International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 17s,2025
https://theaspd.com/index.php

A Review On Factors Affecting The Adoption Of Lean Principles In Construction Waste Management

[1]**Ram Avtar Gautam,** [2]**Gaurav Sharma,** [3]**Divya Negi**
[1]Research Scholar, Lingaya's Vidyapeeth, Faridabad, India, rag8371@gmail.com
[2]Assistant Professor, Lingaya's Vidyapeeth, Faridabad, India, dr.gaurav@lingayasvidyapeeth.edu.in
[3]Assistant Professor, Lingaya's Vidyapeeth, Faridabad, India and Research Scholar at RICS, School of Built Environment, Amity University, Noida, India, divyanegi@lingayasvidyapeeth.edu.in

Abstract: *Construction waste management is a critical aspect of sustainable development, and the adoption of lean principles can significantly improve efficiency, reduce waste, and enhance environmental sustainability. This review examines the key factors influencing the adoption of lean principles in construction waste management. It explores organizational, technological, economic, regulatory, and behavioral aspects that impact implementation. The study highlights barriers such as resistance to change, lack of awareness, and inadequate policies, while also identifying enablers like leadership commitment, training, and advanced technology integration. By analyzing existing literature, this review provides insights into best practices and recommendations for enhancing lean adoption in construction waste management.*
Keywords: *Lean principles, construction waste management, sustainability, waste reduction, lean construction, adoption barriers, enabling factors*

1. INTRODUCTION

The construction industry, a vital sector in the global economy, is often criticized for its inefficiencies, excessive resource consumption, and substantial waste generation. Studies indicate that construction activities contribute to a significant portion of solid waste, negatively impacting the environment and increasing project costs. In recent years, there has been a growing need to adopt more sustainable practices to minimize waste and improve overall efficiency in the construction sector.

Lean principles, originating from the manufacturing industry, have been recognized as an effective approach to reducing waste and enhancing operational efficiency. Lean thinking focuses on eliminating non-value-adding activities, streamlining processes, and fostering continuous improvement. When applied to construction waste management, lean principles can significantly reduce material wastage, optimize resource utilization, and improve project timelines. However, despite the potential benefits, the adoption of lean principles in construction waste management remains limited and uneven across various regions and projects.

Lean principles in construction waste management focus on maximizing efficiency by minimizing various forms of waste throughout the construction process. These principles, derived from lean manufacturing, aim to create more value for the client by streamlining operations and eliminating activities that do not add value. Waste in construction can take many forms, such as excess materials, time delays, rework due to defects, unnecessary transportation, overproduction, and inefficient use of resources. By applying lean principles, construction firms can significantly reduce these inefficiencies and improve project outcomes. The core strategies involve continuous improvement (Kaizen), standardization of processes, effective collaboration among stakeholders, and a focus on reducing variability and uncertainty. Lean waste management emphasizes optimizing resource use, minimizing excess inventory, improving logistics, and designing processes that minimize waste generation from the outset. Ultimately, adopting lean principles in construction waste management contributes to more sustainable and cost-effective project delivery while reducing the environmental impact of construction activities.

Several factors influence the adoption of lean principles in construction waste management, including organizational culture, leadership commitment, technological capabilities, and the availability of skilled personnel. Resistance to change, lack of awareness, and the initial cost of implementing lean practices are often cited as barriers to their widespread adoption. Moreover, the fragmented nature of the construction industry, involving multiple stakeholders with differing priorities, further complicates the integration of lean principles.

Lean principles in construction waste management are essential due to the pressing need for efficiency, cost reduction, and sustainability in the construction industry. The construction sector is known for its high levels of material waste, inefficiencies, and resource-intensive processes, all of which lead to increased project costs, environmental harm, and delays. By implementing lean principles, construction firms can address several challenges in several ways.

Understanding the factors that affect the adoption of lean principles in construction waste management is essential for promoting more sustainable practices in the industry. This study seeks to explore these factors and provide insights into how construction firms can overcome challenges to successfully implement lean principles. By identifying the key drivers and barriers, the study aims to contribute to the development of strategies that enhance waste management efficiency and sustainability in construction projects.

2. Construction Industry in India

The Construction industry in India consists of the Real estate as well as the Urban development segment. The Real estate segment covers residential, office, retail, hotels and leisure parks, among others. While Urban development segment broadly consists of sub-segments such as Water supply, Sanitation, Urban transport, Schools, and Healthcare. The construction Industry in India is expected to reach $1.4 Tn by 2025.

- **Cities Driving Growth** - By 2030, cities are expected to generate 70% of India's GDP (MGI, 2011).
- The construction industry market in India works across 250 sub-sectors with linkages across sectors.
- **Residential**- An estimated 600 Mn people are likely to be living in urban centres by 2030, creating a demand for 25 Mn additional mid-end and affordable units.
- Under NIP, India has an investment budget of $1.4 Tn on infrastructure - 24% on renewable energy, 18% on roads & highways, 17% on urban infrastructure, and 12% on railways.
- **Schemes such as the revolutionary Smart City Mission** (target 100 cities) are expected to improve quality of life through modernized/ technology driven urban planning.
- 54 global innovative construction technologies identified under a Technology Sub-Mission of PMAY-U to start a new era in Indian construction technology sector.
- The size of India Construction market is around USD 639 billion in the current year and is anticipated to register a CAGR of over 6% during the forecast period.

3. Construction Waste

Construction waste refers to the by-products generated during the construction, renovation, demolition, or maintenance of buildings and infrastructure. These waste materials can be in the form of excess materials, debris, or unusable remnants that accumulate throughout various phases of a construction project. Common types of construction waste include concrete, wood, metals, bricks, glass, plastics, and insulation materials. Additionally, packaging materials, site clearance waste (such as soil and vegetation), and hazardous substances (such as asbestos and paints) also contribute to the waste stream.mConstruction waste is a significant environmental issue due to its high volume and improper disposal practices, which can lead to landfills filling up rapidly, pollution, and the depletion of natural resources. It also increases project costs due to the need for waste management, removal, and disposal, while inefficient use of resources impacts overall project profitability.

Effective management of construction waste involves practices such as waste minimization, reuse, recycling, and proper disposal. Reducing waste at the source, using eco-friendly materials, and optimizing designs to avoid overproduction are key strategies to minimize the environmental footprint. Recycling and repurposing construction materials can reduce the need for virgin resources and lower the amount of waste sent to landfills. Many countries and organizations are implementing regulations and guidelines to promote sustainable waste management practices in the construction industry, emphasizing the importance of reducing, reusing, and recycling materials to build more sustainably. By adopting waste reduction strategies like lean principles, construction companies can significantly reduce both the financial and environmental costs associated with construction waste.

4. Review of Past Studies

Eze et al. (2024) highlight the potential of Building Information Modeling (BIM) in reducing construction waste (CW) at the design and pre-contract stages, emphasizing its ability to address errors, specifications, site conditions, planning, and procurement issues. Similarly, Ahmadzadeh Amid et al. (2023) find that BIM, combined with modern technologies, can significantly enhance waste management across a project's lifecycle. Several studies identify critical obstacles to lean construction (LC) implementation. Singh et al. (2024) use an AHP model to determine that managerial and resource-related issues are the most significant barriers in India. Moradi and Sormunen (2023) reinforce these findings, stating that lack of awareness, resistance to change, and inadequate top management support hinder lean adoption. Ayfokru et al. (2023) observe similar challenges in Ethiopia, where poor site management, material handling, and frequent design changes contribute to excessive waste.

Rosli et al. (2023) find that employee involvement, operational efficiency, and continuous improvement enhance project performance, though poor information flow has a negative impact. Aljawder and Al-Karaghouli (2024) explore the role of AI, IoT, and technology in LC adoption but note significant structural and cultural challenges. Studies demonstrate that lean principles can improve sustainability by reducing waste, improving efficiency, and enhancing overall project performance. Lean tools like just-in-time (JIT), value stream mapping, and real-time monitoring systems are found to be effective in minimizing waste and optimizing resource allocation (Ahmed & Zhang, 2021).

5. CONCLUSION

Lean principles in construction waste management have received increasing attention in the past few decades as the construction industry seeks to minimize waste, improve efficiency, and reduce environmental impacts. Here's a summary of findings from past studies on this topic:

1. Waste Identification and Reduction: Lean construction aims to eliminate or minimize different types of waste commonly identified as overproduction, waiting times, excess inventory, unnecessary transportation, defects, over-processing, and unused skills. Studies show that identifying and mapping out these waste types through value stream mapping (VSM) and process analysis can reveal inefficiencies and redundancies that contribute to resource waste and cost overruns.
2. Just-in-Time (JIT) Delivery: Research demonstrates that JIT principles can greatly reduce material waste by ensuring materials arrive only when needed. This approach minimizes inventory costs, reduces the risk of material damage, and cuts down on the need for large storage spaces. In construction, JIT can be challenging due to variables like weather and supply chain delays, but studies suggest that well-coordinated scheduling and supplier partnerships improve its feasibility.
3. Pull Planning and Scheduling: Pull planning techniques, which focus on aligning project tasks based on actual demand rather than forecasts, have been effective in streamlining construction schedules. Studies reveal that pull planning enhances coordination among project teams, reducing idle time and improving task flow, leading to reduced waste.
4. 5S for Site Organization: The 5S methodology—Sort, Set in order, Shine, Standardize, and Sustain—has been widely studied and applied in construction sites to improve site organization. Research shows that adopting 5S principles minimizes the amount of time workers spend searching for tools and materials, reducing inefficiencies and contributing to a safer, more organized worksite with less material waste.
5. Continuous Improvement and Kaizen: Lean construction encourages a culture of continuous improvement, often achieved through Kaizen, or small, incremental changes. Studies have found that involving workers at all levels in identifying problems and suggesting solutions helps reduce waste and fosters a sense of ownership over quality and efficiency.
6. Use of Building Information Modeling (BIM): Many studies highlight the role of BIM in enhancing lean construction by improving project visualization and collaboration. BIM facilitates clash detection, more accurate quantity take-offs, and better coordination among stakeholders, which can reduce rework and material wastage.
7. Value Engineering (VE): Lean principles are often complemented by value engineering to identify

cost-effective ways to meet project goals. Past research suggests that VE can reduce material usage, avoid costly design changes mid-project, and ensure that every component adds value to the end product, minimizing waste.

8. Waste Audits and Measurement: Studies indicate that measuring waste through audits or data tracking helps quantify waste sources and drive more effective waste reduction strategies. Waste metrics also help to establish baselines, enabling project teams to set realistic goals for waste minimization and measure progress.

REFERENCES

1. Eze, E.C., Aghimien, D.O., Aigbavboa, C.O. and Sofolahan, O. (2024), "Building information modelling adoption for construction waste reduction in the construction industry of a developing country", Engineering, Construction and Architectural Management, Vol. 31 No. 6, pp. 2205-2223. https://doi.org/10.1108/ECAM-03-2022-0241.

2. Rosli, M. F., Muhammad Tamyez, P. F., & Zahari, A. R. (2023). The effects of suitability and acceptability of lean principles in the flow of waste management on construction project performance. *International Journal of Construction Management*, *23*(1), 114-125.

3. Singh, A., Kumar, V., Mittal, A. and Verma, P. (2024), "Identifying critical challenges to lean construction adoption", Construction Innovation, Vol. 24 No. 1, pp. 67-105. https://doi.org/10.1108/CI-09-2022-0229.

4. Aljawder, A., & Al-Karaghouli, W. (2024). The adoption of technology management principles and artificial intelligence for a sustainable lean construction industry in the case of Bahrain. *Journal of Decision Systems*, *33*(2), 263-292.

5. Ayfokru, F., Mitikie, B. B., & Tekile, A. K. (2023). Evaluation of the implementation of lean techniques to reduce construction process waste in real estate firms in addis ababa, Ethiopia. *Advances in Civil Engineering*, *2023*(1), 2379347.

6. Moradi, S., & Sormunen, P. (2023). Implementing lean construction: a literature study of barriers, enablers, and implications. *Buildings*, *13*(2), 556.

7. Ahmadzadeh Amid, S., Noorzai, E. and Golabchi, M. (2023), "Identifying factors affecting waste production throughout the construction project life cycle and proposing BIM-based solutions", The TQM Journal, Vol. 35 No. 6, pp. 1449-1470. https://doi.org/10.1108/TQM- 09-2021-0272.

8. Karaz, M., Teixeira, J. C., & Rahla, K. M. (2021). Construction and demolition waste—A shift toward lean construction and building information model. In *Sustainability and Automation in Smart Constructions: Proceedings of the International Conference on Automation Innovation in Construction (CIAC-2019), Leiria, Portugal* (pp. 51-58). Springer International Publishing.

9. Issa, U. H., & Alqurashi, M. (2020). A model for evaluating causes of wastes and lean implementation in construction projects. *Journal of civil engineering and management*, *26*(4), 331-342.

10. Bajjou, M. S., & Chafi, A. (2020). Identifying and managing critical waste factors for lean construction projects. *Engineering management journal*, *32*(1), 2-13.

11. Igwe, C., Hammad, A., & Nasiri, F. (2022). Influence of lean construction wastes on the transformation-flow-value process of construction. *International Journal of Construction Management*, *22*(13), 2598-2604.

12. Mohammadi, A., Igwe, C., Amador-Jimenez, L., & Nasiri, F. (2022). Applying lean construction principles in road maintenance planning and scheduling. *International journal of construction management*, *22*(12), 2364-2374.

13. Ahmed, R. R., & Zhang, X. (2021). Multi-layer value stream assessment of the reverse logistics network for inert construction waste management. *Resources, conservation and recycling*, *170*, 105574.

14. Ahmed, S., Hossain, M. M., & Haq, I. (2021). Implementation of lean construction in the construction industry in Bangladesh: awareness, benefits and challenges. *International Journal of Building Pathology and Adaptation*, *39*(2), 368-406.

15. Spišáková, M., Mésároš, P., & Mandičák, T. (2021). Construction waste audit in the framework of sustainable waste management in construction projects—case study. *Buildings*, *11*(2), 61.

16. Aravindh, M. D., Nakkeeran, G., Krishnaraj, L., & Arivusudar, N. (2022). Evaluation and optimization of lean waste in construction industry. *Asian Journal of Civil Engineering*, *23*(5), 741-752.

17. Likita, A. J., Jelodar, M. B., Vishnupriya, V., Rotimi, J. O. B., & Vilasini, N. (2022). Lean and BIM implementation barriers in New Zealand construction practice. *Buildings*, *12*(10), 1645.

18. Koskela, L. (2020). Theory of lean construction. In *Lean Construction* (pp. 2-13). Routledge.

19. Marzouk, M., & Elmaraghy, A. (2021). Design for deconstruction using integrated lean principles and bim approach. *Sustainability*, *13*(14), 7856.

20. Formoso, C. T., Bølviken, T., & Viana, D. D. (2020). Understanding waste in construction. In *Lean Construction*(pp. 129-145). Routledge.

21. Shang, G., & Sui Pheng, L. (2014). Barriers to lean implementation in the construction industry in China. *Journal of technology Management in China*, *9*(2), 155-173.

22. Salem, O., Solomon, J., Genaidy, A., & Minkarah, I. J. J. O. M. I. E. (2006). Lean construction: From theory to implementation.

Journal of management in engineering, *22*(4), 168-175.

23. Johansen, E., & Walter, L. (2007). Lean construction: Prospects for the German construction industry. *Lean construction journal*, *3*(1), 19-32.

24. Albalkhy, W., & Sweis, R. (2021). Barriers to adopting lean construction in the construction industry: a literature review. *International Journal of Lean Six Sigma*, *12*(2), 210-236.

25. Moyo, T., & Chigara, B. (2023). Barriers to lean construction implementation in Zimbabwe. *Journal of Engineering, Design and Technology*, *21*(3), 733-757.

26. Aziz, N. M., & Zainon, N. (2023). Driving factors for lean-BIM implementation in Malaysia's construction industry: qualitative interview-based study. *Smart and Sustainable Built Environment*, *12*(4), 872-891.

27. Shaqour, E. N. (2022). The impact of adopting lean construction in Egypt: Level of knowledge, application, and benefits. *Ain Shams Engineering Journal*, *13*(2), 101551.

28. Evans, M., Farrell, P., Zewein, W., & Mashali, A. (2021). Analysis framework for the interactions between building information modelling (BIM) and lean construction on construction mega-projects. *Journal of Engineering, Design and Technology*, *19*(6), 1451- 1471.

29. Benachio, G. L. F., Freitas, M. D. C. D., & Tavares, S. F. (2021). Interactions between lean construction principles and circular economy practices for the construction industry. *Journal of construction engineering and management*, *147*(7), 04021068.

30. Dehdasht, G., Ferwati, M. S., Zin, R. M., & Abidin, N. Z. (2020). A hybrid approach using entropy and TOPSIS to select key drivers for a successful and sustainable lean construction implementation. *PloS one*, *15*(2), e0228746.

31. Abu Aisheh, Y. I., Tayeh, B. A., Alaloul, W. S., & Almalki, A. (2022). Health and safety improvement in construction projects: a lean construction approach. *International journal of occupational safety and ergonomics*, *28*(4), 1981-1993.

32. Suresh, M., & Arun Ram Nathan, R. B. (2020). Readiness for lean procurement in construction projects. *Construction Innovation*, *20*(4), 587-608.