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Lean Horizons: Overcoming Barriers And Embracing Enablers In Construction Industry Adoption

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Abstract:

This study aims to assess the awareness and adoption of lean in the Indian construction sector and Lean offers a promising approach to reducing waste and improving efficiency in the construction industry, however, there is lacuna on the awareness and adoption of lean practices in this sector. This article will assess the awareness of lean principles, the adoption of lean practices, the barriers to and enablers of lean and the results will provide valuable insights into lean acceptance and identify areas for improvement and the research will also offer endorsements for promoting the awareness and adoption of lean practices and the research found that the top three barriers to lean adoption are lack of top management backing, lack of awareness and comprehension of lean principles, and lack of skilled workforce. The top three enablers of lean adoption are top management backing, continuous improvement culture, and employee engagement and the most frequently used lean tools are 5S, visual management, and kaizen. The research concludes that the awareness and adoption of lean practices and is still in its initial phases, but there is a mounting awareness and interest in lean among construction professionals and organizations.

Keywords: Lean, Construction, 5-S, Barriers, Enablers, top tools.

1. Introduction

The construction business is a major dimension to the global economy, and is also a major consumer of resources and producer of emissions. Various literatures have agreed on the wastage generated in the construction sector and lean management offer a hopeful method to reduce waste and improve efficiency. However, there is dearth of research on the awareness and adoption of lean practices in the Indian construction sector. The construction business in India stands at the crossroads of rapid development, playing an essential part in the nation's growth trajectory. As demands for infrastructure soar, optimizing operational processes becomes imperative for sustained growth. Within this landscape, the infusion of lean, rooted in waste reduction, presents itself as a transformative paradigm. However, the extent of awareness and the actual acceptance of lean within the construction sector remain dynamic and underexplored.

The construction domain, characterized by its intricate network of stakeholders, complex processes, and diverse challenges, necessitates innovative strategies to enhance productivity (Dubois & Gadde, 2002). Lean practices, originally derived from the manufacturing sector, have exhibited substantial success in streamlining operations and aiming at continuous improvement. This research seeks to navigate the nuanced terrain of

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the Indian construction sector, unravelling the layers of awareness surrounding lean principles and assessing the tangible adoption of these practices. Against the backdrop of a globalized economy, where lean tools have demonstrated usefulness across numerous sectors, their integration into Indian construction milieu requires careful deliberation (Singh & Rathi, 2019). Cultural influences, regulatory frameworks, and the industry's specific challenges pose distinct variables that shape the landscape of lean adoption and this study aims to delve into these intricacies, providing a comprehensive analysis that goes beyond a mere evaluation of surface-level awareness to uncover the underlying factors influencing the implementation of lean practices in the Indian construction sector.

As the industry grapples with the need for increased efficiency, reduced waste, and sustainable practices, understanding the current state of “awareness and adoption” of lean becomes not only a scholarly pursuit but also a practical necessity and through this study, we intent to contribute insights to industry practitioners and policymakers alike, fostering an environment conducive to the effective employment of lean in the Indian construction sector and in doing so, we aspire to provide a more streamlined, resilient, and sustainable future for construction projects in India (Tafazzoli et al. 2020).

This study purposes to assess the awareness and adoption of lean in the Indian construction industry and the following :

- Awareness of lean
- Adoption of lean:
- Barriers to adoption of lean in construction
- Enablers of adoption of lean in construction

2. Significance of the research

This research is significant for the following reasons:

- It is the first comprehensive study of the awareness and adoption of lean practices in the “Indian construction industry”.
- The research will classify the blockades and enablers to the adoption of lean, which will provide appreciated acumens for all stakeholders.
- The research will provide recommendations for promoting the awareness and acceptance of lean.

3. Literature Review: Challenges in the Construction Industry in India

The construction business in India, a dynamic contributor to the nation's growth and GDP, is confronted with a myriad of complexities and challenges that impact its efficiency, sustainability, and overall development of the industry and this literature review seeks to explore and examine the key trials faced by the “construction sector in India”, drawing insights from various scholarly works, empirical studies, and industry reports.

1. Regulatory Challenges: One of the foremost challenges is the complex and often ambiguous regulatory environment and researchers have consistently highlighted the maze of permits, approvals, and compliance requirements that can impede project timelines and escalate costs and inadequate enforcement and frequent changes in regulations further compound the challenge, making it difficult for construction companies to navigate the regulatory landscape efficiently (Yap et al. 2019).

2. Infrastructure Deficits: While construction projects are essential for addressing India's growing infrastructure needs, the industry itself grapples with deficits in basic infrastructure and Inadequate transportation networks, power shortages, and insufficient logistical support contribute to project delays and cost overruns and the literature underscores the need for synchronized efforts between the “government and the private sector” to discuss these gaps and facilitate smoother project execution (Kaur, 2020).

3. Skilled Labor Shortages: The lack of skilled labor remains a persistent challenge and despite the sector's potential for job creation, attracting and retaining skilled workers poses difficulties and studies emphasize the need for comprehensive skill development programs,

improved working conditions, and enhanced incentives to attract a skilled workforce, essential for maintaining project quality and timelines (Sanni-Anibire et al. 2022).

4. Technological Lag: The sector has been comparatively sluggish in adopting advanced technologies, posing a significant challenge in the contemporary era. Research suggests that the hesitancy to embrace technological innovations hampers productivity and efficiency and the incorporation of “Building Information Modeling (BIM), Internet of Things (IoT), and other Industry 4.0 technologies” is advocated to address this challenge and bring the Indian construction sector on par with global standards (Erdogan, 2021).

5. Financial Constraints: Financial constraints, both for project developers and contractors, emerge as a critical hurdle in the construction industry and limited access to capital, high interest rates, and delayed payments are recurrent issues and literature underscores the importance of financial reforms, improved credit facilities, and streamlined payment mechanisms to alleviate financial burdens and enhance the sector's overall financial sustainability (Sayidganiev et al. 2022).

6. Land Acquisition and Clearance Delays: Land acquisition and associated clearance processes are notorious for causing delays in construction projects and literature emphasizes the need for a streamlined and transparent land acquisition process, coupled with clearances obtained in a time-bound manner and delays in these processes not only extend project timelines but also escalate costs, impacting the overall economic viability of construction projects (Elong, 2020).

7. Environmental Sustainability Challenges: Increasing awareness of environmental sustainability has brought attention to the construction sector's influence on the environment and researchers highlight challenges related to waste management, energy consumption, and adherence to sustainable construction practices and the literature advocates for the integration of green building practices, renewable energy solutions, and stringent environmental regulations to mitigate the environmental impact of construction activities (Zhang et al. 2019).

8. Quality Control and Safety Concerns: Ensuring construction quality and safety standards remains a significant challenge in the Indian context and the literature points to issues such as inadequate training, lax enforcement of safety regulations, and a lack of quality control measures and comprehensive training programs, stringent regulatory enforcement, and a cultural shift towards prioritizing safety are proposed as avenues to address these challenges (Alaloul et al. 2020).

The literature review on pain points in the construction sector in India delivers a complete overview of the multifaceted hurdles tackled by the sector and from regulatory complexities to environmental sustainability concerns, the literature emphasizes the unified nature of these challenges and underscores the necessity for a all-inclusive method.

4. Comprehensive Analysis of Lean Tools in Operational Excellence

Lean principles have become synonymous with operational excellence, driving firms towards “efficiency, waste reduction, and continuous improvement” and this literature review examines key lean tools, including “5S, Value Stream Mapping (VSM), Visual Management, Kanban, Kaizen, A3, Mistake Proofing, Single-Minute Exchange of Dies (SMED), Push-Pull Systems, and Jidoka” exploring their theoretical foundations, empirical applications, and synergies in fostering lean transformations across various industries. (Leksic et al. 2020)

1. 5S Methodology: The 5S practice, comprising “Sort, Set in order, Shine, Standardize, and Sustain”, is a foundational lean tool focused on workplace organization and research underscores its role in creating an “organized, efficient workspace, reducing waste, and fostering a culture of continuous improvement” (Chandrayan et al. 2019).

2. Value Stream Mapping (VSM): VSM provides a visual depiction of the complete process, aiding in “identifying and eliminating non-value-added activities” and literature emphasizes its effectiveness in streamlining processes, enhancing flow, and facilitating informed decision-making for process improvement (Narke & Jayadeva, 2020).

3. Visual Management: It involves the use of visual ways to pass information and the literature discusses its application in creating a transparent work environment, promoting

communication, and facilitating quick problem identification and resolution (Singh & Kumar, 2021).

4. Kanban: Kanban, a pull-based system, regulates production by signaling when to produce and replenish inventory and studies highlight its adaptability in various contexts, promoting a smooth flow of work, reducing overproduction (Htun et al. 2019).

5. Kaizen: Is a philosophy of “continuous improvement”, making small and persistent changes over time and literature explores its transformative impact on organizational culture, fostering employee involvement, and promoting a mindset of continuous learning and improvement (Rossini et al. 2019).

6. A3 Thinking: A3, a structured problem-solving approach, is extensively discussed in the literature for its efficacy in addressing complex issues and scholars emphasize its role in promoting collaboration, structured problem-solving, and clear communication through the use of a standardized A3-sized document (Burka, 2021).

7. Mistake Proofing (Poka-Yoke): Mistake Proofing focuses on preventing errors in processes and literature reviews its application in minimizing defects, reducing rework, and fostering a culture of quality consciousness by implementing foolproof mechanisms (Tommelein, 2019).

8. “Single-Minute Exchange of Dies” (SMED): SMED targets reducing setup times in production processes and research highlights its impact on enhancing flexibility, reducing downtime, and enabling quick changeovers, ultimately contributing to improved overall efficiency (Tekin et al. 2019).

9. Push-Pull Systems: The literature explores the dynamics of both push and pull production systems and push systems emphasize production based on forecasts, while pull systems align production with actual demand and studies analyze the application of these systems in achieving optimal production flow (Gaur & Tyagi, 2022).

10. Jidoka (Autonomation): It focuses on incorporating quality into the process by enabling machines to notice and stop themselves in case of defects and literature reviews its role in ensuring built-in quality, reducing defects, and enhancing overall process reliability (Tekin et al. 2019)..

This literature review provides a comprehensive exploration of key lean tools, shedding light on their theoretical foundations, practical applications, and synergies in driving operational excellence and from the foundational principles of 5S to the problem-solving efficacy of A3, each tool contributes uniquely to the lean toolkit and the synthesized insights from the literature serve as a valuable resource for organizations seeking to embark on lean transformations, showcasing the versatility and transformative potential of these tools in diverse industries and as the landscape of operational excellence evolves, the adaptability and integration of these lean tools position them as essential instruments for sustained success and continuous improvement. Contribution of literature in lean tools in construction across countries shown in figure 1.

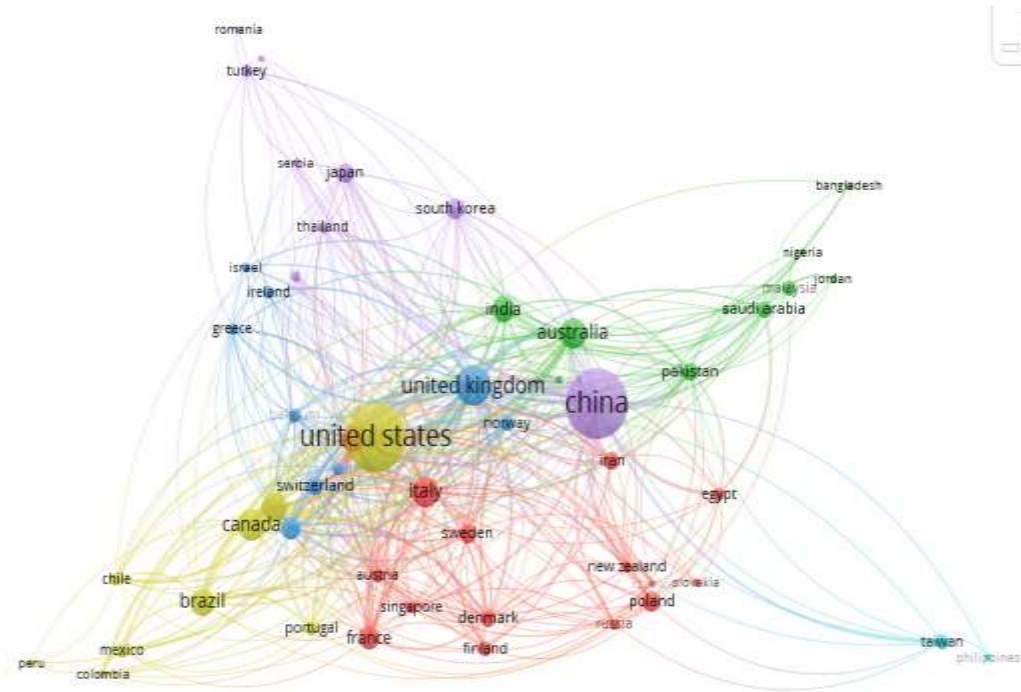


Figure : 1 Contribution of literature in lean tools in construction across countries:
Source; Vosviewer

4.1 Keyword Analysis:

A keyword of the analysis of the literature review on “lean and construction industry” done is depicted in the below given figure 2.



Figure 2: Keyword analysis “lean and construction industry”

The keyword analysis shown in figure 2 indicates that the key words used were “Lean, 5-S, Kaizen, Kanban, Improve, value, productivity, design, barriers, enablers”.

4.2 Benefits of “Lean tools in construction Industry”

Table 1: Lean tools in Construction Industry

Lean Tool	Application in Construction	Benefits
5S Methodology	“Organizing construction sites for efficient material management, reducing waste, and enhancing safety.”	Improved site organization, enhanced safety, and increased operational efficiency. (Kuchekar et al. 2019)
Value Stream Mapping (VSM)	Visualizing construction processes to identify and eliminate non-value-added activities.	Streamlined construction processes, reduced lead times, and improved overall project efficiency. (Setiawan et al. 2021)
Visual Management	Using visual cues to communicate project progress, schedules, and safety information on construction sites.	Improved communication, quick problem identification, and enhanced project transparency. (Singh & Kumar, 2021)
Kanban	Regulating material flow and work progress on construction projects, reducing overproduction.	Efficient resource utilization, minimized overproduction, and improved construction project flow. (Riaz, 2019)

Kaizen	Encouraging continuous improvement in construction processes, involving workers in problem-solving.	Cultivation of a culture of continuous improvement, increased employee engagement, and enhanced efficiency. (Ismyrlis, 2021)
A3 Thinking	Structured problem-solving approach for addressing complex issues in construction projects.	Improved collaboration, structured problem-solving, and clear communication in project management. (Burka, 2021)
Mistake Proofing	Implementing mechanisms to prevent errors and defects in construction processes.	Minimized defects, reduced rework, and enhanced quality consciousness in construction activities. (Marte Gómez et al. 2021)
SMED (Single-Minute Exchange of Dies)	Reducing setup times for construction equipment and processes.	Enhanced flexibility, reduced downtime, and improved efficiency in construction project execution. (Junior et al. 2022)
Push-Pull Systems	Managing material flow in construction projects based on demand, reducing overstock and waste.	Optimized construction material flow, reduced waste, and improved efficiency in project execution. (Gayer et al. 2021)
Jidoka (Autonomation)	Integrating self-detection mechanisms in construction equipment to ensure quality and stop defects.	Ensured built-in quality, reduced defects, and enhanced reliability in construction processes. (Tokat & Tas, 2022)

Source : Author Own

4.3 Barriers of Lean implementation

“Lack of awareness and understanding” Many construction employees are not copiously aware of lean is or application in the construction business and this lack of awareness can act as a resistance to change and difficulty in applying lean across the sector (Demirkesen et al. 2019) and another barrier often studied is **Lack of top management support** (Chaple et al. 2021) Lean implementation requires a obligation from top management and if they are not helpful of lean, it will be difficult for employees to implement and sustain lean practices throughout the organization and the nature of the sector that is **Fragmentation of the sector** (Abu et al. 2021) Thus sector is highly uneven, with many stakeholders in each project and this fragmentation can make it problematic to coordinate and implement lean in entire supply chain of the construction industry and one other barrier is **Resistance to change** (Fournier et al. 2023) This sector is known for its traditional practices and culture and this can make it difficult to change to new ways of working, such as those required by lean.

Lack of skilled workforce (Chaple et al. 2021) Lean implementation needs skilled staff in lean practices and many construction firms do not have a workforce with the skills to practice lean and the lack of skilled workforce can be a detrimental factor in acceptance of lean and another factor is that the **Project-based nature of work** (Bayhan et al. 2019) the industry is “project-based”, with each venture being unique and complex and this challenge is consistently across projects and this characteristic of the industry makes it difficult for firms to adopt lean and also the **Time and cost pressures** (Yadav et al. 2019) Construction companies are often faced with pressure to complete projects “on time and within budget” and this can make it difficult to invest in lean implementation, which can be time-consuming and costly in the short term and this pressure makes it difficult for firms to adopt lean and spend time on lean management practices adding to that the **lack of metrics and**

measurement systems (Narkhede et al. 2020) Many construction companies do not have the metrics and measurement systems in place to track and measure the benefits of lean implementation and this can make it difficult to demonstrate the value of lean and sustain its implementation over the long term and this aspect makes it much more difficult to implement lean.

4.4 Enablers of adoption of lean in construction:

Top management support: It is vital for the fruitful implementation of lean practices in the construction industry and they must be dedicated to lean and deliver the essential resources and support to make lean implementation effective and support can be in “terms of financial resources, time and motivation and Employee engagement” is another key enabler of lean adoption and staffs engagement in the lean implementation and understand the benefits of lean and employees must also be empowered to identify and implement lean improvements and ensure that all employees are engaged in the lean initiative and the **Continuous improvement culture** (Bayhan et al. 2019) is vital as lean is a continuous improvement process and organizations must progress with “continuous improvement culture” in order to sustain lean and continuous improvement should be embedded in all aspects of the organization and **Supplier collaboration** (Moradi & Sormunen, 2023) as lean practices can be extended across the supply chain through collaboration with suppliers and suppliers be a part in the lean employment and should be encouraged to adopt lean practices themselves and there has to be supply collaboration across the layers and Standardized processes are a foundation for lean implementation and organizations should identify and standardize key processes to “reduce waste and improve efficiency” and Just-in-time delivery (JIT) is a lean practice that aims to deliver to the construction site just when they are needed and JIT can help to “reduce waste and inventory costs” and Pull production is a lean practice that involves producing only “what is needed, when it is needed” and pull production can help to reduce waste and improve efficiency.

4.5 Barriers of Lean in construction:

The barriers of Lean in construction industry has shown in table:2.

Table 2 : Barriers of Lean In Construction Industry

Barriers of Lean In Construction Industry
Lack of awareness and understanding of lean principles.
Lack of top management support.
Fragmentation of the industry.
Resistance to change from traditional practices.
Lack of skilled workforce.
Project-based nature of work.
Time and cost pressures.
Lack of metrics and measurement systems.

Source : Author Own

Enablers of Lean in construction:

Important enables of lean in construction industry has shown in table:3.

Table 3: Enables of Lean in Construction Industry

Descriptives of Enables of Lean in Construction Industry
Standardized processes
Continuous improvement culture
Supplier collaboration
Employee engagement
Just-in-time delivery

Pull production
Top management support

Source : Author own

Top lean tools used in construction

Table 4 showing lean tools used in construction industry.

Table 4: Top Lean tools used in construction Industry

Lean tools used in construction Industry
Value Stream Mapping (VSM)
5S Methodology
Visual Management
Kanban
Kaizen
A3 Thinking
Mistake Proofing
SMED (Single-Minute Exchange of Dies)
Push-Pull Systems
Jidoka (Autonomation)

Table 5 : List of lean tools in order of suggested importance for the construction industry

Lean Tool	Justification
5S Methodology	5S creates an organized workspace, improving site organization, safety, and operational efficiency.
Visual Management	Visual Management facilitates transparent communication, enhancing project transparency and quick problem identification.
Kaizen	Kaizen fosters continuous improvement, aligning with the dynamic nature of construction projects.
Mistake Proofing	Mistake Proofing minimizes defects and reduces rework, crucial for maintaining quality in construction activities.
Jidoka (Autonomation)	Jidoka's self-detection mechanisms ensure built-in quality, reducing defects and enhancing reliability in construction processes.
Push-Pull Systems	Push-Pull Systems optimize material flow based on demand, reducing waste, and improving efficiency in project execution.
SMED	SMED reduces setup times, contributing to minimizing downtime and improving overall efficiency in project execution.
Kanban	Kanban regulates material flow, optimizing resource utilization and minimizing overproduction in construction projects.
Value Stream Mapping (VSM)	Flow mapping of the processes, reducing lead times, and ornamental in improved efficiency.
A3 Thinking	A3 Thinking provides a structured problem-solving approach, promoting collaboration and clear communication in project management.

Source : Author Own

5. Conclusion:

This article has reviewed the literature on lean in construction and identified the top barriers and enablers to lean implementation and the top three barriers cited were “lack of top

management support, lack of awareness and understanding of lean principles”, and lack of skilled workforce and the top three enablers cited were “top management support, continuous improvement culture, and employee engagement”. The article has also suggested a list of lean tools in order of suggested importance for the construction industry: “5S Methodology, Visual Management, Kaizen, Mistake Proofing and Jidoka (Autonomation)” and these tools can be used to help construction companies overcome the blockades to lean employment and realize the benefits of lean, such as reduced waste, improved efficiency, and enhanced customer satisfaction and in order to implement lean practices effectively, construction companies should use the following lean tools. The 5S methodology is a lean tool that can be used to organize and standardize the workplace and this can “reduce waste and improve efficiency” followed by Visual management is a lean tool that can be used to communicate and track key performance indicators (KPIs) and this can help to identify and address problems early on followed by Kaizen, a lean tool that focuses on continuous improvement and it involves making small, incremental changes to processes and procedures in order to improve efficiency and quality and Mistake proofing, a lean tool that focuses on preventing errors from happening in the first place and this can be done by designing processes and procedures in a way that makes it difficult to make mistakes and finally Jidoka, a lean tool that focuses on automating tasks in order to reduce waste and improve quality and this can be done by using sensors, robotics, and other forms of automation and by implementing these recommendations, construction companies can increase their chances of success in implementing lean practices and achieving the benefits of lean.

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