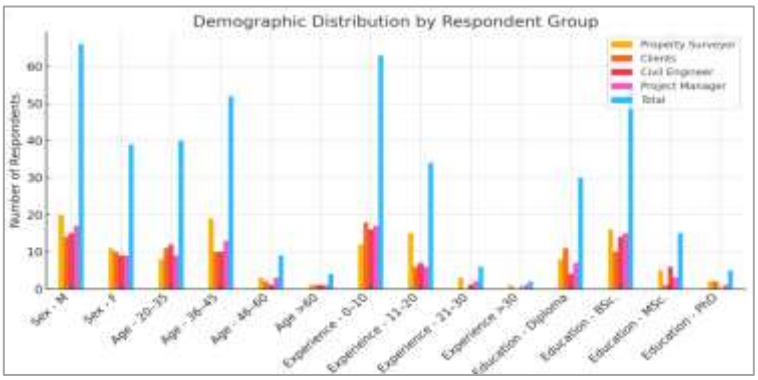

Figure 2: Demographic Distribution by Respondent Group

The demographic profile of the 105 respondents in this study highlights a diverse representation across profession, gender, age, experience, and educational background, which adds credibility and depth to the findings. Males constituted a higher proportion (62.86%) compared to females (37.14%), indicating a male-dominated workforce in the construction sector. In terms of age, the majority (49.52%) fell within the 36–45 age bracket, followed by 38.1% aged 20–35, suggesting a relatively young and experienced workforce. Regarding work experience, a significant portion (60%) had 0–10 years of experience, with 32.38% possessing 11–20 years. This reflects a mix of early-career and mid-level professionals involved in the industry. Only a small percentage (7.61%) had more than 20 years of experience, highlighting fewer senior experts among respondents. The educational qualifications were fairly spread, with over half (52.38%) holding a Bachelor's degree, 28.57% with diplomas, and 14.29% holding a Master's degree. A small group (4.76%) possessed PhDs, indicating the presence of advanced academic knowledge within the respondent group. Overall, this diverse demographic distribution ensures that the insights gathered represent a broad spectrum of perspectives within the construction industry in Faridabad District, Delhi, NCR.

Person: 0	**Property surveyor/ estate**	**Person: 2**	**Clients**	**Person: 4**	**Civil Engineer**	**Person: 6**	**Project Manager**	**Person: 8**	**Average**	**Person: 10**
Factors	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Labour intensive techniques	4.12	3	4.24	2	4.67	1	4.05	4	4.27	3
Limited application of technology	4.67	1	4.08	3	4.11	4	4.49	2	4.34	2
Use of local materials	4.21	2	4.72	1	4.55	2	4.32	3	4.45	1
Building for sustainability	3.92	5	3.81	5	4.12	3	3.88	5	3.93	5
Climate consideration	3.24	6	3.53	6	3.82	5	3.42	6	3.5	6
Project management and oversight	4.05	4	3.93	4	3.79	6	4.72	1	4.12	4

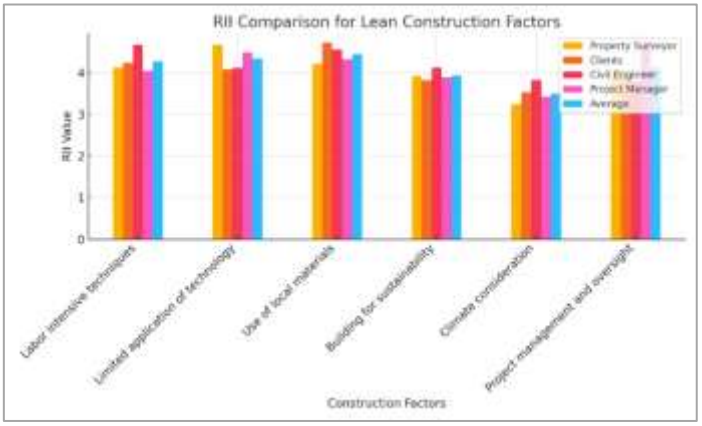

Figure 3: RII Comparison for Lean Construction Factors

The table outlines the Relative Importance Index (RII) rankings of key lean construction trends as perceived by four groups: Property Surveyors, Clients, Civil Engineers, and Project Managers. Among these, "Use of local materials" emerged as the most significant factor overall with an average RII of 4.45, indicating widespread recognition of its value in enhancing sustainability and cost efficiency. This trend was ranked highest by clients, emphasizing their preference for locally sourced and economical building materials.

"Limited application of technology" ranked second (RII 4.34), suggesting that technological gaps are a shared concern across professions, particularly highlighted by Property Surveyors. Civil Engineers rated "Labour-intensive techniques" as the most prominent factor (RII 4.67), reflecting ongoing reliance on manual processes and the potential for inefficiencies.

"Project management and oversight" was rated highest by Project Managers (RII 4.72), underscoring its critical role in ensuring delivery timelines and budget compliance. Conversely, "Climate consideration" received the lowest average RII (3.5), signalling that environmental concerns are not yet a top priority despite growing global sustainability agendas.

Person: 0	**Property surveyor/estate**	**Person: 2**	**Clients**	**Person: 4**	**Civil Engineer**	**Person: 6**	**Project Manager**	**Person: 8**	**Average**	**Person: 10**
Factors	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Value-added activities	4.12	7	3.98	7	4.23	7	4.09	7	4.11	8
Flow and pull	3.96	8	4.04	6	4.76	1	4.38	4	4.29	5
Work in process (WIP) limiting	4.52	2	3.83	9	4.41	5	4.17	6	4.23	6
Decentralized decision making	3.43	9	4.87	1	3.42	9	3.15	9	3.72	9
Waste reduction	4.82	1	4.22	4	4.53	3	4.72	2	4.57	1
Reducing variability	4.35	3	3.91	8	4.47	4	4.84	1	4.39	3
Sustainability	4.18	6	4.54	3	4.64	2	4.41	3	4.44	2
Collaborative planning	4.25	5	4.65	2	4.38	6	3.99	8	4.32	4
Quality at the source	4.31	4	4.06	5	4.15	8	4.23	5	4.19	7

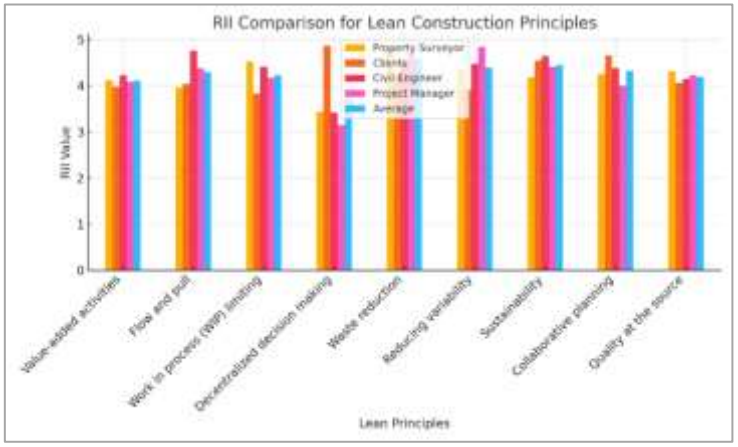

Figure 4: RII Comparison for Lean Construction Principles

Person: 0	Property surveyor/estate	Person: 2	Clients	Person: 4	Civil Engineer	Person: 6	Project Manager	Person: 8	Average	Person: 10
Factors	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Resistance to change	4.54	3	4.06	5	4.63	2	4.05	8	4.32	4
Cultural shift	4.42	4	4.51	2	4.15	5	4.38	5	4.37	3
Lack of training	4.23	5	4.67	1	4.37	4	4.44	4	4.43	1
Supply chain coordination	3.89	7	4.12	4	3.78	8	4.09	7	3.97	8
Data and metrics	3.65	8	3.53	8	4.52	3	4.73	1	4.11	7
Clients' expectations	4.63	2	3.24	9	4.81	1	3.92	9	4.15	6
Project ownership and collaboration	3.51	9	3.62	7	3.74	9	4.51	3	3.85	9
Measuring success	4.76	1	4.48	3	3.99	7	4.37	6	4.40	2
Communication	4.07	6	3.95	6	4.06	6	4.66	2	4.19	5

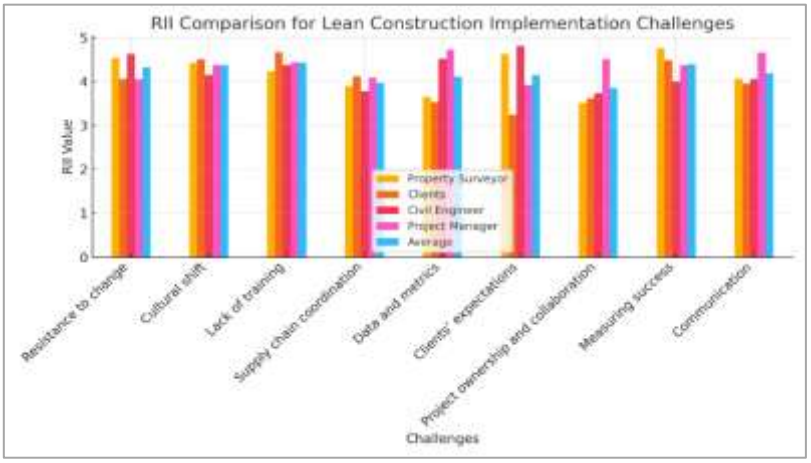

Figure 5: RII Comparison for Lean Construction Implementation Challenges

The table and figure present the Relative Importance Index (RII) and corresponding ranks for various **lean construction principles** as evaluated by different stakeholder groups: Property Surveyors, Clients, Civil Engineers, and Project Managers. The analysis highlights both areas of agreement and divergence in professional perspectives on what constitutes effective lean practices. **Waste reduction** ranks highest overall (RII 4.57), reflecting universal consensus on its critical role in enhancing efficiency and minimizing resource loss. It was especially emphasized by Property Surveyors and Project Managers, indicating operational and managerial alignment on this priority. **Sustainability** also scored highly (RII 4.44), particularly valued by Clients (RII 4.54) and Civil Engineers (RII 4.64), showing growing awareness of environmental responsibilities within construction. Interestingly, **Flow and Pull Systems** received the top rating from Civil Engineers (RII 4.76), underscoring its significance in process optimization, while Project Managers gave highest priority to **Reducing Variability** (RII 4.84), indicating a strong focus on achieving predictability and control in project execution. On the other hand, **Decentralized Decision Making** scored the lowest average RII (3.72), with particularly low ratings from Project Managers and Civil Engineers. This suggests limited confidence in distributing authority across teams, potentially due to perceived risks in coordination or accountability.

Person: 0	**Property Surveyor/estate**	**Person: 2**	**Clients**	**Person: 4**	**Civil Engineer**	**Person: 6**	**Project Manager**	**Person: 8**	**Average**	**Person: 10**
Factors	RII	Rank	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Faster project completion	4.34	4	3.88	8	4.25	5	4.12	7	4.15	6
Cost control	4.26	5	3.97	7	4.81	1	4.55	5	4.40	4
Enhanced quality	3.85	9	4.14	5	3.92	8	3.9	9	3.95	8
Client satisfaction	4.09	6	4.89	1	4.47	3	4.56	4	4.50	3
Continuous improvement	3.93	8	4.05	6	3.84	9	4.33	6	4.04	7
Competitive advantage	3.48	10	3.76	10	4.09	6	3.87	10	3.80	10
Sustainability	4.77	2	4.63	2	4.46	4	4.61	3	4.62	2
Better safety records	4.02	7	3.82	9	3.68	10	4.04	8	3.89	9
Reduced waste	4.81	1	4.61	3	4.73	2	4.88	1	4.76	1
Improved workflow	4.45	3	4.19	4	3.94	7	4.79	2	4.34	5

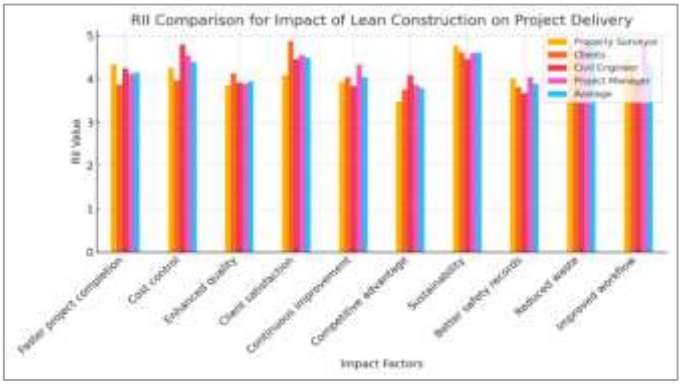

Figure 6: RII Comparison for Lean Construction on Project Delivery

The table provides insights into how various professional groups—Property Surveyors, Clients, Civil Engineers, and Project Managers—perceive the impact of lean construction practices on project delivery, using the Relative Importance Index (RII) as a metric. Across all groups, "Reduced waste" is unanimously acknowledged as the most impactful outcome of lean construction (average RII: 4.76), indicating the centrality of resource efficiency in lean implementation. This is followed closely by "Sustainability" (RII: 4.62), which received strong support from all respondents, particularly Property Surveyors and Clients, highlighting lean construction's alignment with environmental and social goals.

"Client satisfaction" ranked third (RII: 4.50), driven largely by the Client group rating it highest (RII: 4.89). This reinforces the client-centric nature of lean construction, which seeks to maximize value and minimize waste. "Cost control" and "Improved workflow" also scored well, suggesting that economic and process efficiencies are widely recognized benefits. Lower-rated factors included "Enhanced quality", "Better safety records", and "Competitive advantage", indicating that while important, these aspects are not perceived as the primary outcomes of lean practices. "Competitive advantage" ranked the lowest across all groups (RII: 3.80), suggesting a gap in leveraging lean for market positioning.

4. CONCLUSION AND FUTURE SCOPE

The evaluation of lean construction practices for improving construction project delivery in Faridabad District, Delhi, NCR, has yielded critical insights into how lean methodologies are perceived, adopted, and implemented across various stakeholder groups in the construction industry. Through a structured and data-driven approach, this study captured the perspectives of Property Surveyors, Clients, Civil Engineers, and Project Managers, enabling a comprehensive understanding of lean construction's potential to transform construction project outcomes. The analysis reveals that lean construction principles are widely recognized for their ability to reduce waste, enhance sustainability, and improve workflow efficiency. Across all stakeholder categories, *"Reduced waste"* consistently ranked as the most important outcome, signifying the collective appreciation of resource optimization. *"Sustainability"* and *"Client satisfaction"* also emerged as high-impact factors, indicating a shift towards more environmentally conscious and client-centric project delivery frameworks. Meanwhile, *"Cost control"*, *"Improved workflow"*, and *"Faster project completion"* were identified as critical benefits that can lead to better financial and operational outcomes for construction firms. The Relative Importance Index (RII) helped quantify stakeholders' perceptions and highlight variations in priorities across professions. For instance, Civil Engineers valued *"Flow and Pull"* systems and *"Sustainability"*, whereas Project Managers emphasized *"Reducing Variability"* and *"Project Oversight"*—a reflection of their operational focus. Conversely, Clients prioritized *"Client Satisfaction"* and *"Use of Local Materials"*, pointing to their emphasis on cost-efficiency and regional economic integration. Such findings reinforce the importance of tailoring lean strategies to the specific roles and expectations of each stakeholder group. Despite the overall positive outlook, the study also uncovered significant barriers to lean implementation. *"Resistance to change"*, *"Lack of training"*, *"Cultural shifts"*, and *"Data and metrics availability"* were among the most cited challenges. These impediments suggest that while lean construction has theoretical appeal, its practical adoption requires organizational change, capacity building, and strong leadership. The low prioritization of *"Decentralized Decision-Making"* also reflects existing hierarchical structures that may hinder collaborative practices a critical component of successful lean construction.

Future Scope

The study opens multiple avenues for further research and practical application

- **Longitudinal Studies**: Future research should conduct long-term assessments to evaluate how the implementation of lean practices evolves over time, and what sustained impacts they have on project outcomes in terms of cost, quality, and delivery.
- **Comparative Regional Analysis**: Similar studies can be replicated in other districts within Delhi, NCR or in East Africa to compare lean adoption trends, contextual challenges, and regional best practices.
- **Digital Integration**: As *"Limited application of technology"* was highlighted as a critical issue, future studies can focus on how Building Information Modelling (BIM), AI, and other digital tools can support lean implementation and enhance data-driven decision-making.
- **Policy and Institutional Frameworks**: There is scope to investigate how government policy, procurement practices, and regulatory frameworks can incentivize the adoption of lean principles in public and private construction projects.
- **Training and Education Modules**: Curriculum development and professional training programs can be designed to enhance lean construction literacy among industry practitioners, especially targeting junior professionals with 0–10 years of experience, who comprised the majority of respondents.

While lean construction holds significant promise for improving project delivery in Faridabad District, realizing its full potential will require collaborative stakeholder engagement, systemic reforms, and continuous investment in human and technological capital.

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