

Exploring the Influence of Sustainable Lean Practices on Construction Site Timelines and Performance in the U.K.: A Comprehensive Literature Review

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ABSTRACT

This study reviews the literature on how sustainable lean techniques affect project timelines and performance in UK construction and examines the larger picture of sustainable lean construction methods using a variety of academic sources. Using lean principles to meet project deadlines and improve performance has garnered attention in the construction industry. This journal comprehensively analyses how lean methods affect construction project management, including deadlines and outcome. Case studies and prior research data are used to assess lean construction methods. The results suggest that lean principles and methods, such as minimizing waste, continuously improving processes, and mapping the value stream, can improve efficiency, task completion, and project performance. However, lean method integration requires strong leadership, effective stakeholder communication, and a culture that strives for progress. This study adds to current knowledge by revealing the practical effects of lean construction project management.

Keywords: Lean practices, Sustainability, Construction Industry, Project Management, Timelines

1.0 INTRODUCTION

1.0.1 Background and rationale

“In recent decades, there has been an increased knowledge of the significance of lean construction (LC) in effectively

managing construction projects and easing the implementation of the fourth industrial revolution in the construction industry (Construction 4.0); this, in turn, has the potential to improve practices and

outcomes within the construction industry” (Al Balkhy et al., 2021).

Babalola et al. (2019) state that the global construction industry widely applies lean concepts and practices. However, the specific lean methods utilized in infrastructure and building project planning, design, and construction remain unidentified.

“Research indicates that the implementation of lean methodologies leads to a substantial decrease in delays, cost overruns, and quality problems, resulting in an overall enhancement of project performance” (Orlov & Kankhva, 2021).

Applying sustainable lean methodologies is necessary in the dynamic construction industry to enhance efficiency minimize waste and foster awareness on the ecological environment. The UK, known for its continuing stance on sustainability, is at the lead forefront of integrating lean principles with sustainable building projects.

In order to achieve sustainable lean building approaches, it is necessary to develop a comprehensive strategy that addresses social, economic, and environmental objectives. These strategies reduce project timeliness and enhance overall performance metrics by integrating activities, optimizing processes, and fostering a culture of continuous improvement.

Lean principles like just-in-time production, human rights and value, streamlining operations, and continuous improvement must be implemented. However, the construction sector has faced challenges in applying these principles due

to the complex nature and constraints of construction projects” (Anastasopoulos et al., 2012)

" Common and noteworthy developments in the engineering, architectural, and building sector over the past ten years are sustainable construction projects (SCPs), which comprise the whole building process and the materials used in it” (Jian et al. 2022).

1.0.2 Objectives of the Literature Review

This study examines the influence of lean methods on project timelines and performance in construction and site management, addressing the following research questions:

1.0.3 Research Questions

1. What is the impact of implementing sustainable lean techniques on the project time management in the construction industry?
2. What advantages arise from integrating sustainable methodologies with lean principles in construction projects?
3. How does lean approaches, such as Just-In-Time manufacturing and scheduling systems for lean production, improve productivity and reduce waste in building projects.
4. Which key factors contribute to enhancing the efficiency of lean processes in construction?
5. What is the impact of implementing lean construction principles on the sustainability and environmental performance of construction projects in the UK?
6. How can the UK construction industry benchmark its lean methods against global standards to enhance efficiency and competitiveness?

1.0.4 Methodology

- Conduct a thorough review of relevant academic journals, reports, case studies, and articles.
- Search academic resources using Google Scholar with terms like "performance," "construction project timelines," "sustainable lean practice," and "UK."
- Use inclusion and exclusion criteria to identify studies that directly address the topic and provide significant insights.
- Analyse the selected literature to identify important themes, conclusions, and knowledge gaps.

2.0 LITERATURE REVIEW

2.0.1 Sustainable Lean Practice

“Lean is a management philosophy that was developed from Taiichi Ohno's Toyota Production System (TPS) and became known as Lean in the 1990s (Crainer, 2002, pp. 197-199; Womack, Jones, & Roos, 2007, p. 9 as cited in Yamamoto, K., Milstead, M. and Lloyd, R., 2019, pp.22); the TPS is known for minimizing the seven wastes to increase customer value” (Yamamoto, K., Milstead, M. and Lloyd, R., 2019, pp.22). “Global construction productivity has fallen for 40 years; the situation can be improved with lean construction, as lean construction is the result of a new construction production management strategy” (Aziz and Hafez, 2013).

“Construction activities that prioritize sustainability practices contribute to the achievement of Sustainable Development Goals (SDGs); among these practices, lean construction techniques are particularly effective in reducing the environmental impact of the construction industry by eliminating waste” (Hasan, Işık and Demirdöğen, 2022). Lean principles were used to identify waste and value in a sustainable building project (Lapinski et al., 2006).

Bashir et al. (2010) reviewed the literature and found six barriers to sustainable lean construction in UK firms: financial, educational, governmental, attitudinal, top managerial, and technical.

2.0.1.1 Lean practices, Strategies, Project timelines, Performance and External factors.

“Lean product management serves as the fundamental basis for the LC project delivery system, aiming to meet customer expectations, improve performance, and deliver value” (Mollasalehi et al., 2016 as cited in Noorzai 2021).

"Lean construction (LC) aims to understand manufacturing inside and out, increase value, decrease project duration, and eliminate inefficiencies" (Aziz and Hafez, 2013; Koskela 1992; and Arayici et al. 2011 as cited in Noorzai 2021).

Lean techniques (LTs) can enhance project planning, component and material tracking, and safety, (Hardin and McCool ,2015). “According to the research, "Daily Huddle Meetings" is the best LT for improving construction-related success factors; the proper LT must also be chosen with careful consideration by the construction manager” (Hardin and McCool ,2015).

In this research, the relationship between LTs (Lean technique) and CSFs (Construction Success Factors) is examined to enhance site management effectiveness. The construction phase is vital to the entire project life cycle, and the use of LTs has a beneficial effect on the productivity of this phase.

Critical Success Factors.

Successful lean practices and tools require certain factors. Examples include top management support, thorough employee training and effective company-wide communication.

Source: Own Creation, (2022). A conceptual framework for productivity improvement, CSFs, LTs, and LPs.

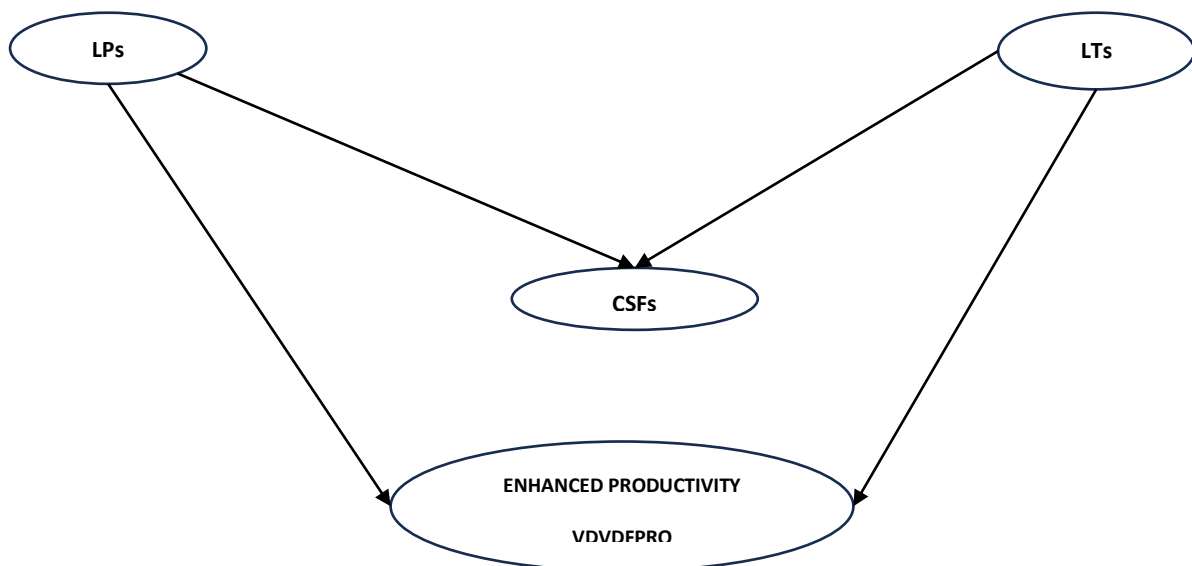


Figure 1. The conceptual framework of the relationship between LPs, LTs, CSFs and enhanced productivity performance.

2.0.1.2 Lean construction and sustainability: UK construction industry overview and sustainability
Sustainable construction refers to the building's ability to address the challenges posed by sustainable development (Ershadi et al., 2021 as cited in Waheed, Khodeir and Fathy, 2022). “The objective is to minimize

the use of building materials and energy consumption, resulting in decreased pollution and waste throughout every stage of the project” (Waheed, Khodeir and Fathy, 2022).

The UK construction industry has four main sectors: building, civil engineering, materials, and related services. Building

materials and products make up 40% of the UK construction industry and 20% of manufacturing. This particular sector generates an annual revenue of £40 billion (Holton et al., 2010). “Since the 1970s, U.K. and international construction companies must follow sustainability principles; this wave of high-level global governance opinions is changing sustainable development research funding policies” (Bradford & Lombardi 2007, pp.4). Miyatake (1996) suggested optimizing energy, materials, and resources in building and civil engineering projects. Regularizing these activities will increase recycled, rejuvenated, and repurposed materials and reduce energy and natural resource consumption because they generate a lot of debris at the end of a facility's lifespan. Lean construction uses transformation, flow, and value generation. TFV production methods include material flow, customer orientation, and transformation. These methods require labour, tools, and materials. According to Akanbi et al. (2019), lean construction improves project outcomes and management by fixing classic management flaws. According to Bennett and Crudgington (2003), “the U.K. construction sector is actively and adaptively addressing the contemporary need for sustainability; this is motivated by both regulatory requirements and market incentives to enhance sustainable practices” (Ogunbiyi et al., 2014). Building professionals believe lean construction and sustainable practices are beneficial, according to a survey. “These objectives include strengthening the company's reputation, achieving a competitive advantage, optimizing operational efficiency and productivity,

improving ecological standards, and meeting customer expectations” (Ogunbiyi et al., 2014). Sustainability-lean integration cuts waste, research shows. The biggest issue is changing resistance. Lean construction aids sustainability.

2.0.2 THEORETICAL FOUNDATIONS.

2.0.2.1 The theory of lean construction.

One theoretical framework that aims to apply lean principles and practices to the construction industry is Lean Construction. Its goal is to enhance the efficiency and performance of projects by minimizing waste, improving continuously, and maximizing value.

2.0.2.2 Sustainability Theory: Sustainable building methods affect the environment and last longer, according to sustainability theory. It explores ways to make construction projects more socially responsible, environmentally friendly, and resource efficient.

Since the late 2000s, the UK highway construction supply chain has used lean thinking. Tezel et al. (2018) describe it as having fundamental principles. "Lean construction (LC), as a philosophy of project management, offers solutions to enhance productivity, reduce waste, and tackle industry-related issues," (Aslam et al.). The concept of sustainable development involves meeting current needs while safeguarding future possibilities (Brandon & Lombardi, 2007).

According to Li (2015), value stream mapping is a lean tool utilized in the manufacturing industry to visually represent production processes in order to

identify and minimize different types of waste.

2.0.2.3 Just-in-Time (JIT) Theory.

Lean construction is a methodology that prioritizes the efficient and timely delivery of materials to the appropriate location, ensuring the required level of quality and quantity (Ballard and Howell, 2010 as cited in Hussein and Zayed, 2021).” The Just-in-Time (JIT) concept is founded on six fundamental principles. The six principles mentioned include the pull system, waste elimination, smooth workflow, total quality management, supplier relations, and top management commitment” (Sui Pheng and Joo Chuan, 2001)

"Indeed, the methodology has resulted in remarkable advantages in the manufacturing sector, such as substantial decreases in operational expenses, enhanced quality, and elevated customer satisfaction" (Choi, T.Y. et al. 2021). According to Hussein and Zayed (2021)," it is stated that the principal obstacle to attaining wider acceptance of Modular Integrated Construction has basically been its logistical administration." Lean methods, especially Just-In-Time, can solve this problem.

2.0.3 Lean Implementation in the UK Construction Sector:

“The UK construction industry is using lean methods to increase productivity, lower costs, and improve project outcomes” (Forbes & Ahmed, 2011).

Lean construction is a new way of doing things that uses lean methods in construction. Its main goal is to improve quality and efficiency in the U.K. construction sector, which will have an

effect on project performance (Akanbi et al., 2019).

2.0.3.1 Justification of Application of lean practice in the UK Construction Site

“The UK construction industry may benefit from lean construction management; the Egan Committee stated that lean thinking would lead the UK construction industry to improve quality and efficiency” (Sarhan et al.,2013).

“Although lean construction practice has yielded significant advantages in the last twenty years, the adoption of the lean concept in the UK appears to be limited; UK contracting organizations involved in lean construction face challenges that must be resolved in order to promote the broader implementation of lean concepts and reap their advantages while further research is encouraged to determine which strategy is suitable to address range of challenges” (Bashir et al., 2015). The construction business is known for its dynamic nature, since it undergoes frequent changes in regulations, technologies, and market demands. The emphasis on ongoing development in lean building renders it a versatile framework that empowers companies to sustain competitiveness and adaptability in light of changes.

The study acknowledges the need for careful planning and resource allocation, but it does not provide specific frameworks for integrating lean construction principles into different project categories. "Lean construction is an ongoing improvement process that may take time to implement; training workers, applying principles, choosing and using tools, managing cultural change, and evaluating for improvement take time." (Bashir et al., 2015).

2.0.4 Theoretical Gaps of the lean practice in the UK Construction Sector.

Based on the findings and gaps, Bashir et al. (2015) argue that lean principles should be used on UK construction sites. Lack of complete integration models for different construction projects is one reason. Lean principles may benefit from future research on this topic. More literature gaps include:

- Additional investigation is needed to analyse the disparities in lean problems across different building sectors.
- Lean techniques' long-term viability and ever-changing characteristics require longitudinal impact studies. An examination of how business culture influences the effectiveness of implementing lean strategies.
- The goal is to examine effective client and supplier engagement methods for lean initiatives.
- Assessing lean construction-specific training programs to improve employee training and skills.

- Quantitative impact analysis is the use of quantitative techniques to evaluate the consequences of lean operations.
- Investigation into the potential of integrating new technology to optimize the use of lean building techniques.
- Examining how UK laws affect lean adoption and implementation.

To better understand Lean construction's challenges and opportunities in the UK, more research can address these theoretical gaps. Thus, implementation strategies and project outcomes will improve.

2.0.5 Impact on Project Timelines.

Implementing lean methods can lead to significant reductions in project durations by increasing stakeholder involvement, optimizing processes, and minimizing delays. The utilization of lean tools, such as Value Stream Mapping (VSM) and housekeeping, has been associated with improving schedule adherence and ensuring timely completion.



Fig 2: shows the conceptual picture of application of sort, set in order, shine, standardize, and sustain (5S) approach to store housekeeping on site, depicting a real-life scenario before and after.

Source: Gupta, S., & Jain, S. K. (2015). An application of 5S concept to organize the workplace at a scientific instruments manufacturing company. *International Journal of Lean Six Sigma*, 6(1), 73–88.

<https://doi.org/10.1108/IJLSS-08-2013-0047>

3.0 SUSTAINABILITY AND WASTE REDUCTION

Lean approaches reduce waste and optimize resources, improving construction project productivity, quality, safety, and client satisfaction.

Timeliness and the amount of time it takes to complete a project are both affected by a wide variety of factors. The project scope must be defined precisely and concisely. Resource allocation and task sequencing can be impacted by uncertainty and frequent scope changes.

Qualified workers, tools, and supplies affect project schedules. Misallocation of resources causes inefficiency and congestion. Agile (Scrum, Kanban) or traditional (waterfall) project management methods determine task planning, execution, and monitoring. Agile methods can reduce delays by being more adaptable and flexible. Scope creep, caused by repeated poor scope definitions, can delay the project (Kerzner, 2022).

Lock, D., & Wagner, R. (Eds.) (2018) state that "skilled resources and their effective allocation to project tasks are important to keeping to timelines; otherwise, resource scarcities or improper allocation can cause delays". To avoid any delays, it becomes necessary to establish efficient

communication with stakeholders to ensure that their expectations are met, and apt decisions made (Larson, Gray and Gray, 2011).

According to J. T. Marchewka (2019), "external factors like regulatory approvals, vendor deliveries, and market conditions may affect project schedules, so they must be actively managed. Addressing these issues and incorporating them into project planning and execution can help project managers meet deadlines and deliver quality results.

3.0.1 Lean Practices and Strategies.

According to Albliwi et al. (2015), "the implementation of lean principles such as just-in-time production, value stream mapping, 5S (sort, set in order, shine, standardize, and sustain), and others can effectively decrease project durations and enhance productivity by eliminating non-value-added activities".

3.0.2 Project Timelines.

Project completion is faster and more resource-efficient with Lean project scheduling. Strategic project task and activity assignment is needed for efficient scheduling. Good task management goes beyond making lists. It requires knowledge-based resource allocation, dependencies,

and logical activity organization. This schedule follows basic principles.

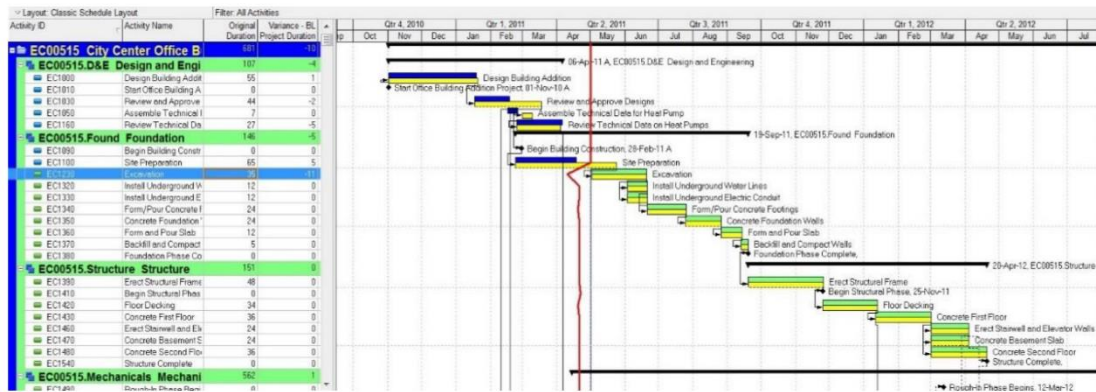


Fig 3: Conceptual project phase Gantt chart to manage schedule and timelines to minimize delays. The blue bar shows the baseline, and the yellow bar shows the actual timeline. EC160 activity was delayed by five days. **Source:** <https://doi.org/10.3390/buildings9090191>.

3.0.3 Performance Metrics.

Lean places a strong emphasis on measuring key performance indicators (KPIs) like cycle time, defect rates, and customer satisfaction. By tracking these metrics, projects can be monitored in real-time, and deviations can be addressed quickly (Koskela et al., 2002).

Supply chain disruptions, regulatory requirements, and market demand can affect lean construction project implementation. "Maintaining project efficiency requires adapting lean strategies to accommodate external influences" (Womack & Jones, 1996).

3.0.4 Real-life example of successful lean implementation in construction projects:

3.0.4.1 The Shard, London 2012: This endeavour incorporates Just-In-Time (JIT) delivery, modular construction, meticulous planning processes, and streamlined logistics to ensure punctual completion and minimize environmental footprint (Davies, Gann and Douglas, 2009)

In defining habitat initiatives, these architectural constraints, according to lean methodology, lead to reductions in material resources. Alterations to the building process can be made in the future to achieve even quicker completion times and lower production costs.

The image below shows the house's interior with ceiling coverings removed to highlight interior ceiling design functions.

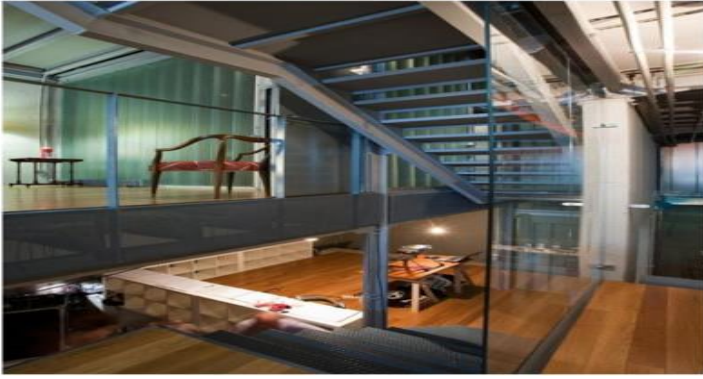


Fig 4: Interior of Guardiola–Babecka single-family house in Madrid.

Source: Indoor Environment Quality and Health in Energy-Efficient Buildings. (2022). MDPI.

<https://doi.org/10.3390/books978-3-0365-3666-8>.

Table 1 : Real-life example of successful lean implementation in construction projects

THEMES	SUBTHEMES	DIRECT QUOTES FROM PAPERS THAT SUPPORT THE THEMES	RESEARCH GAPS
Lean construction, evaluation, implementation	Execution and Evaluation	“The construction industry has adopted lean methodologies to reduce waste and optimize profits, inspired by the achievements of the lean production system in manufacturing.” (Salem et.al, 2005)	More empirical research needed on lean construction's long-term effects on project outcomes and profitability..
Lean project delivery, integrated practices	Lean Thinking	“Unfortunately, the construction industry lags significantly in adopting performance enhancement and optimization techniques, as well as in terms of its overall competitiveness.” (Forbes & Ahmed, 2011)	Research needed on overcoming barriers to adopting lean practices in the construction industry and methods to accelerate integration.
Lean thinking, construction performance improvement	Lean Thinking in Construction	“This statement highlights the potential benefits of adopting lean thinking in the construction sector. The	Investigation into specific lean techniques that can most effectively improve

THEMES	SUBTHEMES	DIRECT QUOTES FROM PAPERS THAT SUPPORT THE THEMES	RESEARCH GAPS
		<p>productivity of the global construction industry has declined over the past four decades.</p> <p>An effective approach to tackle this problem is to adopt lean construction methods.” (Aziz & Hafez, 2013)</p>	<p>productivity in various types of construction projects.</p>
Sustainable development, strategic planning, BIM	Strategic Sustainable Development	<p>“Highlights the potential for strategic and sustainable growth in the construction industry; however, the UK construction industry must also address other sustainability issues, particularly the negative impacts caused by waste production.” (Alwan et al., 2017)</p>	<p>BIM integration with lean and sustainable practices and its effects on waste reduction and project sustainability.</p>
Lean practices, construction industry	Systematic Review	<p>“The global construction industry is adopting lean methods. The extent and variety of lean techniques used in building and infrastructure project planning, design, and construction, as well as their benefits, are unknown.” (Babalola et al., 2019)</p>	<p>Comprehensive studies needed to map global lean techniques' benefits in different construction contexts.</p>

3.0.5 An overview of the comments from the literature based on the publications provided:

"Lean Processes for Sustainable Project Delivery" (2006) shows how lean processes can be sustainable. Critics have cited the lack of case studies and empirical evidence, highlighting the need for more research.

Critical of "Site Implementation and Assessment of Lean Construction Techniques (2005)" for its limited scope and lack of statistical data, this calls for more research.

"Applying Lean Thinking in Construction and Performance Improvement (2013)" examines lean construction performance effect. Its lack of quantitative data and in-depth analysis has been criticized despite its high reputation. This emphasizes rigorous research.

Based on encouraging literature, Modern Construction: Lean Project Delivery and Integrated Practices (2010) promotes lean construction methods. Criticism of limited case studies and empirical data calls for stricter research methods.

According to "Strategic Sustainable Development in the UK Construction Industry (2017)" literature review, UK builders deeply study sustainable development strategies. Lack of quantitative data and shallow analysis suggest stronger research methods would be needed.

"Implementation of Lean Practices in the Construction Industry: A Systematic Review (2019)" found that more analysis is needed despite criticisms like high abstraction and lack of case studies..

3.0.6 Findings from the Literature Review:

1. Site Implementation and Assessment of Lean Construction Techniques (Salem et al., 2005):

- The construction industry is adopting lean methodology to reduce waste and increase profitability, taking inspiration from the successes of lean manufacturing.
- There is a lack of thorough research and accurate statistical data, emphasizing the need for more rigorous research methods.

2. Lean Processes for Sustainable Project Delivery (Lapinski et al., 2006):

- Lean principles enhance efficiency and enhance operational effectiveness in complex projects.
- Additional case study illustrations and empirical data are required in the literature to strengthen the reliability of research conclusions.

3. Modern Construction: Lean Project Delivery and Integrated Practices (Forbes & Ahmed, 2011):

- Emphasizes the effectiveness of lean methodologies in contemporary construction.

- The lack of comprehensive case studies and empirical evidence has been criticized, emphasizing the need for more rigorous research.
4. **Effects of Lean Construction on Sustainability of Modular Homebuilding (Nahmens & Ikuma, 2012):**
 - Lean building is suggested as a practical and efficient approach to achieve sustainable construction.
 - Criticized for its limited sample size and low generalizability, emphasizing the need for more comprehensive investigations.
 5. **Applying Lean Thinking in Construction and Performance Improvement (Aziz & Hafez, 2013):**
 - Highlights the advantages of adopting lean thinking to improve efficiency in the construction sector.
 - Critics have pointed out the absence of quantitative data and comprehensive analysis, emphasizing the necessity for additional rigorous research.
 6. **Strategic Sustainable Development in the UK Construction Industry (Alwan et al., 2017):**
 - Alwan et al. (2017)'s "Strategic Sustainable Development in the UK

Construction Industry" offers insights on integrating sustainability into construction practices. This framework provides a framework for industry-wide environmental improvements. However, the study's limited empirical data may limit its applicability to different construction projects and scales.

7. **Implementation of Lean Practices in the Construction Industry: A Systematic Review (Babalola et al., 2019):**

Highlights the growing adoption of lean concepts and methods in the construction sector. • Critics have pointed out the lack of concrete case studies and the high level of abstraction, indicating the need for more extensive research.

8. **Sustainable Construction Projects Management (Jiang et al., 2022):**

- Utilizes waste management, energy management, building materials management, and other sustainable strategies in conjunction with lean construction.
- Emphasizes the broader range and benefits of incorporating lean and sustainable practices in the construction sector.

4.0 DISCUSSIONS

Sustainable lean practices on construction sites improve project efficiency and effectiveness. Performance metrics are crucial for assessing the impact of these practices, including productivity and

environmental sustainability. Sustainable lean practices need performance metrics to be evaluated. Stakeholders can quantify productivity, waste reduction, resource optimization, and project timeline adherence to evaluate these practices. The data-centric approach helps identify strengths and

weaknesses for the continuous improvement. To ensure project success and client satisfaction, organizations should monitor quality assurance metrics like defect rates and standard compliance. Prioritizing quality reduces risks and costs by reducing redoing work and project delays.

Sustainable lean practices prioritize quality and cost reduction by eliminating waste and optimizing resources. Cost-reduction metrics like material use and energy consumption reveal these practices' economic benefits. Organizations can save money now and in the future by implementing energy

efficiency and materials conservation strategy. When assessing sustainable lean practices, safety is crucial. Monitoring workplace accident and injury metrics helps organizations assess their safety and work practices. Waste reduction and process optimization improve project performance and safety by

reducing risks. Sustainable lean practices ensure timely project completion, budget compliance, and quality, which boosts client satisfaction. Customer satisfaction and loyalty are measured by client feedback

and project delivery performance. By supporting clients' environmental and Corporate Social Responsibility (SCR) goals, companies can improve their reputation. Research on sustainable lean practices in UK construction can examine how Lean and sustainability initiatives impact project timelines, costs, and effectiveness. Successful UK sustainable construction case studies, challenges, and best practises are documented. UK construction projects can improve quality, customer satisfaction, safety, and cost with sustainable lean methods. For successful implementation, regulatory constraints, ignorance, and change resistance must be overcome. External factors like market conditions, stakeholder engagement, regulatory constraints, and technology also matter.

5.0 CHALLENGES IN IMPLEMENTING LEAN PRACTICES IN CONSTRUCTION.

Sustainable lean practices may face regulatory constraints, stakeholder resistance, and organizational norms. Stakeholder inertia or fear of disrupting workflows highlights the importance of stakeholder engagement and change management strategies. Organizational culture and norms may hinder leadership commitment and cultural transformation initiatives, emphasizing their importance.

Regulatory restrictions may limit the implementation of specific sustainable practices, emphasizing the importance of compliance and risk management. However, raising awareness, improving knowledge, and encouraging innovation

can help construction sites adopt sustainable lean practices. Lack of well-defined processes and procedures hinders lean construction project implementation. Standardising processes and best practises help lean construction projects achieve efficiency and consistency (Howell et al., 1993). Contractors, subcontractors, and workers can resist lean adoption, so organizations must use change management and cultural transformation (Ballard, 2000).

6.0 MANAGERIAL IMPLICATION AND RECOMMENDATIONS

Construction site managers should actively endeavour to recognize the interdependence of lean and sustainability principles. By integrating lean methodologies that consider social and environmental factors, managers can improve long-term results. Waste reduction, energy conservation, and ethical sourcing improve project schedules and results while reducing environmental impact.

Construction site managers can employ the following suggestions to improve the implementation of lean practices and sustainability.

Give priority to engaging with stakeholders.

Local communities, government agencies, and supply chain partners are key stakeholders in sustainable lean. Project managers must involve stakeholders in decision-making and explain sustainability benefits. Involving locals in green building projects can improve community relations and project acceptance.

Adopt and utilize digital technologies

Modern technologies like data analytics, the IoT, and BIM can improve lean construction site procedures. These tools help managers improve communication, resource use, and process efficiency. Building information modelling (BIM) software can help reduce costs and boost productivity during construction.

Enhance Continuous Improvement

Lean emphasizes continuous improvement. Construction managers must foster innovation and learning among workers. Rewarding employees who propose and implement process improvements improves project schedules and performance. Regular Kaizen events or lean workshops can help staff identify and fix building process inefficiencies.

7.0 RESEARCH LIMITATION.

A lack of primary sources limits the literature on "The Impact of Sustainable Lean Practice on Project Timelines and Performance on Construction Sites, U.K." The main limitations are:

- Lack of Real-World Data: Many studies rely too much on theoretical discussions and conceptual frameworks.
- Lack of empirical data casts doubt on the research's validity and reliability when assessing sustainable lean techniques' impact on real-world project performance and deadlines.
- Generalizability is limited by small-sample or highly standardized case studies, which may not represent UK construction projects. Due to this limitation, applying study findings to different construction settings and situations is harder.

- **Insufficient Quantitative Analysis:** Many studies fail to quantify the effects of sustainable lean methods on project performance and timeliness due to a lack of quantitative analysis or statistical data. This limitation makes it harder to evaluate lean methods, limiting the analysis's scope.

8.0 FUTURE RESEARCH

This academic journal provides a thorough explanation and a simple literature review method.

The framework divides content well, and the research questions are clear. However, the references must be current and relevant to the study. A section on literature biases and limitations would boost the review credibility.

To better understand sustainability and lean principles in construction projects, future studies should incorporate more case studies and emphasize empirical data to improve visualization tools for analysis. Bashir et al. (2015) emphasize understanding lean construction implementation strategies to overcome challenges. Future research should find and test ways to combine sustainability and lean construction. This involves assessing how each strategy can be applied in real life to solve UK lean construction

contracting organizations problems. Adding components that show Lean and BIM synergy should be the focus of future research. The final model should

demonstrate Lean and BIM integration. This will help construction executives set priorities, optimize Lean-BIM synergy, and adjust their strategies.

To overcome the long implementation time, cultural resistance, lack of standardization, and legal restrictions that hinder lean construction, in-depth primary research is essential. If the study emphasizes quantitative analysis and becomes more comprehensive, the findings could provide valuable guidance for implementing sustainable lean practices in the UK construction industry.

9.0 CONCLUSIONS

This study reviewed the literature to determine the key concepts, challenges, and factors that enable lean method application and their effects on project schedules, performance, and timelines.

The findings show how site managers can improve construction project schedules and performance using lean principles like value stream mapping, continuous improvement, and waste reduction. Lean methodologies standardize processes, reduce lead times, and engage stakeholders to improve project outcomes. To implement lean methods, cultural resistance, inconsistency, and legal restrictions must be overcome. Study findings included strong leadership, stakeholder engagement, and a culture of continuous improvement.

This study illustrates lean construction project management. The findings show that lean methods improve UK construction project deadlines, performance, and sustainability. Researchers, practitioners, and policymakers should consider these effects. Lean construction site managers must plan and schedule tasks using

challenge-specific strategies. It prevents site cleaning from slowing subcontractor work.

Lean construction requires performance metrics for sustainability and efficiency. Organizations can evaluate and improve productivity, waste reduction, resource optimization, project timelines, quality assurance, safety outcomes, and client satisfaction. Sustainable lean practises benefit organisations economically, environmentally, and socially, helping them succeed and survive despite stakeholder opposition and regulatory restrictions. Lasvaux 2010 (cited in Noorzai, 2021) predicts that construction will affect over 70% of natural lands by 2032. For the past 20 years, the construction industry has adopted new methods and concepts due to the growing importance of lean construction (LC) for waste reduction and building efficiency.

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