International Journal of Builders in Academia (IJBA) Volume 1, Issue 1; August 2025
10.36108/ijba/5202.10.0150

Applying Lean Production Approach to Optimise Materials Management in the Nigerian Construction Industry

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Abstract
In Nigeria, ineffective materials management remains a major challenge within the construction industry, contributing to substandard work quality, increased material waste, budget overruns, disrupted materials flow, and delays in project execution. Addressing these issues calls for a fundamental shift in the operational strategies currently used in the Nigerian construction sector. One promising solution that has gained attention is the adoption of lean production approach to enhance materials management. This study set out to explore how lean production methods could be applied to improve the handling of construction materials. The research involved reviewing relevant literature and analysing selected case studies. Abuja, the Federal Capital Territory of Nigeria, served as the study's focus area, where ten case studies were examined. Data collection was carried out through direct observation using a tick-box checklist. The findings revealed that materials management practices in construction industry currently have a low overall impact on waste reduction. Lean approach such as waste minimization, timely delivery, improved productivity, and just-in-time systems were found to be underutilized across the observed projects. Based on these findings, a clear framework consisting of three key phases lean Initiation, lean implementation, and lean sustainability has been proposed. Ultimately, the study provided valuable insights into effective materials handling practices in the Nigerian construction industry and emphasized the importance of educating construction personnel about the risks and consequences associated with poor materials management.

Key words: Construction, Framework, Lean management, Materials management, Waste

Introduction

The construction industry is a vital sector in Nigeria's economic development, contributing significantly to infrastructure growth, employment, and national GDP (Saka, 2022). However, the industry faces persistent challenges related to inefficiency, high material waste, poor resource utilisation, and rising project costs (Albert, *et al*., 2021). One of the key areas contributing to these inefficiencies is materials management, which encompasses the planning, procurement, handling, and control of construction materials throughout a project's lifecycle. The rapid growth of the construction industry has led to the consumption of nearly 40% of the world's natural resources annually, which in turn contributes to significant waste generation (Dajadian and Koch, 2014; Adewuyi and Otali, 2013). A portion of this waste is not adequately managed and ends up in landfills (Dajadian and Koch, 2014). Material waste is a global concern, affecting both developed and developing countries. As defined by Adewuyi and Odesola (2015), material waste includes anything that fails to add value to a construction project's intended outcome (Albert and Shakantu, 2018). Construction site waste can be categorized into physical and non-physical types. Physical waste comprises items like damaged concrete, bricks, metals, and packaging materials, while non-physical waste relates to inefficiencies such as delays and budget overruns (Nagapan *et al*., 2012). Ineffective materials management practices in Nigeria often lead to delays, cost overruns, material shortages, and excessive waste generation (Albert *et al.*, 2021). Studies have shown that a large percentage of construction waste stems from poor handling, over-ordering, damage, and lack of coordination on-site (Samuel, 2024). These challenges are

exacerbated by the industry's limited adoption of innovative and efficient production approaches (Demirkesen and Tezel, 2022; Saka, 2022). According to Anderson and Thornback (2012), the construction sector plays a central role in sustainability discussions due to its high resource consumption and the large volumes of waste it sends to landfills (Ajayi *et al*., 2016; Bilal *et al*., 2016). This rising concern over material waste has sparked numerous studies and policy measures aimed at reducing it. Prefabrication is among the introduced techniques that show significant potential, with research by Tam (2008) indicating it can reduce construction waste by as much as 84.7%. In Nigeria, the construction industry can be considered as a sector that consumes resources in production of buildings, infrastructure and so on (Dania *et al*., 2007) and produces a significant amount of material waste (Wahab and Lawal, 2011). Ameh and Itodo (2013) highlighted that for every 100 houses built in Nigeria, the number of wasted materials could construct an additional 10 houses, and such waste poses serious challenges, often diminishing project performance (Adewuyi and Otali, 2013). Moreso, the traditional construction project delivery system fails to properly consider non-value adding activities, such as waste; but the general project delivery systems lay much emphasis on project cost, as these non-value adding activities contribute to the final project cost (Albert and Shakantu, 2018).

Lean production, a methodology originally developed in the manufacturing sector, focuses on maximising value by eliminating waste and optimising processes (Kumar *et al*., 2022). Over the years, lean principles have been adapted to the construction industry through approaches like Lean Construction, which emphasise continuous improvement, just-in-time delivery, value stream mapping, and efficient resource use (Basiru *et al*., 2023). Despite its proven benefits globally, the adoption of lean principles in Nigeria's construction sector remains limited, primarily due to low awareness, lack of training, and resistance to change (Dauda *et al*., 2024).

Due to the low level of awareness of lean production approach within the Nigerian construction industry, the sector continues to adopt inefficient techniques. Consequently, key operational strategies that improve production management and minimize waste are rarely implemented and remain poorly understood. Applying the lean production approach to materials management presents an opportunity to address these inefficiencies. By focusing on reducing non-value-adding activities, improving workflow, and enhancing coordination, lean practices can significantly improve materials handling and reduce waste on Nigerian construction sites. In light of these issues, this study investigates the utility of lean production approach as a strategy to enhance materials management within the Nigerian construction industry. The application of lean principles holds potential for significantly reducing material waste and improving overall efficiency in the construction sector.

Literature Review

Connection between lean approach and materials management

Lean approach is the continuous process of improving productivity and reducing waste (Goshime *et al*., 2019; Mahmood and Shevtshenko, 2015). Waste comes in many forms, including time, effort (labour), or other resources that are used in the production process (King, 2019; Yates, 2011). As part of lean approach, materials management is an important aspect of keeping inventory low and maintaining the flow of products through construction project (Meng, 2019). Having good inventory control in place is critical for construction industry looking to operate lean and maintain profitability in the long run (Tezel *et al*., 2018).

Material management is the process of maintaining inventory levels (Arijeloye and Akinradewo, 2016). Construction industry strives to reduce inventory as much as possible without jeopardizing their ability to meet customers' expectations (Perkins and Skitmore, 2015). Excess inventory is a form of waste and reducing it can improve profitability by lowering the cost of production (Chen *et al*., 2019). In some cases, it can also pose safety or security hazards. Construction industry must consider the time spent managing an inventory system and employee hours spent handling items or collecting information about them like taking pictures or entering data (Ajayi *et al*., 2016). An important aspect of materials management is getting raw materials into construction site as quickly as possible (Allen and Iano, 2019). The longer it takes to get a part into production, the more money loss and the less productive the team becomes.

A critical part of achieving lean construction is lean material management by reducing the amount of time it takes to turn raw materials into finished products (Ansah *et al*., 2016; Albert *et al.,* 2018). In order for this to happen, there is a need for a reliable system to manage construction materials inventory and flow throughout the construction site to prevent delays in the production process (Adewuyi and Odesola, 2015). It is also important to track how much inventory at hand at any given time and know when it's time to order more supplies (Perkins and Skitmore, 2015). This way, one can be prepared for any possible delays in production or unexpected surges in demand. Reducing raw material lead time eliminates the need for inventory and increases flexibility in responding to market changes (Suri, 2020). In addition, reducing inventory helps reduce costs related to storage and labour (Adewuyi and Otali, 2013). One way to reduce lead times is to source materials from suppliers close to project site (Suri, 2020). Shorter shipping distances mean less time and money spent on shipping costs, which translates into lower costs per unit. Shortened delivery times also mean it is easier to match production schedules with demand, especially when trying to avoid waste (i.e., having too much inventory). When materials have shorter distances to travel, there is a reduced risk of damage during transportation (Torretta *et al*., 2017). This means less maintenance and repair needed in the future as well as less time spent inspecting damaged goods before they are put on the shelf or shipped off-site for repair. Another way to reduce lead times on raw materials is with blanket purchase orders (BPOs) or consignment agreements (West, 2021). These allow construction industry to quickly secure products from a supplier without having to use an RFQ every time, which can be a lengthy process (Arijeloye and Akinradewo, 2016). However, BPOs are not as useful for low-volume, high-variety materials because suppliers may not be able to accommodate specific needs in such an arrangement. Additionally, if demand for product is not high enough, a supplier may not want to offer an attractive price point (Albert and Shakantu, 2018). In general, BPOs are best suited for high-volume and low-variety items, as they ensure a quick flow of raw material into construction project site. Materials management is a critical part of construction project, and using a lean approach to manage materials means raw materials are available when they are needed but inventory levels are kept low to avoid excess costs of storage and material handling and damage (Alvim and Oliveira, 2020). Operating with a reduced lead time decreases inventory costs, increases flexibility to respond to market fluctuations, and increases responsiveness to customer demands and deadlines (West, 2021).

Achieving lean production approach to material management can seem like a daunting process. However, implementing the proper techniques and inventory management system is a great first step, that allows construction industry to easily gain control of inventory so that they may create and implement inventory and supply policies that utilize construction materials for production.

The conceptual framework

The conceptual framework serves as the backbone of the research process, guiding the study toward achieving its objectives. It illustrates how existing literature interprets a particular issue and informs the actions required throughout the research. Built upon prior knowledge and insights from previous studies, the framework provides justification for the chosen methodology by offering a structured foundation upon which the research approach is developed (Dehalwar and Sharma, 2023). This includes lean management system, lean construction techniques/tools, efficient resource procurement, and site material management practices.

Lean management system

Lean management is an approach centred on improving organizational processes through continuous, incremental enhancements (Czarnecka *et al*., 2017). According to Collar *et al*. (2012) lean management aims to increase productivity by eliminating waste and ensuring that every step in a process or value chain adds value. Unlike traditional project management, lean project management differs not only in its goals but also in the way its phases are structured, how these phases interact, and the roles played by stakeholders at each stage (Ballard and Howell, 2003). Emerging in the 1990s, lean construction is derived from lean

production principles and forms a core component of lean project management (Karim and Nekoufar, 2011).

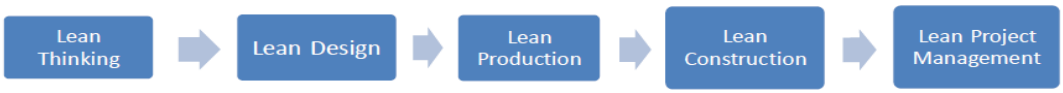

Figure 1: Lean concepts
Source: Karim and Nekoufar (2011).

Lean process management helps organizations reduce waste by identifying, analyzing, and optimizing individual processes and their overall workflow (Tanha *et al*., 2025). A key factor in the effective implementation of lean process management is the human component, which plays a vital role in ensuring sustainable success over time (Puvanasvaran *et al*., 2008). The core objective of lean process management is to cut costs by eliminating non-value-adding activities commonly referred to as waste from the processes involved in delivering products or services.

Lean construction techniques/tools
Lean construction emphasizes efficient resource use to meet client demands while minimizing waste (Al-Aomar, 2012). As outlined by Marhani *et al.* (2012), lean principles aim to eliminate non-value-adding tasks, enhance output by addressing customer needs, minimize variation, reduce cycle time, simplify processes, increase flexibility, and foster continuous improvement and benchmarking. These includes: concurrent engineering, continuous improvement, re-engineering, just in time, value-based management, visual management, total quality management, last planner system, six sigma.

Efficient resource procurement
Procurement involves the systematic planning and scheduling of material purchases and deliveries from suppliers, which includes securing materials, equipment, labour, and services required for project execution (Zeb *et al*., 2015). The most efficient procurement method is through a competitive bidding process, which ensures that the negotiated price meets all specified requirements (Kini, 1999). A strategy like just-in-time delivery can help reduce construction waste by ensuring that materials are delivered only when needed, minimizing storage time and preventing issues such as over-ordering and damage from double handling (Albert *et al*., 2024; Ajayi *et al*., 2017). Inefficient coordination in material procurement can lead to significant waste in construction projects (Ajayi, 2017). Therefore, it is essential to adopt effective measures to prevent waste arising from poor purchasing decisions. The success and profitability of a project heavily depend on how materials are procured and managed (Chen *et al.*, 2022). Efficient material purchasing coordination is critical not only for minimizing waste but also for the overall success of the project (Ajayi *et al*., 2017). Additionally, careful attention should be given to the quality and reusability of materials (Ajayi *et al*., 2017). Lean procurement aims to identify and eliminate waste across all procurement activities, employing various tools and techniques (Yin *et al*., 2014).

Site material management practices
Efficient management of construction site materials is essential for boosting productivity and minimizing issues like rework, defects, delays, disputes, and budget overruns. For construction professionals, this means ensuring that projects are completed on time, within budget, to the required quality standards, and meeting client specifications (Olubunmi *et al*., 2014). Therefore, material management practices need to be carefully planned and implemented in construction projects. Proper material management is vital for achieving increased productivity, profitability, cost savings, and successful project completion with optimal quality (Phu and Cho, 2014). Surplus materials and waste often accumulate on construction sites after building activities. Waste can arise at any stage, from the design phase to construction, and even during the building's

operation. Thus, effective management of surplus and waste materials on-site is crucial for successful material management and project outcomes (Phu and Cho, 2014; Albert *et al*., 2025).

Positioning of the conceptual framework

This framework represents the research's viewpoint on the proposed research solution and offers guidance for the study. Based on the preceding discussion of the conceptual framework, lean management serves as the foundation of the entire structure by promoting continuous improvement and minimizing waste throughout organizational processes. It serves as the overarching philosophy and strategic approach aimed at maximizing productivity by ensuring that each step in a process adds value. In construction, lean principles are applied through specific techniques known as lean construction. Methods such as Just-In-Time (JIT) delivery, the Last Planner System, Six Sigma, and Visual Management translate lean principles into practical tools that streamline material flow, improve communication, and reduce variability on-site. Procurement plays a critical role as the point where lean strategies begin to take shape in practice, while site material management represents the frontline where lean production delivers its most visible and measurable results. Figure 2 illustrates the conceptual framework that guided the research methodology for applying the lean production approach to materials management in the Nigerian construction sector.

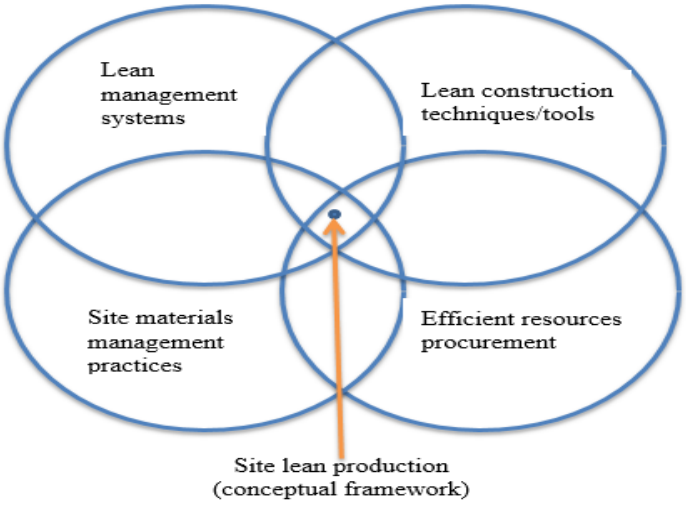

Figure 2: Conceptual framework

As highlighted in the previous discussion, the conceptual framework sits at the intersection of lean management systems, lean construction principles, efficient resource planning, and on-site materials management practices, as illustrated in Figure 2.

Methodology

This study investigates the use of the lean approach as a strategy to enhance materials management in construction industry, in Abuja, Nigeria. The research adopted the qualitative method of research inquiry. Although there are several types of qualitative methods such as, narrative analysis, ethnography, phenomenology, grounded theory. The collective case study approach was deemed appropriate for this research as stipulated in the work of Creswell (2014). In this study, direct observation in the in-depth case studies provided an understanding of the Poor Materials Management (PMM) on construction sites as offered by Taylor-Powell and Steele (1996). As a research method, observation enables the research to obtain a detailed description of social settings or events to situate people's behaviour within their own sociocultural context (Hennink *et al*., 2011). Observation provides the opportunity to document activities, behaviour and physical aspects without depending on peoples' willingness and ability to respond to questions (Taylor-Powell and Steele, 1996). Building construction sites in Abuja was chosen as research population for this study because it is one of Nigeria's metropolitan cities with the highest population of

the built environment professionals in the country. It has many ongoing building construction projects, the proximity to the study area (FCT, Abuja), and the location of the construction projects in the same area makes the study more economical in terms of cost and time. From this population, a sample of ten building projects were selected, with a value of 200 million Naira and above, using purposive non-probability sampling techniques. The rationale for the purposive non-probability (typical case sampling selection) is that building construction projects of this value and above are typically likely to have ineffective materials management compared with projects of less value (Patton, 2002).

Between January 2024 and April 2024, visits were made to each of the project sites, and covert observation was employed. Individuals were unaware that they were being observed, and the observer remained concealed or embedded within the environment to document behaviour, actions, and interactions (McKechnie, 2008). Observations were conducted for an average of five hours per day over the four-month period. The study considered the majority of the building materials such as cement, aggregate, reinforcement, timber, mortar and block used in projects. These materials represent a significant percentage of the total cost of buildings in most of the traditionally built residential and commercial buildings in Nigeria. The construction processes observed included materials usage onsite, loading/offloading of materials from procurement, storages, recycling of some waste materials on site, proper storage of materials, quality control, periodic site meeting, just in time delivery, flow within the process as waste is reduced, productivity as well as effective handling of materials and movement on site. The site workers involved in each operation in term of planning, monitoring and control were observed.

For data collection, based on the literature review, recording sheets with checklists were pre-set with variable (Likert items) and responses to observe and document the lean approach to materials management as related to material management practices and lean management principles. Recording sheet 1 consists of 11 statements (Likert items) on utility of material management practices. The study rated proper storage of materials on site; planning, monitoring and control; timely delivery; waste reduction; productivity; handling of materials; recycling of some waste materials on site; re-use of waste materials in projects; reduction in duplicated orders; optimise resource usage; as well as quality improvement. Recording sheet 2 consists of eleven statements (Likert items) on utility of lean management systems. The observer rated maximise value; minimise waste; timely delivery; control system; improve productivity; improve materials handling system; provides good environment for success of the organisation; continuous improvement; improve resource utilisation; reduced inventory level and the introduction of just in time system as well as quality improvement. For the purpose of anonymity, the names of the project sites are not disclosed in this article. Instead, they are represented by case study (CS) numbers CS1to CS10 for the ten projects studied.

The Statistical Package for the Social Sciences (SPSS) version 23 was used to conduct descriptive analysis of the data computing the mode that describes the most frequently occurring. To measure the central tendency of the materials management practices and lean management principles, the statements (Likert items) were rated on an ordinal three-point Likert scale. In the words of Schmee and Oppenlander (2010), "Likert-type scales use fixed choice response formats and were designed to measure the strength of the perceived agreement or disagreement with statements" (Likert items) The following scale measurement was used regarding modal value: 1 = low; 2 = moderate, and 3 = high. This research used observation of what was observed on site with the observation guide developed for the study. No interviews were conducted. Thus, the voice of the construction professionals was not considered.

Results and Discussion

Site materials management practices

The observed practices are discussed in Table 1

Table 1: On-site materials management practices observed

statement	Case studies 3= high; 2 = moderate; 1 = low										Mode
	CS1	CS2	CS3	CS4	CS5	CS6	CS7	CS8	CS9	CS10	
Proper storage of materials on site	2	3	3	2	1	2	2	3	2	1	2
Planning, monitoring and control	2	3	1	2	2	1	3	2	2	3	2
Timely delivery	1	2	1	1	1	2	1	3	1	2	1
Waste reduction	1	2	3	1	3	2	1	3	2	1	1
Productivity	1	1	2	1	1	2	1	2	1	1	1
Handling of materials	1	1	1	2	1	2	1	3	2	3	1
Recycling of some waste materials on site	1	1	2	3	1	1	2	1	3	2	1
Re-use of waste materials in projects	3	1	1	2	1	2	1	2	1	3	1
Reduction in duplicated orders	2	3	2	1	2	3	2	2	1	3	2
Optimise resource usage	3	2	2	2	1	3	2	2	1	3	2
Quality improvement	3	2	3	2	2	3	3	3	2	3	3
Total											1

Overall modal values of 1 (see Table 1) demonstrate that site materials management practices have a low impact on waste reduction in the construction industry in Abuja, Nigeria.

The results indicate that activities such as planning, monitoring and control; reducing duplicated orders; optimizing resource utilization; and ensuring proper on-site material storage were perceived to have a moderate impact on construction projects, and there is need for improvement in such a way that it minimises damage, preventing accidents and injuries from tripping hazards or falling objects, maintain a tidy site, and loss of materials. This is agreement with the view of Peatie *et al*. (2024). With these, the construction sites can maintain a safe, efficient, and organised storage system. However, timely delivery, waste reduction, productivity, handling of materials, recycling of some waste materials on site, and re-use of waste materials in projects were considered to have low impact on construction projects. This also, agrees with the study by Reddy and Rao (2022), which found that timely delivery of materials in construction projects is generally poor, leading to delays, increased costs, and on-site inefficiencies that negatively impact productivity. The results also align with research by Samuel (2024), which indicates that proper material handling, on-site recycling, and construction waste reuse are frequently undervalued, inadequately implemented, or perceived to have limited influence on the overall success of construction projects. It is imperative for effective site materials management practices for construction projects, thereby implementing strategies to reduce materials waste and encouraging recycling of materials whenever possible, improve efficiency, and ensure a safer working environment.

Lean management systems

The results on lean management system being adopted on the projects studied are presented in Table 2.

It is clear from Table 2 that minimise waste, timely delivery, productivity, materials handling system, resource utilisation, and introduction of just in time system were considered to have low impact on construction projects which mean that most lean construction management were not applied in the construction projects and there is need to streamlining construction processes, reducing waste, and improving project delivery.

Table 2: Lean management systems adopted on site

statement	Case studies 3= high; 2 = moderate; 1 = low										Mode
	CS1	CS2	CS3	CS4	CS5	CS6	CS7	CS8	CS9	CS10	
Maximise value	2	1	2	3	3	2	1	1	2	2	2
Minimise waste;	1	1	2	3	2	1	1	2	1	2	1
Timely delivery	1	2	1	1	1	1	1	2	1	1	1
Control system	3	2	2	3	3	3	1	1	3	2	3
Improve productivity	1	1	1	2	3	1	2	3	1	1	1
Improve materials handling system	1	2	1	3	1	1	3	1	1	2	1
Provides good environment for success of the organisation	2	2	3	3	2	1	1	3	2	2	2
Continuous improvement	2	2	3	2	3	2	2	3	2	2	2
Improve resource utilisation	1	2	1	1	2	1	3	1	1	3	1
Reduced inventory level and the introduction of just in time system	1	1	3	1	1	2	2	1	3	2	1
Quality improvement	2	2	2	2	3	2	2	2	3	3	2
Total											1

Overall modal values of 1 (see Table 2) demonstrate that utility of lean management systems have a low impact in the construction industry in Abuja, Nigeria.

This aligns with the study by Singh *et al*. (2024), which suggests that construction teams and management may be accustomed to traditional methods and are often hesitant to adopt new practices. Additionally, some stakeholders might not fully understand lean principles or how to implement them effectively in construction. Construction workers often prefer familiar routines and may fear that new methods will complicate their work or jeopardize their jobs. Lean management is a powerful approach to improving efficiency, reducing waste, and delivering value to customers. However, quality improvement, continuous improvement, maximise value were considered to have moderate impact on the projects. This means that quality improvement, continuous improvement, and maximizing value were seen as having a moderate level of influence or effect on the projects. Quality improvement in construction refers to the systematic efforts made to enhance the standards of every aspect of a construction project, including materials, workmanship, processes, and finished outcomes (Egwunatum *et al*., 2022). The goal is to meet or exceed project specifications, client expectations, and regulatory requirements while minimizing defects and rework. Continuous improvement in construction refers to an ongoing effort to enhance construction processes, efficiency, quality, and productivity over time (Omotayo *et al*., 2022). Rather than settling for "good enough," it encourages teams to consistently evaluate their performance, identify areas for improvement, and implement small, incremental changes that lead to better project outcomes. Maximizing value in construction means delivering the highest possible benefit to the client or end user relative to the resources used such as time, money, labour, and materials (Albert *et al*., 2021; Chen *et al.,* 2022). It's not just about

cutting costs; it's about achieving the best balance between quality, cost, and functionality to meet the project's goals efficiently and effectively.

Framework for Lean Approaches to materials management in Nigeria

In an attempt to achieve the aim of this research as stated in this study and based on the investigations and interpretations conducted on the empirical findings, some areas with major opportunity for improvement in materials management were identified. Despite the fact that materials management can benefit from the lean production approach, the Nigerian construction industry still lacks a coherent and general framework to initiate the Lean approach in this sector. A plan for remedial action was thus proposed through a framework. Therefore, this research proposes a lean approach to materials management in the Nigerian construction industry. The framework is presented in Figure 3.

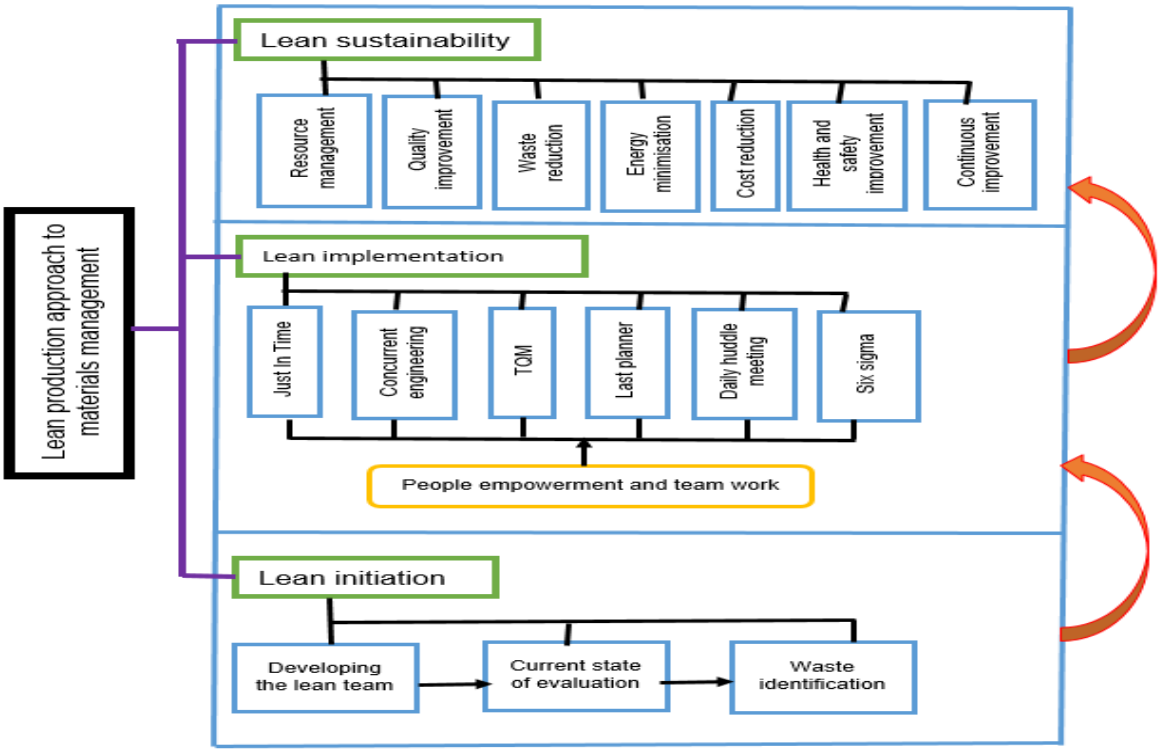

Figure 3: Lean production approach to materials management framework

It consists of three main phases, namely: lean initiation, lean implementation, and lean sustainability, and further discussed in below. It presents the flow directions of the lean approach and information.

Lean Initiation

To succeed in today's competitive construction market, it is essential to focus on improving work quality, increasing efficiency, reducing waste and costs, and boosting profits. As a result, various project management strategies, such as lean construction, lean project management, and value engineering, have been developed to enhance construction performance. These strategies are carried out through a series of activities:

i. Building the lean team: Lean teams consist of employees and lean experts (like consultants or academics) who support the construction industry in driving positive change and addressing issues effectively. For these teams to succeed, they must include members from all relevant departments within the Built Environment and possess the authority to implement process improvements. Full engagement from all levels of the organization, from top management to the operational staff, is necessary for the team's success.

ii. Current state evaluation: This involves gathering information on value-adding (VA) and non-value-adding (NVA) activities by utilizing the Lean principle of value stream mapping (VSM) and visual control techniques.
iii. Waste identification: To effectively identify waste, the lean team must employ the right tools to uncover causes and their effects, leading to better solutions on-site. During this stage, the team will analyse both VA and NVA activities. Various types of waste, including overproduction, waiting, transport, motion, extra processing, and defects, need to be identified. Minimizing these wastes is key to improving project profitability.

Lean implementation
After identifying waste, the next step is to begin applying Lean principles to optimize processes and operations. At this stage, the emphasis is on nurturing a Lean culture through training programs that empower individuals and communication strategies that enhance teamwork. To achieve long-term success, the construction industry must commit to the Lean culture and consistently empower its workforce. This study recommends several Lean tools that are most applicable to materials management in Nigeria's construction sector, including Just in Time, Visual Management, Concurrent Engineering, Total Quality Management, Last Planner, Daily Huddle Meetings, as well as Six Sigma. It is concluded that the design, pre-construction, and construction phases are the most effective periods to integrate these Lean tools, given their role in resource planning during pre-construction and reducing material waste during the construction phase.

Lean sustainability
The Lean approach can significantly enhance sustainability in construction, contributing to the long-term quality of Nigeria's construction industry. By utilizing lean tools, waste reduction can be achieved. The benefits of lean sustainability include improved resource management, waste minimization, energy savings, design optimization, enhanced quality, cost reductions, elimination of non-value-adding activities, continuous improvement, and better health and safety outcomes.

Conclusions and Recommendation
The findings from this study revealed that materials management practices in construction industry have a low overall impact on waste reduction. This is largely due to insufficient implementation of effective strategies like proper storage, recycling, and timely delivery. While moderate efforts are seen in areas like planning and resource optimization, overall practices remain inefficient. Lean principles such as waste minimization, timely delivery, improved productivity, and just-in-time systems were found to be underutilized across the observed projects. The dominant mode for these practices was consistently "low," indicating that most lean tools are either poorly understood or not applied at all in practice. A clear framework consisting of three key phases lean initiation, lean implementation, and lean sustainability has been proposed. This framework is meant to address waste, improve resource utilization, and drive long-term improvements through systematic adoption of lean tools and team-driven improvements.
The study recommends that construction firms in Nigeria should invest in structured lean awareness and training programs targeting professionals at all levels. These should include workshops on tools like Value Stream Mapping (VSM), Just-in-Time (JIT), Last Planner System, and Six Sigma. Each project should initiate multidisciplinary lean teams consisting of project managers, procurement officers, resident builders, and lean facilitators. These teams should be tasked with identifying waste, evaluating current practices, and leading process improvements.

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