

# Lean Based Sustainability Project's Challenges Based on Different Construction Projects: A Review

**Gzing Adil Mohammed<sup>1</sup>, Dr. Dilshad K. Jaf<sup>2</sup>, Dr. Ahmet Oztas<sup>3</sup>**

<sup>1</sup>*Assist Lecturer, Oil, Gas and Energy Management Department/ College of Businesses /Charmo University /Sulaymaniyah, Kurdistan Region, Iraq.*

<sup>2</sup>*Department of Civil Engineering/College of Engineering/ Salahaddin University- Erbil/Erbil, Kurdistan Region, Iraq.*

<sup>3</sup>*Department of Civil Engineering/College of Architecture and Engineering / Epoka University/ Albanya  
Email: [gzing.adil@chu.edu.iq](mailto:gzing.adil@chu.edu.iq)*

Integrating lean construction concepts with sustainability's practice can be considered as a game-changing strategy which lead to increase construction productivity and decrease environmental affects rate. Lean construction originally focuses on optimizing construction process and eliminating wastes which naturally is in line with sustainability's emphasis on recovery resources, reduce CO2 footprints and whole environmental responsibilities. This study tries to present a comprehensive challenges by the integration of lean and sustainability through intensive literature reviews. The important opportunities can gain from the synergy is reducing the project cost, minimizing the project completion time, reduce environmental harm and involving technologies which promote creativity. Through integrating the two approaches many challenges will be arise. Financial issues, decentralized supply chain, lack of uniform metrics and standards to asses the integrations efficiency, special expertise training, etc. The challenges categorized into five main groups considering that applied in developing and developed country. Involving stakeholders and continues improvement (kaizen) are the most significant factors to enable the success of this integration.

**Keywords:** Lean; Sustainability; Barriers; Construction Management; Integration.

## **1. Introduction**

Construction accounts for 40% of the world's energy use, 38% of its greenhouse gas emissions, 12% of its use of drinkable water, and 40% of its solid waste emissions (Abanda et al., 2017, Bajjou and Chafi, 2018, Watkins and Sunjka, 2020). One of the main factors promoting economic growth in developing countries is the construction industry. Which is characterized by excessive waste production, excessive water and electricity use, significant carbon dioxide emissions, and numerous inefficiencies that increase waste throughout the growth processes (Zhang et al., 2018, Teng et al., 2019, Watkins and Sunjka, 2020). The construction sector is now dealing with a number of issues, such as poor quality, low productivity, cost overruns, and completion delays. To bring forward a general improvement and change in the state of the construction industries today, these essential issues must be resolved. The implementation of Lean construction and Lean project management methodology is the only way to address the necessity for change (Ahuja, 2013). The construction industry has embraced the concepts of lean construction (LC) and sustainability to improve productivity and efficiency across all operations, from top management to on-site construction (Dixit et al., 2017). According to (Vieira and Cachadinha, 2011) LC was brought in to modify the construction industry's production management system. The goal of this notion is to increase customer value by reducing waste of any kind, including money, time, resources, and equipment, and producing a superior end result. There is potential to improve present sustainable development methods by lowering waste in progress through lean construction and by minimizing negative environmental, social, and economic impacts through lean building (Horman et al., 2004, Watkins and Sunjka, 2020). As the theory behind Lean Thinking evolved, so did a number of methods for implementing its ideas such. Tools and techniques like Value Stream Mapping (VSM), 5S, Just in Time (JIT) Last Planner and Percentage Plan Compete (PPC), Map of Irregularities and Kaizen (continuous improvement) . These methods were developed, refined, and adjusted. The primary goal of these many Lean tools is to validate on the ground what the theory itself states, which is to cut waste and optimize resources and processes (Vieira and Cachadinha, 2011).

All businesses, regardless of the industry in which they work, play an integral part in promoting the plant's sustainable development, thus corporate management and planning have to consider sustainability into account (Cepinha et al., 2007). In general, sustainable construction seeks to achieve two main goals: (1) reduce the adverse effects of construction on the environment and, at the same time, (2) create and preserve a healthy environment for building occupants or the surrounding population of the developed projects (Cepinha et al., 2007, Nguyen and Nguyen, 2024).

This study is focusing on separately understanding on sustainability and lean construction barriers and examining the challenges through merging the two approaches in the projects.

## **2. Research Methodology**

A systematic literature review was implemented based on different construction projects. what distinguishes this kind of literature from the traditional literature review is clarity and systematicity of the approach to formulate the research question, specify relevant studies and

evaluate their quality and analysing the evidence by using a suitable approach (Hashem and Al-Zwainy, 2022). This study reviewed different papers relevant to integrating lean and sustainability's barriers in construction projects . Different keywords with various phrases have been relied to emphasize on the study area, lean -sustainability barriers, barriers in construction projects and integrating lean and sustainability barriers in construction. Figure 1 illustrate the literature review processes.

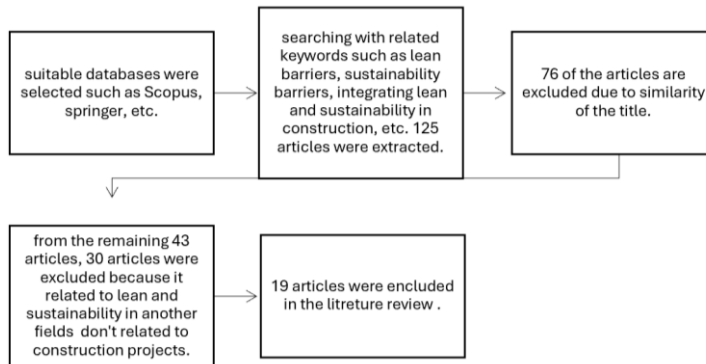


Figure 1 literature Review Methodology

The reviewed articles was selected from different databases such as Scopus, Research Gate, Science Direct , MDPI, Elsevier, Springer and Emerald Insight. The purpose of choosing these database because it include the majority of prominent and relevant publications in lean, sustainability and construction management. Table 1 Provide a sufficient information regarding the journal name, publication date and the articles title. The gathered papers passed through steps to revise and filter. The chosen articles analysed the significant and the importance of synergy lean and sustainability in construction projects. The previewed articles focuses on the parries which obstacle integrating lean and sustainability . The reviewed was based on the area the study held (developed and developing countries), the application of this synergy and the analysis method. Integrating the two concepts in the construction industry has significant impact on reducing wastes and energy consumption, maximizing the value and efficiency, enhance work flow and continues improvement. Lean tools and techniques which adapt sustainability are also investigated.

Dataset of integrating lean and sustainability barriers of reviewed article are substantially questionnaire. Other methods like observing construction site, interview with expertise in lean and sustainability and literature survey was also conducted. The following steps are the articles primary methodology:

1. The studies began with literature review regarding the lean concepts in construction projects and how it driven sustainability. The application and the benefits from this synergy and barriers from integrating the lean and sustainability concepts in construction projects is the focused area. The review included books, chapter of books, journals and conference.
2. Questionnaire had been designed depending on the gathered data from the literature review, case studies, site survey and interviews with expertise in lean and sustainable construction. Majority of publications used Semi structured, matrix and Likert scale as a

method to measure the importance of the lean-sustainability barriers.

3. Different data analysis have been used to asses the results and figure out the final decisions. It consist of RII (Relative Importance Index), Delphi analysis, Root Cause analysis, Fuzzy MICMAC analysis, Last Matrix, Statistical analysis and qualitative analysis. Table 1 illustrate the analysis approaches that have been used in each article.

Table 1 Reviewed Articles

References	Application	Analysis Method	Area of Study
(Awad et al., 2021)	Eliminating waste, increasing work efficiency, increase work flow, increase productivity	Qualitative Analysis	
(Saieg et al., 2018)	enhances efficiency in a traditionally inefficient industry, reduce economic and environmental impacts.	Qualitative Analysis	Literature Review
(Rosli et al., 2023)	improve information flow, maximize the value, increase operation efficiency, enhance continues waste management	PLS-SEM analysed measurement and structural models	Malaysia
(Carvajal-Arango et al., 2019)	enhance employee skills and promote teamwork diversity, minimize non-value-adding activities and increasing output value, enhance waste management	Qualitative Analysis	Literature Review
(Tetik et al.)	Improve the regulatory and policy issues	Qualitative Analysis	Literature Review
(Tafazzoli et al., 2020)	Energy efficiency, cost reduction, enhance jobsite safety	The Relative Importance Index (RII)	The USA
(Bae and Kim, 2008)	Improve safety in projects, enhance productive process, improves transparency in construction processes, reduces inventory	Qualitative Analysis	Literature Review
(Anandh et al., 2022)	Minimizing project time and resources, reducing construction waste	Statistical Analysis, Non-Parametric test (chi square and One-Sample T- test )	
(Aslam et al., 2021)	Enhancing waste reduction strategies	Last Matrix	Canada
(Erdil et al., 2018)	Improve project outcomes	Statistical and graphical analysis, Root cause analysis technique	
(Cruzado-Ramos and Brioso, 2020)	Enhancing implementing sustainability performance metrics.	Delphi Analysis	Peru, South America
(Cherrafi et al., 2017)	Provide a structure for enhancing financial and environment performance	Interpretive Structural Modelling (ISM), Fuzzy MICMAC analysis	
(Cruzado-Ramos and Brioso, 2020)	Minimizing resources and environmental footprints	Delphi Analysis	California, the USA
(Ismail et al., 2023)	Enhance quality and safety, improve design, optimize project planning and implementation	The Relative Importance Index (RII), Statistical analysis (SPSS)	
(Moradi and Sormunen, 2023)	Reducing waste, better utilizing resources	Qualitative Analysis	Malaysia
(Rahman et al., 2013)	Improve knowledge in lean and sustainability integration	Thematic analysis, Content analysis	Literature Review
(Pandithawatta et al., 2020)	Positive stakeholders attitudes toward lean-sustainability	Qualitative Analysis, Content analysis ( NVivo	Sri Lanks, Malaysia

	integration, importance of green professionals to success	software)	
(Abd Jamil and Fathi, 2016)	Enhance productivity, Reduce waste, optimizing resources use	Qualitative analysis	Malaysia
(Marhani et al., 2013)	Minimizing waste, increase efficiency and quality, support environment protect	Qualitative Analysis ( Documentary analysis )	Langkawi, Malaysia

### 3. Results and Discussion

One of the well-known and common topics that connect lean practices and sustainability concepts are eliminating waste (materials) and adding value to the customer, Which results in reduced pollution and minimizing resource depletion (Huovila and Koskela, 1998, Bae and Kim, 2008). Many authors oblige their study focusing on implementing this integration for a low portion of project lifecycle project processes while its found few of endover implement this integration to the whole processes. Four reviewed articles focused on design phase as a study area. Delphi analysis and qualitative analysis were implemented to emphasize the challenges extracted from the case studies, interviews and past studies. Rare lean-sustainability synergy and difficulties in quantity measuring sustainability performance are the most common barriers among others (Awad et al., 2021, Saieg et al., 2018, Bae and Kim, 2008, Cruzado-Ramos and Brioso, 2020).

Challenges vary from one country to another depending on its development. In developed countries like USA, Canada and Australia , Lean and Sustainability were able to prove their success in developing construction strategies, reducing the impact on the environment, and overcoming most of the challenges that caused them to fail. Rationally organizational related barriers have been limited such as engagement of stakeholders in sustainability practices, improve collaboration and communications, and reducing the fear of adopting new management strategy . On the opposite side, it seems that hiring specialized expertise, extra initial cost and create a high skilled team are challenged issue (Tafazzoli et al., 2020). While in developing countries the challenges become more due to the lack of the construction industry and unstable economic environment. Cherrafi (2017) identified 15 barriers which classified into main 5 groups (governmental, financial, human attitude, organizational, materials). Human attitudes barriers ranked the first group obstacle the success of the integrating lean and green, such as resistance to change, lack of education and awareness, poor communication and collaboration and poor quality of human resources.

The key success factors to overcome these challenges are the significant of involving the stakeholders and continuous improvement (Kaizen) in lean-sustainable concepts (Rosli et al., 2023, Pandithawatta et al., 2020). From stakeholders perspective toward the synergy , many literature show the lack of collaboration among the stakeholders (Moradi and Sormunen, 2023) and awareness regarding sustainability practices and lean implementation (Rahman et al., 2013). A systematic training and increasing awareness is crucial to overcome stakeholder barriers (Abd Jamil and Fathi, 2016, Marhani et al., 2013).

This study attempts to categorize the barrier in five groups as it is mentioned in Table 2, the distribution will set and identify between developing country and developed country. It is

seems that organization and human related issue is get more hindered and obstacle towered a lean and sustainability application, separately and combined together. While in developed country the technical and financial related challenges has found frequently mentioned in there studies.

Table 2 Lean-Sustainability Integration Barriers

Lean-Sustainability Integration Barriers	
Organizational and managerial issues	Resistance from middle management to implement lean construction.
	Lack of clear definitions for conceptual frameworks.
	Contractors' unwillingness to adopt additional requirements.
	Challenges to create a high level of teamwork.
	Integration of lean with sustainable construction lacks attention.
	Improper waste management practices in construction
	Lack of comply from owners and top management.
	Fear of adopting new management methods.
	Inadequate incentives for private sectors
	Non-involvement of contractors at early stages.
	Lack focusing on environmental and social aspects.
	Weak organizational support for sustainability initiatives.
	poor of communication and cooperation between departments.
	Lack corporate culture separating environmental and improvement decisions.
	Inappropriate identification of lean and green areas.
	Need for efficient management in construction projects.
	Misconceptions regarding Lean and Green integration.
Lack of stakeholder engagement in sustainable practices.	
Technical issues	Lack of quantification of lean construction's impact on sustainability.
	obstacles in comparing that come out due to incommensurable frameworks.
	Poor safety performance risks owner's reputation and liability.
	Unprivileged material care and low-quality materials.
	Inaccuracies in quantity survey.
	Lack of knowledge on sustainable construction applications.
	Insufficient organizational resources for implementation.
	Absence of implementation strategies and tools.
	Poor quality of human resources.
	Lack of reliable performance indicators for sustainability evaluation.
	Green materials and its application technologies are not familiar .
	Delays in project timeline and cost impact.
Cultural and Human Attitudes	Environmental impact due to construction activities.
	Selection criteria for consultant can have obstacles.
	Traditional delivery models do not support integration.
	Insufficient training opportunities in lean construction for professionals.
	Difficulty of providing specialized expertise.
	New green technologies pose additional risks to personnel.
	Social sustainability aspects are often overlooked in sustainable certifications such as LEED.
	Order taking complexity in construction processes.
	Resistance to change within the construction industry.
	Uncertain gain of sustainability efforts.
	Existing systems fail to support effective project delivery methods.
Lack of expertise training and education	
Lack of Kaizen method to be applied.	

	Fear of failure and resistance to change.
	Unreliable data collection systems.
	Limited literature on Lean Construction and sustainability integration.
	Fragmentation in Sustainable Construction practices across project life cycle.
<b>Governmental and Regulatory Issues</b>	Regulatory barriers to innovative techniques.
	Lack of compatible contractual frameworks.
	Insufficient government intervention for sustainable construction.
<b>Financial Issues</b>	Lack Additional initial costs to the project
	Lack of funds for green projects.
	Need for larger-scale implementation to validate contributions.
	Fund constraints and high costs.

#### 4. Conclusions

Integrating sustainability and lean construction can have a substantial impact on medium and large projects. While this approach may raise initial costs, it ultimately helps reduce future operational expenses. Both strategies focus on minimizing energy consumption while delivering high productivity, ensuring that clients are aligned with the concept. Additionally, customer satisfaction tends to increase after the commissioning phase. Involving stakeholders and continues improvement are the most significant factors to enable the success of this integration. The main barriers that found among the article can be concluded as below:

1. Adopting technologies like 3D printing and BIM will provide facilitate to reduce time and human attitude barriers while rise a new challenges related technological issues like special technological training.
2. Lack of quantity measurements to measure the impact of lean concepts on social, economical and environmental dimensions.
3. Insufficient literature about lean and sustainability synergy, thus there is always a gap need to be study.

Further study is needed toward metric to measure quantity performance of lean and sustainability need to be focused more in future studies.

#### Acknowledgements

The authors are grateful for the financial support towards this research by the Civil Engineering Department, College of Engineering, Salahaddin University. Postgraduate Research Grant (PGRG) No. SU.G/2023/HIR/MOHE/ENG/39 (12-53-9).

#### References

1. ABANDA, F., TAH, J. & CHEUNG, F. 2017. BIM in off-site manufacturing for buildings. *Journal of building engineering*, 14, 89-102.
2. ABD JAMIL, A. H. & FATHI, M. S. 2016. The integration of lean construction and sustainable construction: A stakeholder perspective in analyzing sustainable lean construction strategies in Malaysia. *Procedia Computer Science*, 100, 634-643.

3. AHUJA, R. 2013. Sustainable construction: is lean green? ICSDEC 2012: developing the frontier of sustainable design, engineering, and construction.
4. ANANDH, S., SINDHU NACHIAR, S., MARIAPPAN, P. & SAI ABESHEK, C. 2022. Integrating Lean and Sustainability Approach for Construction Firms. *Advances in Construction Management: Select Proceedings of ACMM 2021*. Springer.
5. ASLAM, M., GAO, Z. & SMITH, G. 2021. Development of Lean Approaching Sustainability Tools (LAST) matrix for achieving integrated lean and sustainable construction. *Construction Economics and Building*, 21, 176-197.
6. AWAD, T., GUARDIOLA, J. & FRAÍZ, D. 2021. Sustainable construction: Improving productivity through lean construction. *Sustainability*, 13, 13877.
7. BAE, J.-W. & KIM, Y.-W. 2008. Sustainable value on construction projects and lean construction. *Journal of green building*, 3, 156-167.
8. BAJJOU, M. & CHAFI, A. 2018. A conceptual model of lean construction: a theoretical framework. *Malaysian Construction Research Journal*, 26, 67-86.
9. CARVAJAL-ARANGO, D., BAHAMÓN-JARAMILLO, S., ARISTIZÁBAL-MONSALVE, P., VÁSQUEZ-HERNÁNDEZ, A. & BOTERO, L. F. B. 2019. Relationships between lean and sustainable construction: Positive impacts of lean practices over sustainability during construction phase. *Journal of cleaner Production*, 234, 1322-1337.
10. CEPINHA, E., FERRÃO, P. & SANTOS, S. 2007. The certification of buildings as an enterprise strategy of the real estate sector: a national scope analysis. *Portugal SB07. Sustainable Construction, Materials and Practices: Challenge of the Industry for the New Millennium*, IOS Press, Amsterdam, 113-120.
11. CHERRAFI, A., ELFEZAZI, S., GARZA-REYES, J. A., BENHIDA, K. & MOKHLIS, A. 2017. Barriers in Green Lean implementation: a combined systematic literature review and interpretive structural modelling approach. *Production Planning & Control*, 28, 829-842.
12. CRUZADO-RAMOS, F. & BRIOSO, X. Sustainability performance evaluation in building projects by integrating lean and sustainable management using the delphi method. *Proc. 28th Annual Conference of the International Group for Lean Construction (IGLC)*. Berkeley, California, USA, 2020. 805-816.
13. DIXIT, S., MANDAL, S. N., SAWHNEY, A. & SINGH, S. 2017. Area of linkage between lean construction and sustainability in Indian construction industry. *International Journal of Civil Engineering and Technology*, 8.
14. ERDIL, N. O., AKTAS, C. B. & ARANI, O. M. 2018. Embedding sustainability in lean six sigma efforts. *Journal of Cleaner Production*, 198, 520-529.
15. HASHEM, A. S. & AL-ZWAINY, F. M. S. 2022. Factors Affecting in Estimation of Durations and Costs for Oil Projects: A Systematic Literature Review. *Mathematical Statistician and Engineering Applications*, 71, 3354-3367.
16. HORMAN, M. J., RILEY, D. R., PULASKI, M. H. & LEYENBERGER, C. Lean and green: Integrating sustainability and lean construction. *CIB World Building Congress, 2004. International Council for Research and Innovation in Building and ...*, 2-7.
17. HUOVILA, P. & KOSKELA, L. Contribution of the principles of lean construction to meet the challenges of sustainable development. *Proceedings IGLC, 1998*.
18. ISMAIL, N. A. A., HASBULLAH, I. S., MOHAMED, M. A., MARHANI, M. A., ROOSHDI, R. R. R. M., SAHAMIR, S. R. & GOLIZADEH, H. 2023. Lean-BIM Collaborative Approach for Sustainable Construction Projects in Malaysia. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 33, 356-366.
19. MARHANI, M. A., JAAPAR, A., BARI, N. A. A. & ZAWAWI, M. 2013. Sustainability through lean construction approach: A literature review. *Procedia-Social and Behavioral Sciences*, 101, 90-99.
20. MORADI, S. & SORMUNEN, P. 2023. Integrating lean construction with BIM and

- sustainability: a comparative study of challenges, enablers, techniques, and benefits. *Construction Innovation*, 24, 188-203.
21. NGUYEN, T. A. & NGUYEN, T. A. 2024. Building Information Modeling (BIM) for Construction Project Schedule Management: A Review. *Engineering, Technology & Applied Science Research*, 14, 13133-13142.
  22. PANDITHAWATTA, T., ZAINUDEEN, N. & PERERA, C. 2020. An integrated approach of Lean-Green construction: Sri Lankan perspective. *Built Environment Project and Asset Management*, 10, 200-214.
  23. RAHMAN, A., GONZALEZ, V. A. & AMOR, R. Exploring the synergies between BIM and lean construction to deliver highly integrated sustainable projects. 21st Annual Conference of the International Group for Lean Construction, July31-August, 2013. 1-12.
  24. 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, 114-125.
  25. SAIEG, P., SOTELINO, E. D., NASCIMENTO, D. & CAIADO, R. G. G. 2018. Interactions of building information modeling, lean and sustainability on the architectural, engineering and construction industry: a systematic review. *Journal of cleaner production*, 174, 788-806.
  26. TAFAZZOLI, M., MOUSAVI, E. & KERMANSHACHI, S. 2020. Opportunities and challenges of green-lean: An integrated system for sustainable construction. *Sustainability*, 12, 4460.
  27. TENG, J., MU, X., WANG, W., XU, C. & LIU, W. 2019. Strategies for sustainable development of green buildings. *Sustainable Cities and Society*, 44, 215-226.
  28. TETIK, M., KOSKELA, L., PIKAS, E. & VENDEL, K.-R. EVALUATION OF THE LITERATURE SYNTHESSES ON LEAN CONSTRUCTION CONTRIBUTIONS TO SUSTAINABILITY.
  29. VIEIRA, A. & CACHADINHA, N. Lean construction and sustainability-complementary paradigms-a case study. *Proceedings of the 19th Annual Conference of IGLC*, 2011. IGLC Lima, Peru, 611-621.
  30. WATKINS, J. & SUNJKA, B. 2020. Combining green building and lean construction to achieve more sustainable development in South Africa. *South African journal of industrial engineering*, 31, 133-143.
  31. ZHANG, L., WU, J. & LIU, H. 2018. Turning green into gold: A review on the economics of green buildings. *Journal of cleaner production*, 172, 2234-2245.