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The Integration of Lean Construction and Sustainable Construction: A Stakeholder Perspective in Analyzing Sustainable Lean Construction Strategies in Malaysia

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Abstract

The simultaneous implementations of Sustainable Construction (SC) and Lean Construction (LC) concepts/practices are feasible in a strategic approach to accomplish improvement in reducing waste, which resulted in both positive environment and economic outcomes. Although both concepts/practices are capable of attaining significant environmental and economical benefits, organizations still experiencing difficulty to integrate the concepts successfully. The literature indicates that the construction industry in many countries have encountered poor implementation and integration of both concepts. Therefore, this paper aims to lay the groundwork for future empirical study by investigating on various dimensions of SC and LC, where the theoretical and practical findings provided a foundation for integrating the two initiatives to yield the efficient use of valuable resources.

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Keywords: Lean construction; sustainable construction; stakeholder involvement; strategy

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1. Introduction

Lean construction (LC) promises outstanding results in managing the construction process and achieving the project's goals by eliminating waste. In the case of Sustainable Construction (SC), systematic training and research are crucial to provide proper interaction and collaboration with the stakeholders, thus enhancing the quality of life for the future construction industry[55].

Usually, LC and SC practices are two separate and independent strategies, where Lean's process goal is to improve economic standards, while sustainability aims to improve the environmental objectives. However, through enormous research and industry practices, it is found recently that the two practices are interdependent and shares the exact basics of waste elimination[39]. Therefore, components related to SC can be integrated into the concept of LC to enhance and preserve the natural resources, economic growth, and environment without compromising the future. This is possible because the integration of concepts will enhance the performance and the impact of building construction by realizing hidden cost reductions towards the environment[56,74]

It is clear that the global construction industry will significantly benefit from adopting both SC and LC concepts, however the literatures revealed that the implementation process is fairly poor with slow or no progress.[16,22,67] Furthermore, lean process is problematic for the construction industry in many countries within the past years.[9,10,16,25,49,57,72] Due to the actual scenario in the construction industry, many applied researchers have become increasingly interested in exploring the context of sustainable development, LC, and innovation. Despite these the heavy interest, a study by Common et al.,[19] revealed that the emergence of lean culture within various European construction companies is actually lower than the expectation.

Considerable gaps are found at the level of development as identified in the previous studies on LC within the context of structural and cultural aspects, namely human attitudinal, lack of adequate lean awareness and knowledge, and lack of top management commitment that hinders the successful implementation of LC in the UK construction industry[19,67]. Apart from the aforementioned aspects, some of the other factors that are hindering the successful implementation of SC were also discussed in the literature, namely inefficient strategy, improper management and leadership styles, inadequate stakeholder engagement, and reluctant to foster sustainability as cultural values.[7,22,31,46] Koskela and Howell[35,43] highlighted that the involvement of various stakeholders in the industry is essential to deliver successful projects, which will reflect towards substantial effort in achieiving a greener environment[28,61].

Based on the above explanation, our study aims to provide the insights of the theoretical integration of LC and SC for the application and practice of Sustainable Lean Construction (SLC). The research work herein will contribute new ideas on the implementation of LC and SC, and concurrently enhances the performance and the productivity of construction projects. The central research question of the proposed research is:

What are the fundamental characteristics of SC and LC, how can SC and LC be integrated strategically into SLC?

The structure of this paper is as the followings, section 2 introduces the research methodology that details out the various aspects of the proposed research. Section 3 aims to provide a comprehensive review that supports the contextual settings of SC, LC, and the disputes of integrating the SC and LC concepts into an overall concept of SLC. Subsequently, section 4 analyzes and synthesizes the literatures in the area of SLC to develop a framework on the strategy of SLC integration.

2. Research approach

The focus of this paper is on SLC conceptualization and implementation, and the paper consists of an integrative literature review[50,65], and a coding framework[15]. In the literature review, the aim is to provide a better understanding of the SLC concept in both theoretical and practical aspects, hence the concepts of SC and LC are explored, discussed, and synthesized into an SLC concept. Theoretically, sustainable construction emphasizes reductions in building energy use, water use, materials employed, and pollution[4]. On the other hand, lean construction emphasizes reductions in the waste present in the processes used to design and construct buildings in producing products valuable to the customer, while eliminating all other unnecessary activities, defined as waste[34,42]. SC and LC both

exhibit significant synergies on minimizing resource use as both *"strive for the efficient use of resources through the reduction of waste"*[64], while the practical contribution to the current practice and the future empirical work are explained in the findings section and future work section within this paper. In a nutshell, this paper improves the existing literature by integrating SC and LC concepts, where the major research highlight is that the integrative approach adopts the stakeholder approach. The importance of choosing the stakeholder approach is to understand and analyze the project stakeholders' environment, consequently enabling to determine the right type of approach according to the stakeholders[1,21], where approaches can be either SC, LC or an integrated SC and LC concepts.

3. Findings of the review

The systematic literature review of the previous empirical studies is presented in Table 1, where all three aspects of SC, LC, and SLC will be discussed, namely the theoretical foundations of the literature, the principles that underlie these foundations, and the sources in the literature that reports these foundations and principles. Under the subsections within this section, the contents of Table 1 will be explained in detail.

Table 1. SC and LC practices.

Theoretical foundations	Principles	Sources
Sustainable construction practices		
-The integration of Social, Economic, and Environmental attributes	-Innovative business strategies that improved the lifecycle of the production with additional focus on the waste reduction.	8,14,17,59,70
-Design & Procurement	-Improved the project's lifecycle value through green design and the promotion of best construction procurement practice throughout the supply chain	23,66,71
-Technology and innovation.	-Enhanced the company's capacity towards technology & innovation to empower sustainability concept throughout the construction process.	22,38,40,76
-The organizational structure & process.	-Reorganized the organizational process to facilitate the implementation of sustainable policy and strategy	30,53
-Education and training	-Increased organizations' commitment to SC through better education and training for project stakeholders.	18,24,58
-Measurement and reporting	-Development of existing benchmarks that evaluated the companies' environmental and social performance and consequently identified the areas for improvement	63,77,81
Lean Construction		
-The revolution of manufacturing principles in building environment and meeting customer needs.	-LC was designed as a production management based approach for project delivery: a new method to design and build capital facilities.	5,12,43,52,54,80
	-New production philosophy to maximize value, minimize waste and resources to enhance customer values.	26,35,56,57,68,82
-Balanced use of resources	-A balanced use of people, materials, and resources.	51
	-Reduced costs, eliminated waste and delivered projects on time.	27,34,42
Disputes to integrating SC and LC concepts.		
-Lack of focus to environmental elements.	- An enormous number of construction projects suffered due to the inadequate attention on environmental issues.	72
-The integration of team accountability, base organization, cultural issues, and leadership management	-The crucial elements to the success of SLC implementation that affected the structural relationship between cultural values and coping behaviors in implementing SLC concept.	6,10,32,37,44,47,54,55
-Inadequate commitment and	-Limited experience and knowledge led to the significant amount of waste.	41,79

knowledge integration.	-The effects of contractual arrangements design-build (DB) on communication.	36
-Transparent communication.	-The commitment to open, frequent and genuine communication at all levels of the integrated design team.	6,37,44,62,74

3.1. Sustainable Construction

Sustainable construction is a comprehensive integration of environment, social and economic issues. The aspects that are important in this matter are the quality of life, work efficiency, and a healthy work environment. The practices in the concept of SC enables to enhance the capacity of technology and innovation, which directly improves the strategy and practice of construction business right from the start and up to the end process that manages the waste.[22,76]

By implementing a clear sustainability strategy, contractors will be enable to identify and select their specific SC practices that focuses on their commitments and improves their knowledge. Most related researches reported that proper education and training will increase stakeholders' commitments and knowledge at every level. Furthermore, according to Abdullah et al.,[3], commitment and knowledge were the vital elements to a successful implementation of sustainable concepts.[22] The case studies so far have justified that firms will benefit more from the sustainability implementation if it is holistically applied throughout the organization rather than only in the projects.[11,41] Meng et al.,[56] argued that insufficient commitment and knowledge had led to one of the common factors that produced the current barriers.[37] Apart from that, adequate knowledge will boost stakeholders' performance and motivation, especially in an increasingly technology-savvy environment with more transparent workforce that provides an enhanced communication medium and sharing of knowledge.[76,77]

Despite the benefits of SC, unsustainable design and construction processes, and constant degradation of the environment due to the construction process still exist in most developing countries, and Malaysia is part of the negative processes.[54,55] In line with this issue, Lam et al.[46] explored factors impeding to the successful execution of sustainable specification in construction. Some of the factors are cultural barriers, lack of green technology and techniques, reliability, quality of specification, leadership and responsibility, stakeholder involvement, and guide and benchmarking systems.[22,67,68] On the other hand, both developed and non-developed countries struggle with the SC concept.

Although several efforts have been carried out by developed nations to fully transform into sustainable construction practices, however a large number of empirical studies reported that many barriers prevent the development of sustainable construction in these countries.[7,13,31,67] Many sustainable practices that comprised of topics on safety, efficiency, productivity, and waste minimization, are actually interlinked.[27,41] and difficult to be implemented. Accordingly, Houvila and Koskela[34] strongly suggested that a concrete methodology for implementing all these sustainable construction topics was imperative for a sustainable development.

3.2. Lean Construction

The major concern related to the 'rethinking construction' as reported by Egan[24] is the development to improve the culture, organizational and managerial style of the industry to breakthrough the hurdles, attitude, roles, relationships, actions and communications among the project stakeholders.[43,68] Likewise, the culture, and the organizational and managerial styles are the crucial pillars for a continuous improvement, which implied a constant delivery of greater value and increasing mutual competitive advantages.[3,43] Through stakeholder collaboration and continuous improvement, the team members can identify opportunities to eliminate the activities that do not add value.[56,68,82] Conversely, Lim[51] suggested that Lean is all about achieving a balanced use of people, materials, and resources. In other words, lean implementation facilitates an organization to reduce costs, eliminate wastes, and deliver projects on time.[27,34,42]

According to Bertelsen[12], LC is similar to the current practice that aims of to enhance customer satisfaction and performance of the firms. The primary objective is to minimize the waste to improve and support the new

production philosophy.[26,35] Howell[35] characterized LC as a conceptual foundation and understanding of waste resource, which explains the projects that are managed on a traditional basis experienced adversaries and difficulty in controlling the outcome. In traditional case, the practice is to optimize the piece, while lean aims to optimize at the project level, and it requires a different approach towards managing work.[79] Though LC efforts could have been proven to be highly rewarding for the construction industry, it does not seem to be adopted in the global construction industry.[67,68] Furthermore, there appears to be some significant structural and cultural barriers towards the adoption, namely inadequate lean awareness, knowledge and skills, and lack of top management commitment, technology limitation, poor implementation strategy, inefficient stakeholder relationship management, the lack of supportive organization and teamwork, inefficiency communication in sharing vision and consensus, and other minor problems that consequently hindered the construction industry from following the objectives of lean concept.[3,16,54,55,68]

Malaysia, as a developing country, the concept of lean construction in the industry is still considerably new and fresh.[55] A major reason that Malaysia has limited implementation and scarce research framework of lean concept is a concomitant factor with the developed nations that similarly hesitate to adopt the concept.[3] According to Johansen and Walter[79], the implementation of the lean concept in the construction industry is still restrained and sluggish. This issue had been supported by Common et al.,[18] based in the United Kingdom and by Johansen and Walter[79] based in the Netherlands, where these authors clearly stated that there has been a slow progress in the construction industry in promoting lean concepts.

Although many companies employed skilled professionals that are well versed in the construction processes and aware of the changes and improvements within the industry, there are still issues hindering the implementation of lean concept. In the literature, it was evident that applying the lean principle or tool will be insufficient without a consistent strive for a lean culture.[16,54,68] Therefore, it is essential to extensively engage in the lean concept in a balanced approach throughout a system with the following characteristics, namely personal focus, collaboration, and motivation in delivering value to customers.[33,79] Therefore, our study strives to improve these lacking areas to enhance the performance of construction projects, which consequently will provide a better implementation platform for SLC.

3.3. Integrating SC and LC into SLC

Some literatures contend that the theory of lean construction is already offering a conceptual basis and potential for novel methods and tools that foster sustainability concept at various perspectives.[3,34] Integration efforts are required for further development with the objective of enhancing the quality of life through the integration of SC and LC.[47,54,55]

The Pentagon and Toyota South Campus are two practical cases that have been thoroughly examined on the integration process of SC and LC concepts.[41,47] A study of the Pentagon renovation project showed that the integration process saved both money and time by demonstrating a strong relationship between sustainability and lean concepts. These projects have been completed by using an innovative contracting strategy and delivery process designed to eliminate many contractual barriers. As a result, the projects were able to build highly efficient facilities that are completed within project budget and schedule. [41,47]

Due to the significant impacts from the construction activities toward the society and environment, global government bodies have introduced various policies and regulations to control the relative impacts.[76] However, it is found that the majority of the projects have suffered due to lack of consideration towards the environment.[72] Similarly, Scherrer-Rathjea et al.,[69] stated that although the significant benefits offered by LC relative to waste reduction and improved business profit, the integration of LC and SC may result in better cost saving, waste reduction, and environmental impact.[34,37] Therefore, there are actually synergies between lean and eco-sustainability. The strengths and weaknesses of lean and eco-sustainability revealed the significant opportunities for integrating initiatives to potentially achieve the LC and SC objectives.[41,48]

In order to effectively achieve the implementation of SLC, commitment and knowledge are the crucial elements.[41,79] An empirical study conducted by Koranda et al.,[41] investigated the relationships among worksite, design, environment, and SC and LC in perspective of small construction projects. The empirical evidence justified that many project managers were found to have insensibly applied lean concepts (such as the reduction of on-site inventory), and have limited experience and knowledge on sustainable and lean projects that led to a significant

amount of waste. Moreover, Koranda et al.[41] ascertained that contractual arrangements were found to limit the interaction and the integration knowledge between designers and contractors. Frequent communication between parties helped to integrate knowledge and information related to, for example, regional conditions, materials, practices, and uncertainties.[6,44] In the case of a Design-Build (DB), the project owner provides contract to DB firm during the early stage of the project development process, therefore the communication between the designers and contractors occurred frequently and openly than it does in conventional DB projects.[36,74] Such communication helped the designers and contractors to align their project objectives and reduced design construction conflicts, which further facilitated the application of LC and SC.[37,62]

4. Discussion: Future work for improvement

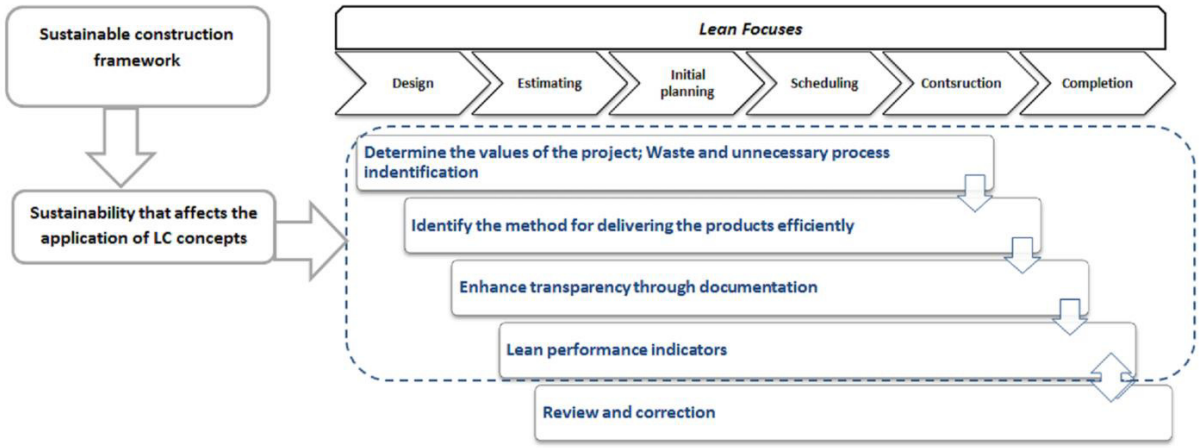

Fig.1. A simplified model for integrating SC and LC in a Construction Project. Koranda et al., (2012)

It is widely acknowledged that developing countries have experienced great challenges in finding a holistic approach to guarantee sustainability in the construction industry. An enormous framework of literatures is available on the problems encountered by the global construction industry that is discussed in the previous sections. However, limited research has been carried out by academics and practitioners on the challenges faced by the local countries specifically in the Malaysian construction industry (MCI).[3,4,22,51,54,55,67] Abdul Rahman et al.,[2], found 45.9 percent of delays actually occurred in the completion dates during the construction stage, and the construction projects were not cost effective.[56] Another significant challenge in the MCI is an inadequate consideration of the important component of economic growth and social development,[3,4,31,55] which has been the source of significant negative impact on the physical environment, such as soil erosion and sedimentation, flash floods, destruction of vegetation, dust pollution, noise pollution.[43,56,68,75] There is an urgent need to address these issues in the MCI, where sustainability challenges have been taken into consideration. Since, the LC has demonstrated as sustainability, the adoption of LC in construction practices may lead to pollution reduction.[20,54] Based on the literature review of the crucial elements on integrating SC and LC, our future empirical study will innovate a new operational framework by utilizing the model of integrating LC and SC practices. The similar model is shown in Fig.1 that was proposed by Koranda et al.,[41] which will be an interpretation system in the context of project stakeholder analysis.

The objective of the model attempts to simplify the process by integrating the findings of the study with the existing techniques and literature on the implementation of SC and LC concepts. The components of sustainable construction bearings that have value, focus on waste elimination, which are part of a process that will affect project schedules and costs will be documented extensively hence to integrate with lean construction. The components

mainly emphasize the fundamental contribution of the flow view (eliminating waste).[42,43] The primary concerns of this model are two key issues, namely conflicts of delivering values and project stakeholder collaboration for integrating the SC and LC concepts. Every stakeholder should concentrate on maximizing the gains from a construction project,[21,35] thus, the project team needs to clearly define the values for their project, identify waste, and unnecessary processes in their project.[43] These values should be identified in the early stage of the project, which should be eliminated during the planning, scheduling, and construction stages.[41] The involvement of project managers from planning until project completion is vital in ensuring the materials are delivered efficiently. Therefore, lean process should be applied by all parties at all stages, aspects, and activities of the end-to-end project cycle.[3,37,56] As a result, SC and LC implementations may be easier if the stakeholders are able to determine the right type of action at a various stages.[1,21] The performance indicators are also highlighted in the bottom of the column of Fig.1, these indicators are the essential conditions for the designers and contractors to be able to integrate the LC and SC concepts. By checking these indicators, stakeholders may have a better understanding of their position in the integration progress of LC and SC.[5,21,68,71]

On the contrary, the model proposed by Koranda et al.,[41] was derived from the case studies of small and medium construction projects, which only involved the architects, engineers, and contractors from the construction organizations. However, our study will extensively engage the project stakeholder analysis, simply because stakeholder engagement is highly regarded as part of the dimensions of SC practice.[29] In other word, stakeholder engagement is important because each stakeholders can have different perceptions of what constitutes the success of a project.[1,21,61] The improved version of the model enables the project team members to recognize each LC and SC functions and priorities, therefore LC and SC are effective when all of the construction stakeholders involve holistically. The extensive collaboration is crucial among general contractors, construction managers, subcontractors, and material suppliers, of whom are committed to the concept that will result in an optimistic flow of the activities at different phases of the project.[37,44,47]

In future study, our empirical framework will also include constraint analysis as part of the activity , process and practice within the end-to-end production or project process that prevents inefficient flow. The analysis can be a useful feedback and gauging system for review and correction, which enables the stakeholders to identify the problems and provide continuous improvement effort because each constraint will add time and cost.[1,76] Once problems are identified, performance improvements should be carried out to eliminate or minimize each constraints to accomplish greater value.[3,43] The improved model aims to apply an integrated stakeholder approach by using the Aaltonen[1] themes with incentives to address the challenges of integrating SC and LC practices. The approach increases our understanding on the variance of the project stakeholder analysis, because previous literatures have provided limited attention to the project stakeholder analysis.[1,61] Accordingly, the proposed model can be a comprehensive guideline for each stakeholder to articulate their performance requirements (the real value they desire in their new buildings), and allow their teams to develop solutions[21,55,68] by analyzing and understanding the nature of the issues related to LC and SC. As a result, organizations will have an understanding of the required improvement efforts, where these efforts should be focused on obtaining the best results to maximize value with fewer resources utilized throughout the integration process of LC and SC concept.[16,47,64]

5. Conclusion

This paper discusses what the characteristics of lean construction (LC) and sustainable construction (SC) are and how sustainable lean construction (SLC) serves to be effective strategies in establishing the linkage between LC and SC. The fields are at the forefront of rapidly emerging construction management strategies, as considerable publications exploring sustainability and lean construction date from recent years. Our future studies envision the main opportunities and challenges in extending the proposed model by incorporating Building Information Modeling (BIM) and Industrialized Building System (IBS) as the common tools that act as catalysts in developing conceptual framework for lean and sustainable integration. A simplified model as shown in Fig.1 can be used as a benchmark or reference for lean and sustainable improvements with the help of industry experts, project practitioners, project owners and stakeholders. The model demonstrates how the strategic implementation facilitates in LC and SC integration from design phase to the completion phase of a project. It indicates a systematic approach of LC and SC concepts that can be extensively used to achieve LC and SC integration.

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