Digital Innovations & Contemporary Research in SCIENCE, ENGINEERING & TECHNOLOGY
Vol. 13. No. 4, 2025 Series

Article Citation Format
Ibitayo, V.O. (2025): Evaluating the Effect of Lean Construction Techniques on Waste Reduction and Efficiency Improvement in Building Projects in Ibadan. Journal of Digital Innovations & Contemporary Research in Science, Engineering & Technology. Vol. 13, No. 4. Pp 35-42.. www.isteams.net/digitaljournal dx.doi.org/10.22624/AIMS/DIGITAL/V13N3P4

Article Progress Time Stamps
Article Type: Research Article
Manuscript Received: 24th September, 2025
Review Type: Blind Peer
Final Acceptance: 1st November, 2025

Evaluating the Effect of Lean Construction Techniques on Waste Reduction and Efficiency Improvement in Building Projects in Ibadan

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ABSTRACT

The construction industry in Nigeria faces persistent challenges such as excessive material waste, low productivity, cost overruns, and inefficiencies in project delivery. These issues have economic and environmental consequences, especially in rapidly urbanizing cities like Ibadan. Lean Construction, derived from the Toyota Production System, offers strategies such as the Last Planner System (LPS), Value Stream Mapping (VSM), Just-in-Time (JIT) delivery, standardized processes, and collaborative project delivery to improve workflow, reduce waste, and enhance project efficiency.
This study evaluates the adoption of Lean Construction techniques in building projects in Ibadan and their effect on waste reduction and efficiency improvement. A mixed-methods approach, combining structured questionnaires (N=100) and semi-structured interviews with construction professionals, was employed. Findings indicate moderate awareness of Lean principles but limited structured implementation. Projects applying Lean techniques recorded reductions in material waste, rework, labour inefficiency, and improved coordination. Significant barriers included resistance to change, limited training, fragmented delivery systems, and insufficient technological adoption.
The study concludes that Lean Construction offers substantial benefits for reducing waste and improving efficiency. Recommendations include targeted training programs, organizational culture change, enhanced project coordination, and technology integration to facilitate wider Lean adoption in Ibadan's construction sector.

Keywords: Lean Construction, Techniques, Waste Reduction, Efficiency Improvement, Building Projects

1. INTRODUCTION

The construction industry is crucial to national development, yet it continues to face challenges that undermine project performance in developing countries like Nigeria. Persistent problems include material waste, low workflow efficiency, delays, cost overruns, and weak coordination among project stakeholders (Ajayi et al., 2022; Goh & Goh, 2023). Such inefficiencies not only increase project costs but also contribute to environmental degradation, as construction activities generate significant landfill waste and carbon emissions (UNEP, 2023; Osmani, 2023).

In Ibadan, expanding construction activity has accentuated these challenges, particularly in housing and commercial projects. Lean Construction offers a systematic approach to mitigate these inefficiencies. Originating from the Toyota Production System, Lean focuses on eliminating non-value-adding activities, improving workflow, and enhancing productivity across all project phases (Koskela, 2023). Tools such as the Last Planner System (LPS), Just-in-Time (JIT) delivery, Value Stream Mapping (VSM), standardized operations, and collaborative planning have demonstrated effectiveness in reducing waste, enhancing communication, and improving project predictability (Ballard & Howell, 2023; Tezel et al., 2022).

Despite these benefits, Lean Construction adoption in Nigeria remains limited due to cultural resistance, inadequate training, fragmented project delivery, and insufficient technological integration (Sarhan & Fox, 2022; Jørgensen & Emmitt, 2022). Consequently, projects in Ibadan often rely on traditional methods, leading to high levels of material wastage, rework, and workflow inefficiencies. This study investigates the adoption of Lean Construction techniques in Ibadan, focusing on their role in waste reduction and efficiency improvement. It seeks to identify relevant Lean practices, evaluate their effectiveness, explore barriers to implementation, and provide strategies to enhance project performance in the local context.

2. LITERATURE REVIEW

2.1 Concept of Lean Construction

Lean Construction adapts principles of Lean production to the construction sector, aiming to maximize value while minimizing waste and enhancing workflow efficiency (Koskela, 1992). Key features include collaborative planning, reliable task execution, reduced variability, and continuous improvement (Ballard & Howell, 2003; Sacks et al., 2010). Lean emphasizes value from the client's perspective and promotes proactive coordination among project teams, which improves project quality and efficiency.

2.2 Lean Construction Techniques

Several Lean techniques are commonly used in construction:

- **Last Planner System (LPS):** Engages those responsible for task execution to improve planning reliability and reduce workflow variability (Ballard & Howell, 2003).
- **Value Stream Mapping (VSM):** Visualizes material and information flows to identify inefficiencies (Tezel et al., 2022).
- **Just-in-Time (JIT) Delivery:** Ensures materials arrive only when needed, reducing storage waste and damage (González et al., 2018).
- **Standardized Operations & 5S:** Promote order, reduce errors, and streamline workflow (Sacks et al., 2010).

Combined, these methods enhance coordination, reduce rework, minimise waste, and improve predictability.

2.3 Waste in Construction Projects

Common types of construction waste include material wastage, labour inefficiency, rework/defects, time delays, and unnecessary movements (Osmani, 2023). In Nigeria, poor planning, supervision, and storage practices exacerbate these issues (Ajayi et al., 2022). Urban areas like Ibadan face additional challenges due to fragmented subcontractor arrangements and unreliable supply chains, making Lean practices highly relevant for local projects.

2.4 Lean Construction in Nigeria

Lean adoption in Nigeria is in its infancy. While professionals are increasingly aware of Lean concepts, few apply them systematically (Sarhan & Fox, 2022). Barriers include inadequate training, cultural resistance, lack of organisational support, and fragmented project teams (Jørgensen & Emmitt, 2022). Nonetheless, emerging evidence suggests that even partial application of Lean—such as improved planning and material handling—can yield measurable improvements in productivity and waste reduction (Ajayi et al., 2022; Goh & Goh, 2023).

3. METHODOLOGY

3.1 Study Area

The study was conducted in Ibadan, Oyo State, Nigeria, and a city experiencing rapid urban development. Residential and commercial building projects dominate the local construction sector, which is characterized by diverse project delivery systems, varying resource availability, and workforce skill levels.

3.2 Research Design

A **mixed-methods research design** was adopted, combining quantitative and qualitative approaches to provide a comprehensive understanding of Lean Construction adoption. The quantitative component measured awareness, adoption, and perceived impact on waste reduction and efficiency, while the qualitative component explored contextual factors and practical challenges. This approach enhances data credibility and allows triangulation of findings (Creswell, 2018; Fellows & Liu, 2020).

3.3 Population and Sampling

The target population included builders, architects, engineers, project managers, and quantity surveyors operating in Ibadan. A **purposive sampling technique** ensured that only professionals with relevant experience were included. A total of 120 questionnaires were distributed, with 100 valid responses obtained (83.3% response rate). Semi-structured interviews were conducted with 10 selected professionals for deeper insights.

3.4 Data Collection Instruments

- **Structured Questionnaire:** Measured awareness, application, and impact of Lean techniques, as well as waste types and barriers. Likert scales were used, and the instrument was validated through pilot testing.
- **Semi-Structured Interviews:** Explored perceptions of Lean adoption, practical challenges, and opportunities for improvement.

3.5 Data Analysis

Quantitative data were analyzed using descriptive statistics (frequencies, percentages) and Chi-square tests to examine relationships between Lean adoption and efficiency/waste reduction. Qualitative data were analyzed thematically to identify patterns and contextual factors influencing Lean implementation. Results from both strands were integrated to provide a robust understanding of Lean Construction adoption in Ibadan.

4: DATA PRESENTATION, ANALYSIS, AND DISCUSSION

4.1 Introduction

This chapter presents and analyses the data collected from construction professionals in Ibadan, Nigeria. A total of 120 questionnaires were distributed, and 100 valid responses were received, representing an 83.3% response rate. Data were gathered through structured questionnaires and semi-structured interviews to assess the adoption of Lean Construction techniques, the types of waste reduced, efficiency improvements, and barriers to implementation. The results are discussed in relation to the study objectives, providing insights into how Lean practices influence project performance in the local construction sector.

4.2 Demographic Information of Respondents

The study sample consisted predominantly of males (77%), with females accounting for 23%. The age distribution indicated that most respondents (53%) were between 26–35 years, followed by 36–45 years (31%), while the youngest (18–25 years) and oldest (46–55 years) age groups each accounted for 8%. Regarding educational attainment, 55% of respondents held MSc/MTech degrees, while 45% possessed BSc/BTech qualifications, reflecting a relatively high level of advanced education among the participants. In terms of professional roles, engineers made up the largest proportion (54%), followed by project managers (24%), architects (8%), builders (7%), and quantity surveyors (7%).

Experience levels varied, with 44% of respondents having 5–10 years of professional experience, 32% with less than 5 years, and 24% with more than 16 years. This indicates strong representation of mid-career professionals. Finally, 62% of respondents primarily handled residential projects, while 38% focused on commercial projects, highlighting a heavier emphasis on housing developments in the local construction industry.

4.3 Lean Construction Adoption and Waste Reduction

Respondents were asked to indicate whether they had observed reductions in waste as a result of Lean practices. Analysis of the responses revealed that Lean Construction has contributed significantly to minimizing various forms of waste on site. Table 4.1 shows the types of waste reduced and their frequency of occurrence.

Table 4.1: Types of Waste Reduced Through Lean Practices

Waste Type	Frequency	Percentage
Material waste	76	39.4%
Reworks / Defects	56	29.0%
Labour waste	48	24.9%
Time delays	13	6.7%

Material waste was the most frequently reduced (39.4%), reflecting the effectiveness of Lean techniques such as Just-in-Time delivery, improved site planning, and careful material management. Reductions in rework and defects (29.0%) suggest that standardization of work processes and enhanced communication among site teams contribute significantly to fewer errors (Love & Li, 2000). Labour waste reduction (24.9%) highlights gains in workforce efficiency, though improvements in labour productivity require cultural adjustments and active worker engagement. Reduction in time delays was the least reported (6.7%), indicating that scheduling and workflow improvements are partially constrained by external factors such as supply chain delays and incomplete Lean adoption (Salem et al., 2006). Overall, these results confirm that Lean Construction practices effectively target material and process inefficiencies, providing measurable benefits in terms of reduced waste and improved operational performance.

4.4 Association Between Lean Construction Adoption and Efficiency

To determine the relationship between the extent of Lean Construction adoption and efficiency improvements, a chi-square test of independence was conducted. The results are summarized in Table 4.2:

Table 4.2: Chi-Square Test of Association Between Lean Adoption and Efficiency

X^2 Calculated	X^2 Critical	df	p-value	Remark
30.371	12.592	2	0.001	Significant

The chi-square result ($X^2(2, N = 100) = 30.371$, $p = 0.001$) indicates a statistically significant association between Lean Construction adoption and efficiency improvement. Organisations implementing Lean practices more extensively reported greater reductions in waste and enhanced operational efficiency than those with limited adoption.

This result aligns with the observed improvements in material management, reduction of reworks, smoother task flows, and better coordination among project teams. It confirms that structured Lean implementation can generate measurable operational benefits, supporting findings from previous studies (Formoso et al., 2002; Salem et al., 2006; Costa et al., 2019).

4.5 Discussion of Findings

The findings indicate that Lean Construction adoption in Ibadan is moderate, with organisations applying certain techniques informally rather than comprehensively. Material waste was the area most positively impacted, highlighting the ability of Lean methods to optimise resource utilisation. Reductions in rework and labour waste further demonstrate the value of Lean practices in improving workflow and communication. Time delay reductions were limited, reflecting the challenges of implementing scheduling improvements in contexts with fragmented project delivery and external constraints.

The chi-square analysis confirms that greater Lean adoption is significantly associated with higher efficiency, illustrating that organisations embracing Lean principles more thoroughly are better positioned to minimise waste and improve productivity. These findings are consistent with international research showing that Lean practices, particularly when fully integrated, can substantially improve construction performance (Sacks et al., 2010; Tezel et al., 2022; Goh & Goh, 2023). They also highlight the importance of capacity building, organizational culture change, and structured planning to overcome barriers and maximize Lean benefits in Ibadan.

4.6 Summary of Key Findings

1. **Material and rework waste** are the most positively impacted by Lean adoption.
2. **Labour efficiency** improves moderately, requiring more systemic cultural and procedural changes.
3. **Time delays** remain the least affected, highlighting the need for comprehensive Lean integration.
4. **Statistical analysis** confirms a significant association between Lean adoption and efficiency gains.
5. Barriers include **resistance to change, limited training, fragmented project delivery, and inadequate technology**.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study demonstrates that Lean Construction adoption in Ibadan is moderate, with limited structured implementation of techniques such as LPS, VSM, and JIT. Projects applying Lean practices recorded significant reductions in material waste, rework, and labour inefficiency, though improvements in time management were less prominent. A Chi-square test confirmed a significant association between Lean adoption and efficiency.

Barriers to adoption include resistance to change, limited training, fragmented delivery systems, and insufficient technological support. Overall, Lean Construction offers measurable benefits for waste reduction and efficiency improvement, but requires organizational support, training, and cultural adaptation to achieve full effectiveness.

5.2 Recommendations

1. **Capacity Building and Training:** Targeted workshops and on-site demonstrations for all levels of staff.
2. **Promoting Organizational Culture Change:** Encourage collaboration, continuous improvement, and recognition of Lean implementation.
3. **Enhanced Project Coordination:** Implement collaborative project delivery models and structured planning meetings.
4. **Technology Adoption:** Use project management software, scheduling systems, and material tracking tools.
5. **Policy and Professional Support:** Regulatory agencies and professional bodies should provide guidance, incentives, and training accreditation.
6. **Continuous Monitoring:** Establish feedback mechanisms to evaluate Lean adoption and sustain efficiency gains.

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