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SYNERGIZING THE LAST PLANNER SYSTEM, VALUE STREAM MAPPING, AND JUST-IN-TIME APPROACHES TO ENHANCE CONSTRUCTION PROJECT PERFORMANCE IN PLATEAU STATE POLYTECHNIC, NIGERIA.

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ABSTRACT

Recurrent inefficiencies and material waste in Nigeria's construction industry necessitate practical frameworks for improving project outcomes. This study investigates how integrating three Lean Construction tools, the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-in-Time (JIT) can collectively enhance performance. Using a mixed-methods approach involving surveys, interviews, and direct observations, two pilot projects at Plateau State Polytechnic, Barkin Ladi, the Entrepreneurship Complex Phase III and the School of Environmental Studies renovation were examined. Data from 30 professionals, including architects, builders, engineers, project managers, and quantity surveyors, were analyzed using descriptive statistics and the Relative Importance Index (RII). Findings showed high awareness but moderate application of Lean tools, with JIT integration (RII = 0.673) ranking highest, followed by VSM awareness (0.633) and LPS experience (0.627). Key enablers included early project approvals, timely fund disbursement, regular site meetings, and strong supervision, all of which reduced waste and improved scheduling. The study concludes that synergizing LPS, VSM, and JIT promotes planning reliability, cost efficiency, and timely delivery. It recommends that government agencies, funding bodies such as TETFund, and professional institutions like CORBON, NSE, and NIQS integrate Lean principles into their guidelines, procurement systems, and training programs. Emphasis should be placed on practical, hands-on implementation rather than theory alone. Despite its limited sample size, the study provides a credible foundation for institutionalizing Lean Construction practices in Nigeria's built environment.

Keywords: Just-in-Time, Lean Construction, Last Planner System, Project Delivery, Value Stream Mapping, Plateau State Polytechnic.

1. INTRODUCTION

Construction projects in Nigeria are frequently characterized by chronic delays, material waste, cost escalation and unreliable workflow predictability, problems that have been documented across empirical and review studies of the sector. The prospect of minimizing production flow waste on construction sites in Nigeria through the Last Planner System (LPS) (Daniel, Pasquire, & Ameh, 2017) specifically links a substantial portion of these inefficiencies to poor production-flow control and weak coordination between planning and execution phases. Lean construction, derived from the Toyota Production System, offers methodologies and practical-tools to address

these issues by focusing on value creation and waste reduction Odohoedi, Ayandele, & Nnamseh, (2025).

Key Lean principles include: The Last Planner System (LPS) promotes collaborative short-interval planning and reliable workflow commitments, which directly target waiting and handover losses observed on Nigerian sites; case studies and pilot implementations in Nigeria have shown promise for LPS to reduce production-flow waste when adapted to local practice (Daniel, et al., 2017). Value Stream Mapping (VSM) provides a visual, process-level method to identify non-value activities and redesign process flows for efficiency - a technique widely used in construction process improvement research and adaptable to building projects in Nigeria (Oladiran, 2008).

Just-In-Time (JIT) delivery principles reduce onsite inventory and related handling costs by synchronizing supply with demand; although JIT has been more widely studied in Nigerian manufacturing, recent work shows its concepts are transferable and beneficial to construction materials logistics in the Nigerian context (Oladiran & Kilanko, 2022).

Given the complementary strengths of these tools, this study integrates LPS, VSM and JIT into a unified, context-sensitive framework aimed at improving coordination, reducing material waste and compressing schedules on Nigerian construction projects. This paper examines the practical application of these principles in Nigerian construction projects, using the aforementioned case studies as a basis.

2. LITERATURE REVIEW

Lean Construction and Its Relevance in Nigeria

Lean Construction adapts Lean manufacturing concepts to the construction environment, focusing on maximizing value and minimizing waste. However, studies show that while awareness of Lean principles exists in Nigeria, their adoption remains limited (Ahiakwo, Oloke, Suresh, & Khatib, 2013; Daniel, et al., 2017). In Nigeria, Oladiran (2008) identified fundamental challenges in transplanting lean methods, noting that the majority of practitioners had negligible exposure to Lean thinking and lacked the organizational capacity to adopt techniques like Just-In-Time and parallel design.

Similarly, Babalola, Ibem, & Chukwunweike (2019) found that while many firms claimed awareness of Lean concepts, actual application was rare and often superficial. Their study observed that the most utilized lean practices were those that did not require deep systemic change, such as look-ahead scheduling and client-needs identification, while more integrated tools remained underutilized. Ahiakwo et al. (2013) report a case where the Last Planner System (LPS) was implemented on a Nigerian university building project and recorded improvements in time performance, cost savings, and Percentage Plan Complete (PPC). The study highlighted critical barriers such as lack of managerial commitment and initiating LPS only partway into the project life cycle.

Moreover, a critical review by Ahiakwo et al (2013) examined the applicability of lean tools in Nigeria's building industry and pointed out that poor project definitions, waste generation, and weak planning culture hinder adoption of collaborative techniques. On a more recent front, Chukwuemeke, Ajaelu, & Chukwuenye (2025) explored the factors affecting Lean implementation in Uyo, Akwa Ibom State. Their survey of 228 professionals identified that limited awareness, lack of sufficient training, high implementation costs, and cultural resistance significantly impede Lean uptake in the Nigerian context. They argue that despite the recognized benefits of Lean practices such as waste reduction, improved coordination, and client satisfaction - these systemic barriers continue to frustrate practical adoption.

In global terms, the systematic review by Babola, et al (2019), categorized 32 lean practices adopted across design, planning, site management, and health/safety domains. They found that Last Planner and JIT were the most frequently implemented tools internationally, but also noted that in developing countries, partial or inconsistent implementation is common due to resource, cultural, and institutional constraints. Such observations align with Nigeria's experience, where lean practices are often devolved into isolated interventions rather than holistic process change. Thus, while Lean Construction holds strong theoretical relevance for improving productivity, reducing waste, and aligning project workflows, its actual deployment in Nigeria remains nascent. The literature underscores that bridging the gap between awareness and full adoption demands strategic interventions in training, leadership, institutional support, and project-level pilot implementations.

The Last Planner System (LPS)

The LPS promotes collaborative scheduling where commitments are made by those responsible for executing the work, improving planning reliability. Ahiakwo, et al., (2015) implemented LPS in a road construction project in Nigeria and reported a marked improvement in schedule adherence and workflow predictability. In their study, the production plans were initially highly unreliable, but after implementing LPS the project saw stabilized production plans and improved reliability in the schedules.

Similarly, Daniel, et al (2017) found that non-value-adding activities such as waiting, material handling, and over-production were prevalent in Nigerian construction projects, and that many of the current construction practices resembled elements of LPS; the study argues that systematic use of LPS principles has strong potential to reduce these wastes and improve productivity.

Value Stream Mapping (VSM)

Value Stream Mapping helps visualize every step of a process, distinguishing between value-adding and non-value-adding activities. While its use in the Nigerian construction sector is limited, verified studies in Nigerian manufacturing show major gains in time efficiency and waste reduction (Oko, Nwanya, Okorigwe, Godwin, & Daniyan, 2025). Integrating VSM in construction can therefore help identify inefficiencies across design, procurement, and site execution. In a recent study by Oko (2025) on a rice milling facility in Otukpo, Benue State, Nigeria, the authors developed an Existing State Value Stream Map (ESVSM) and then a New State VSM after identifying inefficiencies. They reported reductions of lead time by 61.24%, cycle time by 41.14%, raw material movement time by 64.44%, and non-value-added time by 90.08%. Work-in-Progress was improved by 60.04%, and overall process efficiency improved by 28.68%. Efficiency gains projected by simulation were even higher (Oko, et al., 2025).

Another Nigeria-based study examined the operational efficiency of vehicle manufacturing using VSM. Odohoedi, Ayandele, & Nnamseh (2025) investigated operations at Innoson Vehicle Manufacturing Company and reported that applying VSM resulted in improved workflow smoothness, reduction of non-value-added steps, and notable improvements in operational metrics such as throughput and internal process time (Odohoedi, et al, 2025).

Kumar, Shivashankar, & Rajeshwar (2015) from the international literature, applied VSM in a pump assembly line operation and obtained reductions in cycle time by over 50% along with improved allocation of materials and reduced waste (Kumar, et al., 2015). These foreign cases corroborate Nigerian findings and suggest that VSM can be a powerful tool in identifying process bottlenecks.

Just-In-Time (JIT) in Nigerian Construction Context

Just-In-Time (JIT) focuses on material and resource optimization through timely delivery. Studies have shown that Nigerian construction projects often suffer from poor supply chain coordination, leading to excess inventory, material shortages, and associated cost overruns. For example, in "Investigating the Awareness and Barriers of Just-in-Time Concrete Delivery on Construction Projects" Oladiran & Kilanko (2022) report that although awareness of JIT among construction firms in Lagos is above average, implementation is limited by barriers such as traffic disruptions, cost pressures, and preference for traditional procurement methods. Another study examining "Investigating the Efficiency of Ready-Mix Concrete Adoption in Minimizing Lean Construction Waste on Space-Constrained Sites in Nigeria" found that using ready-mix concrete (a form of JIT concrete delivery) contributed to reduced wastes of overproduction and waiting, faster construction speed, and more uniform quality of concrete.

Aule, et al (2025) in Kaduna State explored various material waste mitigation strategies and found that logistical inefficiencies, including poor storage, transport delay, and untimely supply, are major contributors to material wastage. They suggest that integrating JIT delivery concepts (ensuring materials arrive exactly when needed) could reduce these logistical wastes and improve cost control. Thus, integrating JIT practices especially for concrete and other bulk materials appears promising for improving material flow efficiency, reducing site congestion, and enhancing cost control in Nigerian building projects.

Integrating the Three Tools

Last Planner System (LPS) improves planning reliability, Value Stream Mapping (VSM) reveals where waste occurs, and Just-In-Time (JIT) optimizes supply timing, together, they have the potential to form a holistic Lean framework. The synergy of these tools can enable real-time collaboration, visualization of non-value-adding processes, and synchronized material supply, which are essential for more predictable project delivery in Nigeria. A recent study on the "Effect of the Last Planner System on Road Project Delivery in Lagos State, Nigeria" found that respondents perceive LPS awareness and adaptability positively, and believe LPS strategies can enhance project schedule reliability when applied appropriately.

Oladiran & Kilanko (2022) in "Investigating the awareness and barriers of Just-In-Time concrete delivery on construction projects" report that although awareness of JIT among construction firms in Lagos is above average, obstacles such as traffic congestion and preference for cost over quality hinder its implementation. VSM, Oko, et al (2025), in their study of a rice milling facility in Otukpo (Benue State), demonstrate that VSM yields large reductions in lead time, cycle time, material movement, and non-value-added time after mapping the current and improved process flows. Also, the study "The Operational Efficiency of Vehicle Manufacturing in Nigeria: The Lean Tool Option" shows VSM being successfully used to enhance workflow smoothness and reduce non-value adding steps in manufacturing. These Nigerian studies suggest that when LPS, VSM, and JIT are used in combination, even if not explicitly in all projects, their strengths complement one another. LPS improves planning and predictability; VSM diagnoses where waste and delays occur; and JIT ensures materials arrive just when needed, reducing both slack and congestion on site. Integrating them into a unified framework tailored for the Nigerian setting, considering infrastructural, logistical, and institutional constraints, should enhance project outcomes in timelines, cost, and quality.

Empirical Evidences of Lean Construction Practices in Nigeria

Empirical studies across Nigeria have documented the application and outcomes of Lean Construction techniques, particularly the Last Planner System (LPS), on various project types. These cases provide insights into the country's current level of implementation, performance outcomes, and contextual challenges. Ahiakwo, et al., (2015) conducted one of the earliest and most comprehensive Nigerian field studies on LPS, applying it to a road construction project in Port Harcourt. The research revealed a substantial improvement in schedule adherence, reduction in work-flow variability, and higher reliability of weekly planning commitments. The study concluded that collaborative scheduling, when properly facilitated, enhanced communication between site supervisors and subcontractors, leading to measurable productivity gains. However, it also identified barriers such as inadequate training, weak stakeholder engagement, and inconsistent follow-through on planned activities.

Similarly, Daniel, et al., (2014) examined the application of LPS within a university building project in the North-Central region. Their findings confirmed that systematic planning through the LPS significantly reduced non-value-adding activities such as waiting, idle equipment, and rework. The study further reported that projects adopting LPS principles achieved smoother workflow predictability and enhanced task accountability. Follow-up research by Daniel, et al., (2017) expanded on this, emphasizing that Nigeria's construction sector possesses latent readiness for Lean adoption but requires institutional commitment, management buy-in, and context-specific implementation frameworks. Oladiran (2017) investigated lean construction practices across ten organizations in Lagos State and found that although awareness of Lean tools existed, usage was often fragmented. The most common techniques included daily huddles, visual management, and simplified look-ahead planning. In contrast, more integrated approaches such as JIT material flow and structured value stream mapping were rarely practiced. The study concluded that organizational culture, leadership inertia, and limited technical capacity remained significant deterrents to broader Lean implementation.

A national-level survey by Babalola, et al., (2019) reinforced these observations. Drawing data from 446 professionals across Abuja, Lagos, Port Harcourt, Enugu, and Kaduna, their study revealed that while Lean principles are increasingly recognized for reducing project delays and cost overruns, adoption remains inconsistent. They attributed this to a lack of structured Lean education, resistance to innovation, and inadequate institutional frameworks to support long-term process transformation. Despite these limitations, most respondents perceived Lean Construction as critical to achieving a more sustainable built environment. A more recent regional study by Nnaji, Okafor, Ezeani, & Umeh (2025) assessed Lean Construction practices in Anambra State, focusing on tools such as LPS, JIT, VSM, and Kaizen. Their findings aligned with earlier national studies, showing high awareness but minimal implementation. The most frequently cited barriers were inadequate training opportunities, cultural resistance to collaborative planning, and insufficient governmental policy support. Nonetheless, the study emphasized that integrating Lean methods with Building Information Modelling (BIM) could strengthen coordination, visibility, and resource management in future projects.

Case Study Analysis of Lean Construction Principles in Plateau State Polytechnic Projects

Plateau State Polytechnic, located in Barkin Ladi, Plateau State, Nigeria, has undertaken momentous infrastructure projects aimed at enhancing its educational facilities. Two notable projects include the construction of the Entrepreneurship Complex Phase III and the renovation of the School of Environmental Studies funded by Tertiary Education Trust Fund (TETFUND).

Both projects were completed ahead of their contract schedules, suggesting the effective application of project management and construction methodologies.

Entrepreneurship Complex Phase III

The Entrepreneurship Complex Phase III project was part of the 2021/2022 Tertiary Education Trust Fund (TETFund) intervention, with a budget of ₦450,000,000. The project intended to provide state-of-the-art facilities for vocational and entrepreneurial training, including workshops for various trades such as carpentry, welding, tailoring, and plumbing. The completion of this project ahead of schedule indicates efficient project execution and resource management.

School of Environmental Studies Renovation

The renovation of the School of Environmental Studies was also part of the 2021/2022 TETFund intervention, with a budget of ₦95,000,000. The renovation focused on upgrading existing facilities to meet modern educational standards. The timely completion of this project reflects effective planning and execution. Lean Construction principles in these projects ensure the timely completion and efficient use of resources. Lean Construction principles, such as the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) delivery, focus on reducing waste and improving efficiency in construction processes. The successful completion of these projects within the stipulated time-frames may be indicative of the effective implementation of these principles.

Research gap and Justification for The Study

Although several Nigerian studies have explored the principles of Lean Construction, most have focused on describing awareness levels, identifying barriers, or demonstrating isolated applications of tools such as the Last Planner System (LPS). For instance, Ahiakwo et al. (2015) showed that LPS could improve schedule reliability in a road construction project, while Daniel, et al., (2014; 2017) confirmed that Lean principles reduce rework and waiting time in selected building projects. Likewise, & Oladiran (2017) and Babalola, et al., (2019) observed that awareness of Lean methods is growing among practitioners, but implementation remains fragmented and largely informal. However, these existing studies share a common limitation: they seldom assess Lean Construction in combination with digital tools such as Building Information Modelling (BIM). The emerging synergy between Lean and BIM known globally as Lean - BIM integration has been shown in other contexts (notably in the UK, Finland, and Singapore) to enhance visualization, improve information flow, and strengthen collaboration throughout the project life cycle. Yet, in Nigeria, research exploring how these two paradigms can jointly address issues such as waste, delay, and coordination inefficiencies remains very limited and largely conceptual.

Another gap lies in the contextual adaptation of Lean tools to local realities. Most Nigerian studies report high interest but limited technical capacity, minimal management support, and the absence of policy frameworks to sustain Lean-based innovation (Oladiran, 2017; Nnaji et al., 2025). Moreover, the application of specific Lean techniques such as Just-In-Time (JIT) delivery, Value Stream Mapping (VSM), and collaborative planning through LPS has rarely been examined holistically within public institutional projects such as polytechnic or university developments. These environments often face bureaucratic constraints, fragmented procurement systems, and budget delays, which make them an ideal tested for evaluating Lean - BIM solutions. Therefore, this current study is justified by the need to bridge the gap between awareness and actual adoption. Furthermore, by analyzing implementation barriers and benefits, the study adds empirical depth to the growing but still underdeveloped body of Lean-BIM research in Nigeria.

In essence, while previous scholars have proven that Lean Construction can work in Nigeria, this study moves the conversation forward by demonstrating how Lean principles when coupled with emerging digital technologies and applied in construction project settings can deliver measurable improvements in project delivery, transparency, and sustainability. It also provides a framework adaptable to similar tertiary institutions and public projects nationwide, thereby supporting Nigeria's broader goals of efficient infrastructure delivery and sustainable development.

Conceptual Framework

The conceptual framework of this study illustrates how the integration of Lean construction principles such as Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) can optimize construction project performance in Nigeria, using the construction of Entrepreneurship Complex Phase III and the renovation of the School of Environmental Studies at Plateau State Polytechnic as case studies. The framework is built on the premise that effective planning, workflow optimization, and resource management are critical drivers of project performance. The three Lean tools are conceptualized as interrelated interventions that collectively address common inefficiencies in Nigerian construction projects, such as delays, cost overruns, and resource wastage.

Inputs:

Project Resources (labor, materials, equipment)
Project Scope (new construction vs. renovation)
Stakeholder Engagement (architects, builders, engineers, project managers, contractors, quantity surveyors)

Lean Construction Interventions:

Last Planner System (LPS): This enhances task reliability and stakeholder coordination through collaborative planning, regular site meetings, and monitoring of work plans.
Value Stream Mapping (VSM): Identifies bottlenecks, non-value-adding activities, and inefficiencies in workflow, facilitating process optimization.
Just-In-Time (JIT): It helps ensures timely delivery of materials and resources, reducing inventory costs, delays, and site congestion.

Moderating Factors:

Timely approval processes (Approval in Principle, procurement plans, TETFUND funding approvals)
Proper supervision and compliance with specifications
Early needs assessment and continuous follow-up

Outputs (Project Performance Indicators):

Schedule Performance: Completion of projects ahead of contract deadlines
Cost Efficiency: Reduction of material wastage and cost fluctuations
Quality Assurance: Compliance with design specifications and standards
Stakeholder Satisfaction: Positive feedback from project beneficiaries and team members

Relationships in the Framework

LPS → Schedule Reliability: Collaborative planning improves task execution and reduces delays.
VSM → Waste Reduction & Process Optimization: Mapping workflows highlights inefficiencies, enabling targeted improvements.
JIT → Resource Efficiency & Cost Control: Timely material delivery prevents site congestion and cost escalation.

Moderating Factors → Project Performance: Timely approvals, proper supervision, and proactive needs assessment amplify the benefits of Lean interventions.

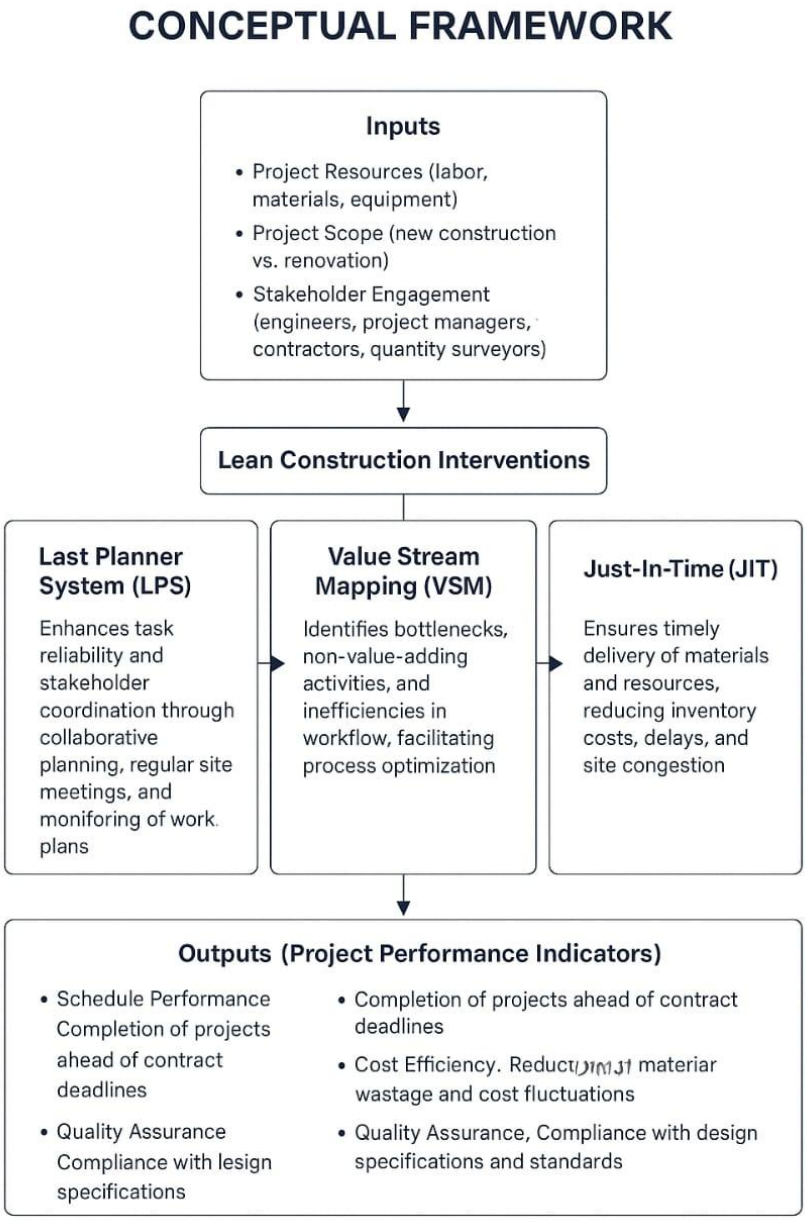

Figure 1: Showing the Conceptual Framework

Figure 1 posits that the synergistic application of LPS, VSM, and JIT leads to superior project performance compared to isolated adoption of individual Lean tools. Yet, this relationship is moderated by organizational readiness, technical capability, and the degree of stakeholder collaboration within the project environment.

Justification of the Conceptual Framework

The conceptual framework reflects the practical realities of construction projects in Nigeria, where delays, cost overruns, and inefficiencies are prevalent (Daniel, et al., 2017; Babalola, et al., 2019). By integrating the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT), the framework offers a structured method for improving planning reliability, workflow visualization, and material flow optimization—three areas consistently identified as sources of waste and inefficiency in the Nigerian context (Ahiakwo, et al., 2013; Oladiran & Kilanko, 2022; Oko, Nwanya, Okorigwe, Godwin, & Daniyan, 2025).

Empirical evidence shows that the implementation of LPS enhances schedule reliability and reduces workflow variability (Daniel et al., 2014; Ahiakwo et al., 2015), while VSM has proven effective in identifying and eliminating non-value-adding processes (Kumar, et al., 2015; Odohoedi, Ayandele, & Nnamseh, 2025). Similarly, JIT principles improve resource coordination and reduce material waste, thereby supporting leaner, more predictable project delivery (Aule et al., 2025; Oladiran & Kilanko, 2022).

Thus, integrating these three tools into a unified framework provides a synergistic model that aligns with global best practices in lean construction (Babalola et al., 2019) while addressing Nigeria's unique institutional and logistical constraints (Chukwuemeke, Ajaelu, & Chukwuenye, 2025; Nnaji, et al., 2025). This integration enables both new construction and renovation projects such as the Plateau State Polytechnic case studies to achieve timely, cost-effective, and high-quality outcomes.

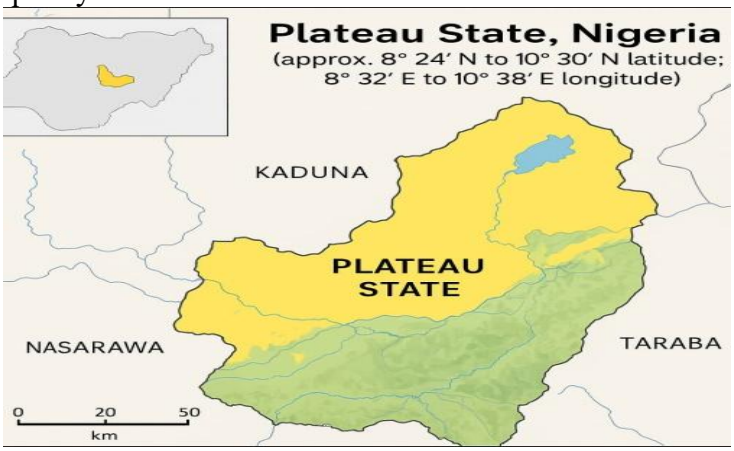

Figure 2: Showing the Map of the Study Area

The selection of Plateau State Polytechnic, Barkin Ladi, shown in Figure 2 specifically the construction of Entrepreneurship Complex Phase III and the renovation of the School of Environmental Studies were chosen as case studies due to their contextual and technical relevance. Plateau State, located in north-central Nigeria between latitudes 8°24′N–10°30′N and longitudes 8°32′E–10°38′E, is characterized by elevated terrain, rocky landscapes, and a cooler climate that influence construction practices, material transport, and scheduling (Wuyep, Vincent, Arin, Daloeng & Baminda, 2014). These geographical features make it a suitable environment to test Lean Construction tools under real-world challenges.

The Entrepreneurship Complex Phase III, a large new-build project, allows for the evaluation of Last Planner System (LPS) and Just-in-Time (JIT) techniques in managing complex logistics and improving workflow reliability. In contrast, the School of Environmental Studies renovation

provides a smaller, controlled setting ideal for assessing Value Stream Mapping (VSM) in minimizing waste and enhancing sequencing within an active institutional environment. Both projects, implemented under the TETFund framework, offer consistent administrative and funding structures, enabling reliable assessment. Overall, these case studies reflect how Lean Construction tools can be adapted to Plateau State's geographic and institutional realities to enhance efficiency, reduce waste, and improve project outcomes.

3. METHODOLOGY

Research Design

This study adopts a mixed-methods approach, integrating both quantitative and qualitative research techniques to evaluate the application and impact of Lean Construction principles specifically the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) on project performance in Nigeria. This methodological choice aligns with previous Lean Construction studies that combined numerical assessment and contextual inquiry to capture both measurable and experiential dimensions of Lean adoption (Ahiakwo et al., 2015; Daniel, et al., 2017).

Surveys

Structured questionnaires were administered to construction professionals, including project managers, site engineers, and quantity surveyors, to quantify the awareness, level of adoption, and perceived effectiveness of Lean tools. This method is consistent with prior studies in Nigeria that used survey instruments to evaluate Lean awareness and adoption barriers (Babalola, et al., 2019; Chukwuemeke, et al., 2025). Responses were analyzed using descriptive and inferential statistics to determine trends and correlations between Lean practices and project outcomes.

Interviews

Semi-structured interviews were conducted with key stakeholders to obtain in-depth insights into implementation challenges, success factors, and contextual adaptations of Lean principles. Qualitative input provides richer understanding of the behavioral and organizational dynamics affecting Lean uptake (Ahiakwo et al., 2013; Oladiran & Kilanko, 2022). Interviews also explored institutional readiness, leadership commitment, and training adequacy factors often cited as crucial to sustained Lean implementation in developing economies (Aule et al., 2023).

Case Study Observation

The study employed a case study approach to provide contextualized, empirical evidence of Lean Construction implementation within a real-world Nigerian institutional setting. The two pilot projects are located at Plateau State Polytechnic, Barkin Ladi, a tertiary institution currently expanding its physical infrastructure with support from the Tertiary Education Trust Fund (TETFund). The projects include:

1. Construction of the Entrepreneurship Complex Phase III, representing a new-build project, and
2. Renovation of the School of Environmental Studies, representing a refurbishment project.

These projects were deliberately selected because they differ in scope, new construction versus renovation allowing for comparative assessment of Lean tool applicability across project types. This duality provides valuable insights into how tools like the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) function under varying workflow and logistical conditions.

Field observations focused on identifying practical manifestations of Lean Construction, including workflow reliability, process efficiency, and adherence to schedule milestones. The following Key Performance Indicators (KPIs) were measured:

Percent Plan Complete (PPC): Used to evaluate planning reliability and short-term scheduling performance under the LPS framework (Ahiakwo et al., 2015).

Material and Resource Efficiency: Assessed to determine waste reduction and process optimization consistent with VSM and JIT principles (Oko, et al.. 2025; & Daniyan, 2025).

Timeliness of Project Milestones and Approvals: Measured to gauge the effect of Lean coordination practices on administrative responsiveness and workflow predictability (Daniel et al., 2017).

Direct observation of project documentation, site progress meetings, and procurement approval processes complemented the survey and interview data. This triangulated approach strengthens the validity of results by linking quantitative performance data with qualitative managerial observations, consistent with best practices in construction management research (Yin, 2018).

Population and Sampling

The study focuses on professionals engaged in construction project delivery within Plateau State, Nigeria, a region that represents the broader challenges and opportunities facing the Nigerian construction industry. The target population comprises professionals directly involved in the planning, design, management, and execution of building projects. These include:

Professionals: Architects, Builders, and Civil, Structural, and Mechanical Engineers actively engaged in design coordination, site supervision, and technical project implementation. Their participation is crucial, as Lean Construction emphasizes cross-disciplinary collaboration to eliminate process inefficiencies (Ahiakwo et al., 2015).

Project Managers: Individuals responsible for overseeing project timelines, budgets, and quality assurance, including members of the Plateau State Polytechnic Project Management Team and TETFund Officers. Their roles are central to aligning resource flow with project schedules a key principle in Lean Construction management (Daniel, et al, 2017).

Cost Managers: Quantity Surveyors and procurement specialists involved in cost estimation, financial control, and materials procurement, ensuring that Lean principles such as Just-In-Time (JIT) and Value Stream Mapping (VSM) are practically integrated to optimize resource use and reduce waste (Oladiran & Kilanko, 2022).

Contractors: Main and subcontractors responsible for executing construction works on site. Their inclusion provides operational insights into workflow management, logistics, and site coordination, all of which are essential to evaluating Lean tool application (Babalola, et al., 2019).

A purposive sampling technique was adopted to select participants who possess direct involvement and decision-making roles in the two case study projects. This sampling approach ensures that only respondents with first-hand experience in planning, monitoring, and executing the pilot projects were included, enhancing the validity and contextual accuracy of the findings (Creswell & Creswell, 2018).

In total, approximately 30 professionals participated in the survey to quantify Lean awareness and adoption levels, while 10 in-depth interviews were conducted to obtain qualitative insights into project experiences, managerial practices, and contextual challenges.

Data Analysis:
The collected data were analyzed using both quantitative and qualitative techniques:
Quantitative Analysis: Statistical tools, including the Relative Importance Index (RII) and descriptive statistics were used to quantify the awareness and perceived effectiveness of Lean tools among professionals.
The RII was calculated using the formula:
R.I.I = ∑W/A x N
Where: **W** represents the weighting assigned by respondents (1-5 scale), **A** is the highest possible weight (5), and **N** is the total number of respondents (30).
Qualitative Analysis: Thematic analysis was applied to interview transcripts and observational notes to identify recurring patterns, themes, and insights related to the implementation and impact of Lean principles.
The integration of these analyses provided a comprehensive understanding of the application and outcomes of Lean construction practices in the selected case studies.

4. RESULTS AND DISCUSSION

Table 1: Showing the Role Distribution of Respondents

Role	Count	Percentage (%)
Contractor	10	33.33
Quantity Surveyor	9	30.00
Project Manager	6	20.00
Engineer	5	16.67
Total	**30**	**100.00**

Table 1 shows that Contractors (33.33%) formed the largest group of respondents, followed by Quantity Surveyors (30%), Project Managers (20%), and Engineers (16.67%). This indicates a well-balanced representation of key professionals engaged in project planning, execution, and cost control within Plateau State's construction sector.
The dominance of contractors underscores their central role in translating management decisions into on-site implementation and coordinating workflow and logistics functions crucial for Lean Construction practices such as LPS, VSM, and JIT (Ahiakwo, et al., 2015; Daniel, et al., 2017; Babalola, et al., 2019). Quantity Surveyors, as the second largest group, contribute to cost management and waste reduction, reinforcing Lean's focus on financial and material efficiency (Ameh & Osegbo, 2011; Oladiran & Kilanko, 2022).
Project Managers (20%) represent the strategic leadership dimension essential for Lean adoption, emphasizing collaboration and schedule reliability, particularly within institutional TETFund projects (Emuze & Smallwood, 2013; Daniel et al., 2017). Engineers (16.67%) provide the technical foundation for Lean implementation through process optimization and defect control (Ahiakwo et al., 2015).
Overall, the respondent composition reflects a multidisciplinary approach consistent with Lean Construction philosophy, where synergy between design, cost, and production professionals ensures optimal performance (Koskela, 2000). The balanced stakeholder mix strengthens data validity and aligns with Yin's (2018) recommendation for triangulation in case study research.

Table 2: Showing Respondents Ratings

S/No	Role	LPS Awareness	VSM Awareness	JIT Awareness	LPS Experience	VSM Experience	JIT Experience	LPS Integration	VSM Integration	J Integ
1	Quantity Surveyor	0	1	1	5	3	3	1	3	
2	Contractor	1	0	1	3	3	2	2	1	
3	Engineer	1	1	0	5	1	5	1	4	
4	Quantity Surveyor	1	1	0	4	5	4	3	4	
5	Quantity Surveyor	0	0	0	5	1	2	4	3	
6	Contractor	1	1	1	3	3	4	1	1	
7	Engineer	0	1	1	3	2	3	1	3	
8	Engineer	0	1	0	4	4	3	2	1	
9	Quantity Surveyor	1	1	0	2	3	1	2	5	
10	Project Manager	1	1	0	2	1	5	3	2	
11	Quantity Surveyor	1	1	0	5	4	4	4	2	
12	Quantity Surveyor	0	0	1	1	1	2	2	2	
13	Quantity Surveyor	1	0	1	5	1	3	1	3	
14	Quantity Surveyor	1	0	1	4	2	1	4	5	
15	Contractor	0	1	1	4	4	1	4	1	
16	Engineer	1	1	0	4	4	4	1	4	
17	Contractor	0	0	1	4	2	3	2	1	
18	Contractor	0	1	1	4	3	5	1	4	
19	Contractor	1	1	1	3	1	3	4	1	
20	Quantity Surveyor	1	0	1	2	5	4	5	5	
21	Project Manager	1	1	1	4	1	4	5	4	
22	Engineer	1	0	1	1	1	3	3	3	
23	Project Manager	0	1	1	1	3	4	1	1	
24	Contractor	1	0	0	1	1	3	1	1	
25	Contractor	1	1	0	1	2	2	3	4	
26	Project Manager	0	1	0	3	2	3	3	3	

S/No	Role	LPS Awareness	VSM Awareness	JIT Awareness	LPS Experience	VSM Experience	JIT Experience	LPS Integration	VSM Integration	J Integ
27	Project Manager	1	0	1	1	4	3	3	3	
28	Project Manager	0	0	0	4	5	4	4	5	
29	Contractor	1	1	1	5	1	4	1	3	
30	Contractor	0	1	1	1	1	1	4	3	

Table 2 reveals varying levels of awareness, experience, and integration of Lean Construction tools, the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-in-Time (JIT) among professionals. Overall, awareness levels were moderate, with slightly higher familiarity in LPS and JIT compared to VSM. This finding aligns with previous studies in Nigeria showing that while professionals increasingly recognize Lean tools, actual comprehension and structured application remain limited (Daniel, et al., 2017; Babalola, et al., 2019).

In terms of practical experience, respondents demonstrated more engagement with LPS, particularly among Quantity Surveyors and Engineers, reflecting its adaptability to project planning and site coordination (Ahiakwo, et al., 2015). The relatively lower experience with VSM suggests that process mapping and waste flow visualization are still emerging concepts within the Nigerian context (Oladiran & Kilanko, 2022).

Integration levels indicate that professionals have begun applying Lean tools collaboratively, especially in JIT and LPS components, to enhance material flow and reduce delays. However, integration remains inconsistent across disciplines, echoing findings by Ameh & Daniel (2014) that fragmented adoption and limited institutional support hinder full Lean implementation.

Generally, the pattern demonstrates growing but uneven Lean maturity among practitioners confirming the need for targeted training, managerial commitment, and supportive organizational policies to institutionalize Lean practices in Nigeria's construction industry (Emuze & Smallwood, 2013; Ogunbiyi, Goulding, & Oladapo, 2014).

Table 3: Showing the Relative Importance Index (RII) Analysis for the three Lean tools across all key metrics

Metric	Mean	RII	Rank
JIT Integration	3.37	0.673	1
VSM Awareness	3.17	0.633	2
LPS Experience	3.13	0.627	3
JIT Experience	3.10	0.620	4
LPS Awareness	3.00	0.600	5
JIT Awareness	3.00	0.600	6
VSM Integration	2.83	0.567	7
LPS Integration	2.53	0.507	8
VSM Experience	2.47	0.493	9

Table 3 presents the Relative Importance Index (RII) of Lean Construction tools across nine performance metrics. The results show that Just-In-Time (JIT) Integration ranked highest (RII =

0.67), indicating that respondents perceive JIT as the most practical and impactful Lean tool in improving material flow and reducing site congestion. This finding aligns with Oladiran & Kilanko (2022), who reported that JIT delivery enhances supply-chain efficiency and minimizes waiting and overproduction wastes in Nigerian projects.

Value Stream Mapping (VSM) Awareness followed closely (RII = 0.63), reflecting growing recognition of its value for process visualization and waste identification. However, its relatively low integration score (RII = 0.56) suggests that while professionals understand VSM conceptually, its technical application remains limited—a challenge also highlighted by Babalola, et al (2019).

Last Planner System (LPS) Experience (RII = 0.62) ranked third, showing moderate use in planning and workflow coordination. Similar studies by Ahiakwo, et al., (2015) confirmed that LPS improves schedule reliability when properly facilitated but faces barriers such as weak managerial support and inconsistent follow-up.

More often than not, the ranking indicates that Nigerian practitioners prioritize practical, logistics-oriented Lean tools (like JIT) over system-based tools (LPS and VSM). This mirrors earlier findings that Lean adoption in developing economies often begins with simpler, high-visibility practices before progressing to more integrative process frameworks (Daniel, et al., 2017). Strengthening institutional capacity, leadership commitment, and technical training remains essential for broader Lean integration (Emuze & Smallwood, 2013).

This study explored how combining the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-in-Time (JIT) principles can enhance construction project performance in Nigeria, using the construction of Entrepreneurship Complex Phase III and the renovation of the School of Environmental Studies at Plateau State Polytechnic as case studies.

From survey data of 30 professionals (engineers, project managers, quantity surveyors, contractors), the awareness levels for LPS, VSM, and JIT were relatively high (about 60 % each). Using a Relative Importance Index (RII) analysis, JIT integration ranked highest, indicating that practitioners placed greater importance on the integrated and timely delivery of materials. VSM awareness and LPS experience followed, suggesting that though many know of visualization (VSM) and planning (LPS) tools, their consistent use is still developing.

In the two case studies, the practical applications of Lean tools were manifest through prompt Approval-in-Principle (A.I.P.), timely procurement and fund approvals, regular site meetings, rigorous monitoring and evaluation of work plans, early needs assessments with TETFUND, and supervision of contractors to ensure specification compliance. These practices aligned with Lean goals of reducing waste, smoothing workflow, and enhancing project reliability.

The successful completion of both projects ahead of schedule demonstrates that the synergy of LPS, VSM, and JIT can be effective in the Nigerian context when supported by timely administrative processes and disciplined execution.

Summary of Interview Responses and Corroborating Literature

Interviews with professionals across various roles, namely; Architects, Builders, Contractors, Quantity Surveyors, Engineers, and Project Managers revealed a growing awareness of Lean Construction principles, though their practical application remains uneven. Most participants agreed that tools such as the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) hold great potential to improve workflow efficiency, minimize material waste, and strengthen project coordination. However, these tools are often applied in isolation rather than as part of a well-integrated Lean framework.

Respondents frequently cited barriers such as limited training opportunities, weak managerial support, poor communication among stakeholders, and the absence of institutional policies to sustain Lean practices. These challenges mirror the findings of Babalola et al (2019) and Daniel, Pasquire, & Ameh (2017), who found that while awareness of Lean Construction is increasing in Nigeria, real implementation is often hindered by organizational rigidity and a lack of technical competence.

On a positive note, several participants shared practical success stories from partial Lean applications. For instance, adopting Just-In-Time (JIT) delivery and short-term planning sessions inspired by the Last Planner System helped reduce site congestion and improve project timelines. This supports Ahiakwo et al (2015), who observed that collaborative planning through LPS enhances workflow reliability in Nigerian construction. Similarly, the benefits of JIT in ensuring timely material delivery and minimizing waste were consistent with the findings of Oladiran & Kilanko (2022).

That said, most respondents admitted that Value Stream Mapping (VSM) is still poorly understood and rarely applied due to its technical nature. This observation echoes Ogunbiyi, et al., (2014), who noted that process mapping and performance tracking remain underdeveloped in many developing construction industries.

Broadly speaking, the interviews paint a clear picture: while the Nigerian construction industry increasingly recognizes the potential of Lean Construction, its adoption remains in its early stages. Successful implementation depends largely on individual initiative, project leadership, and external training exposure. The participants strongly emphasized the need to strengthen Lean education, foster interdisciplinary collaboration, and embed continuous improvement in project culture recommendations that align with Emuze & Smallwood (2013), who advocate for similar reforms in developing economies.

5. CONCLUSION

The findings of this study demonstrate that integrating the Last Planner System (LPS), Value Stream Mapping (VSM), and Just-In-Time (JIT) principles can significantly enhance planning reliability, resource efficiency, and schedule performance in Nigerian construction projects. Evidence from the Plateau State Polytechnic pilot projects shows that LPS promotes collaborative planning and reduces execution uncertainty; VSM helps identify and eliminate non-value-adding activities; and JIT ensures timely material delivery, reducing waste and inventory costs. When these Lean tools are institutionalized through prompt decision-making, regular monitoring, and strong supervision, they collectively improve overall project outcomes. Notably, past Nigerian studies have reported that effective LPS implementation can achieve up to 80% Percent Plan Complete (PPC) and about 30% cost savings.

Although the adoption of Lean Construction methods in Nigeria remains at an early stage, there is growing momentum. Existing research indicates increasing awareness of Lean concepts but highlights persistent barriers such as limited training, inadequate leadership commitment, and weak organizational cultures of continuous improvement. Similarly, while JIT awareness is strong, its consistent application remains a challenge under real project conditions. This study, therefore, adds both practical and empirical insight to Lean Construction research in Nigeria, showing how the synergy of LPS, VSM, and JIT when supported institutionally can drive measurable improvements in project delivery and efficiency.

6. RECOMMENDATIONS

Government agencies, project funders (like TETFund), and professional bodies such as Construction regulatory bodies such as the Council of Registered Builders of Nigeria

(CORBON), Nigerian Society of Engineers (NSE) and the Nigerian Institute of Quantity Surveyors (NIQS) should integrate Lean construction principles into their project guidelines, procurement frameworks, and regulatory standards. This will help entrench practices such as prompt approvals and disciplined process flows. Provide dedicated training and certification programs in LPS, VSM, and JIT for construction professionals. Emphasis should be on hands-on implementation rather than only theoretical knowledge. Clients should enforce the early initiation of Needs Assessment, A.I.P., and procurement planning to avoid delays in fund release or material supply that commonly disrupts schedules.

Use Percent Plan Complete (PPC) and other Lean metrics to monitor workflow reliability, detect deviations early, and drive continuous improvement. Project teams need strict supervision of contractors to ensure compliance with specifications and prevent deviations that lead to rework, an important contributor to waste in Nigerian projects (poor supervision is frequently cited as a major factor in material waste generation). Overcoming inertia and resistance requires commitment from top management, change champions, and nurturing an organizational culture open to innovation. Nigerian studies identify leadership, knowledge, and culture barriers as among the top obstacles to Lean adoption.

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