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RESEARCH ARTICLE

**BARRIERS OF SUSTAINABLE LEAN CONSTRUCTION IMPLEMENTATION:
 HIERARCHICAL MODEL.**

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Abstract

Adaptation of Lean construction ensures the likelihood of success and achieves the project objectives. Identifying the barriers of lean construction implementation is one effective way for adaption of lean construction implementation. These barriers vary in different countries based on, environment, culture, and other related factors. Despite the importance of identifying the barriers for successful adaptation and lean construction implementation, there are inadequate research studies that cover and classify all important barriers in social, economic and environmental aspects. Therefore, the objective of this paper is to identify and classify all significant barriers to a sustainable lean construction implementation through an extensive literature review. A semi-structured format of Delphi interview was conducted to verify all the classified and identified barriers. As a final point, this paper proposes a hierarchical model for the important barriers of lean construction implementation which could aid the decision and policy makers in selecting the best strategy on how to deal with these challenges.

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Introduction:-

The construction industry has long been assessed for being hazardous, fragmented, wasteful, inefficient, and ineffective. In this concern, construction, as opposed to manufacturing, is highly influenced by a unique combination of relatively separate factors, such as industry variable onsite conditions, fragmentation, the inherent uniqueness of projects, exposure to weather, and skilled labor shortages, among several others (Aziz and Hafez, 2013). Such a unique combination of factors goes to uncertainty along the project delivery process and its implementation operations (Salem et al., 2006). Construction activities have an enormous effect on the natural environment, human health, and the overall economy; therefore, the construction industry has the potential to significantly advance sustainability practices (Allen and Iano, 2011).

Lean construction is the application of new technologies which effectively reduce both cost and waste at the same time, improve the management, optimize the use of resources and improve safety during the construction period (Nahmens and Ikuma, 2011). It is demonstrated that lean construction is a practical approach in enhancing sustainability which includes clearly defined goals for the process of delivery (Nahmens and Ikuma, 2011). Lean construction is different from other construction management methods as it contains a clear set of objectives Lean

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construction is an effective method whereby using the right principles, techniques, and resources appropriately can manage and improve the construction process. (Yahya and Mohamad, 2011).

Lean construction has been implemented with substantial income in numerous countries such as Chile (Alarcón et al., 2002), South Africa (Emuze, 2012), Turkey (Polat and Ballard, 2004), Singapore (Dulaimi and Tanamas, 2001), Brazil (da Silva and Cardoso, 1999), USA (Nahmens and Ikuma, 2011), and Netherlands (Eric Johansen et al., 2002). Despite the significant implementation of lean construction of these countries, Picchi and Granja (2004) claimed that these implementations are often very fragmented and limited to the isolated implementation of some lean tools with inadequate theoretical understanding. The surveys in the United Kingdom (Common et al., 2000) and the Netherlands (Eric Johansen et al., 2002) revealed that the reason for unsuccessful implementation in these countries is because of limited knowledge and some loose practices of lean construction in these countries. Furthermore, Common et al. (2000), mentioned the Level of lean conformance and lean culture is lower than the expectation in European construction companies. Therefore, identifying the barriers which hinder the successful lean construction implementation are essential. Furthermore, an adaption of lean construction without identifying these barriers and their effects on projects' success cannot produce desirable results.

Despite the significant role of barriers in the successful adaptation and implementation of lean construction within the construction industry, there are inadequate research studies that present a large number of barriers which cover all aspects of sustainability (economic, environmental, and social). According to the Leong and Tilley (2008), by not identifying the factors that influence the successful lean construction implementation, this may lead to the incapability of the organization to understand which efforts should be improved, where these efforts should be focused, or what effort is required to attain the finest consequence. Hence, to concentrate on the above-mentioned issue, the objective of this study is to gather and to identify all the possible significant barriers and categorize them in related groups through an extensive literature review in the academic publication. In addition, this study aims to propose a hierarchy model of all the important barriers that can assist managers and decision-makers in selecting the best strategy for successful lean construction implementation.

Literature Review

It is proven from the numerous research studies that identifying barriers of lean implementation can help to adapt and implement lean method within the construction industry with success. The goal of identification of lean construction's barriers is to prepare a list of potential barriers that can have a key role in the successful implementation of the lean concept during the construction projects. Hence, this section has tried to identify and collect all the significant barriers of lean construction implementation through an extensive investigation in previous academic publications.

Over the years, several studies have identified barriers of implementing the lean concept in manufacturing and construction projects. The outcome of these studies has resulted in the classification of numerous barriers that created an impact on the implementation of lean construction. Some of these studies concentrated on identifying factors that are effective in the implementation of lean construction (Abdullah et al., 2009; Oladiran, 2008) while others focused on investigating the factors that are active during the execution of lean construction (Alarcón et al., 2002; Johansen and Porter, 2003). Other researches have classified lean barriers into different categories wherein some of these studies concentrated on structural and cultural aspect (Samari et al., 2013; Sarhan and Fox, 2013) or management and strategy aspect (Ayarkwa et al., 2012; Bashir et al., 2010) or barriers that exist during the implementation of lean construction practices (Alarcón et al., 2005; Ansell et al., 2007). Bashir et al. (2015) presented ten challenges related to management, technical, human, and educational issues when organizations are applying lean process. Fernandez-Solis et al. (2012) evaluated the challenges faced by project participants during the Last Planner System (LPS) implementation by selecting 26 project cases from Europe, US, Asia, and South America. These challenges are summarized into organizational inertia, lack of leadership, resistance to change, contract issues, lack of training, and lack of experience and knowledge.

Sarhan and Fox (2013) in a research about barriers of lean construction implementation in the UK presented 9 major barrier groups: culture and human attitudinal issues, fragmentation and subcontracting, financial issues, adherence to traditional management concepts, procurement and contracts, management commitment and support, lean awareness/ understanding, educational issues, and customer-focused. The results indicated that the lack of adequate lean awareness and understanding, lack of top management commitment, and cultural and human attitudinal issues were the most important barrier groups for a successful implementation of lean construction in UK construction

projects. Alinaitwe (2009) classified 40 barriers of lean construction implementation in Uganda's construction industry into 10 groups: barriers to Total Quality Management (TQM), barriers to teamwork, barriers causing variability, barriers to benchmarking, barriers to flow reliability, barriers to JIT, barriers to simplification, barriers to concurrent engineering, barriers to pull scheduling, and barriers to Business Process Re-engineering (BPR). The study revealed that the most important barriers in Uganda's construction industry are: inputs exactly when required, infrastructure in transportation and communication, the capability of teams to maintain alignment with other teams, and certainty in the supply chain. Bashir et al. (2010) in their review study about barriers towards the sustainable implementation of lean construction in the UK presented six important categories of barriers such as financial, management, government, education, human, and technical. In a study by Ogunbiyi (2014) about the implementation of lean in sustainable construction projects in the UK, 17 barriers were introduced and classified into six groups which include people, management, technology, process, resource, and others. The result indicated that resistance to change, cultural barriers, and lack of implementation in understanding and concepts were the top barriers to the implementation of lean construction as a sustainability approach. Shang and Sui Pheng (2014), introduced the 22 barriers of lean construction implementation in China wherein the lack of a long-term philosophy, insufficient knowledge of lean, and absence of a lean culture in the organization were the most important barriers. Marhani et al. (2013) presented seven main barrier groups for implementation of lean construction in Malaysian construction industry which are: technical, management, human attitude, financial, education, the process of lean construction, and government. Asri et al. (2015) in a review study about barriers toward the implementation of the lean concept, proposed six specific barrier groups: financial, educational, management, technical, governmental, and attitudinal aspect. Table 1 presents the most important barrier groups of lean construction implementation in this study.

Table 1:-most important barriers groups of lean construction implementation

Lean construction	Author	Management	Financial	Technical	Resource	People and Culture	Awareness and Education
Barrier	Sarhan and Fox (2013)	X	X		X	X	
	Bashir et al. (2010)	X	X	X		X	X
	Ogunbiyi (2014)	X		X	X	X	
	Marhani et al. (2013)	X	X	X		X	X
	Asri et al. (2015)	X	X	X			X
	Radhika and Sukumar (2017)	X	X	X	X	X	X
	Olamilokun (2015)	X	X	X		X	X

Research Methodology

The previous sections outlined and attempted to identify and introduce all important barriers and classification groups of lean construction implementation through an extensive literature review. A total of 69 drivers and barriers and 6 important classification groups were identified. As explained before, the objective of this study is to identify all significant barriers to three aspects of sustainability (social, environmental and economy). However, the previous researchers in the field of barriers of lean construction implementation, have not covered the environmental aspect of lean construction implementation. As such, the environmental classification group was added through discussion with experts of lean construction implementation in Malaysia in order to present the barriers in this aspect. A pilot survey was then carried out to verify all identified barriers as well as to classify barriers to the most related classification groups. A semi-structured format of Delphi interview was organized with a group of experts that can be used for qualitative surveys. The interview was conducted with 7 Malaysian construction professionals who are aware of the lean process. The interviewees were mostly amongst senior experts with the average of 15 years of experience. The Delphi interview was conducted in three rounds. After the third round, the pilot interview was discontinued in view of the successful/general consensus. Finally, all barriers were verified and classified into seven main groups: management, awareness and educational, financial drivers, resource, technical, people and culture, and environmental. The ultimate hierarchical structure model of significant barriers for lean construction implementation within the construction industry are presented in Figure 1.

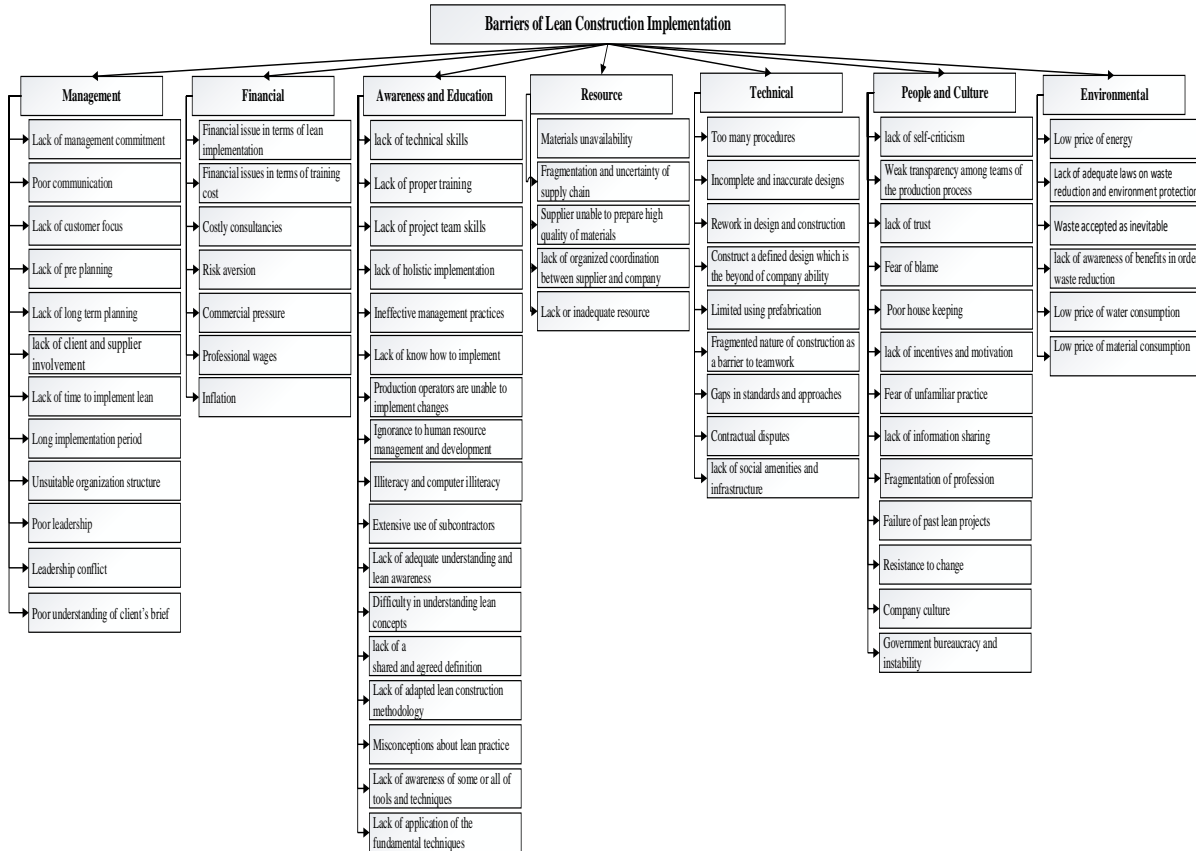


Figure 1:- Barriers Classification for Lean Construction Implementation

Discussion:-

The objective of this paper was to identify and classify all significant barriers of lean construction implementation. Also, this study aimed to propose a hierarchy model of all important barriers of lean construction implementation. In this regard, an extensive literature review was conducted in the field of barriers of lean construction implementation to identify all capable factors which are hindrances in the successful application of the lean method within the construction industry. 69 important barriers were identified which were further verified and classified into seven main groups through the semi-structured format of Delphi interview. Because the key role of lean construction is in improving sustainability, the efforts were primarily focused on the collection of all barriers within three aspects of sustainability. The final hierarchy structure model of barriers which is presented in Figure 1, can aid in the successful and sustainable lean construction implementation. As can be seen from Figure 2, all the classification groups were sub-divided per an aspect of sustainability.

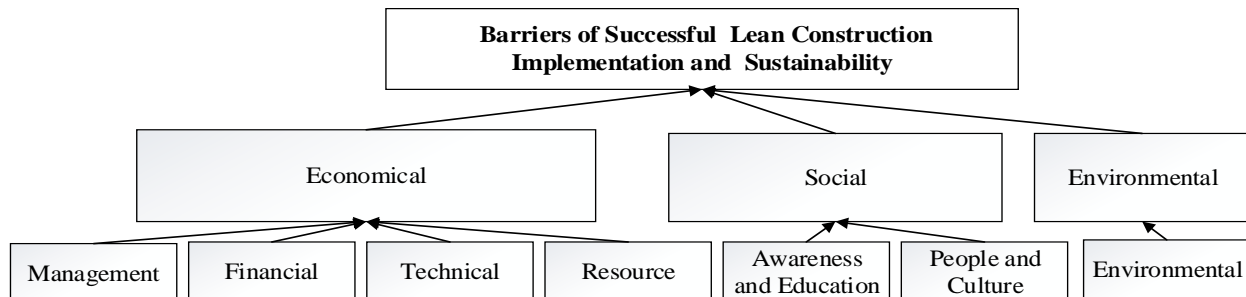


Figure 2:-Effects of barriers of lean construction implementation in each aspect of sustainability

There are several studies which have mentioned the barriers of lean construction implementation in the two aspects of economic and social. However, the barriers of lean construction in environmental aspect have not been well-studied yet. The effect of barriers of lean construction in each aspect is briefly explained below.

Economic Dimension

The economic dimension includes management, financial, technical and resource groups. The problems related in the management groups such as lack of top management communication, poor communication, poor leadership, and etc. has been explained in several researchers (Bashir et al., 2010; Mossman, 2009; Olamilokun, 2015; Sarhan and Fox, 2013). Management of any organizations plays a key role in the successful implementation of innovative strategies. (Olamilokun, 2015), Thus, lack of effect of treating these barriers will have an enormous consequence on the successful implementation of lean construction. Furthermore, the successful lean construction implementation needs sufficient funding to prepare relevant equipment and tools, adequate professional wages, investment in development programs and training, incentives and reward systems, and employment of a lean specialist to deliver the direction to both employees and employers during the primary implementation (Bashir et al., 2010; Sarhan and Fox, 2013). Moreover, the barriers which are classified under technical group, have a direct influence on the success of employing certain lean construction techniques and tools such as simplicity, reliability, benchmarking and flexibility (Bashir et al., 2010). Finally, to develop an effective plan within a construction project needs a sustainable and reliable supply chain of resources. Lean construction is based on Just In Time (JIT) delivery which means right resources are available at the right time at the right place in the right quality and quantity, and at the right cost. Lack of successful implementation of JIT principle leads to waste and cost overrun within construction projects and ultimately the desired objectives of the project will not be achieved (Dehdasht et al., 2018).

Social Dimension

Social dimension consist of awareness and education, and people and culture groups. Although there are numerous publications in the field of barriers of lean construction implementation, it seems the barriers related to social dimension are the most common barriers in lean practice (Bashir et al., 2010). Human culture and attitude are one of the main factors affecting the lean construction implementation in several construction industries (Howell and Ballard, 1999). A lean culture has a fundamental role in constructing the behavior of the employees wherein if it is not in place, the risk of unsuccessful lean construction implementation will increase in spite of the attempts made to implement lean process and techniques (Shang and Sui Pheng, 2014; Womack and Jones, 1996). The lean culture is a crucial pillar for continuous improvement as it shapes the organizational and managerial styles of a company and increases mutual competitive advantages, as well as ensures a constant delivery of greater value (Huovila and Koskela, 1998; Jamil and Fathi, 2016). Human attitude is one of the main aspects that may slow down the adoption of lean construction in the industry particularly during the physical implementation phase if neglected (Howell, 1999).

Awareness and education problems during lean construction implementation could be due to the execution of lean principles and techniques that were applied from manufacturing sectors to the construction industry (Erik Eriksson, 2010). For that reason, some of these principles and techniques were not entirely adapted based on the nature of the construction industry. Abdullah et al. (2009), proposes that to be able to clearly understand the concept of lean construction, it is necessary to have a full knowledge and understanding about lean manufacturing method in advance. Alinaitwe (2009), suggests that stakeholders and managers who are active in the construction industry must be given adequate training for them to acquire the requisites, expertise, and knowledge in adopting lean construction concept. Insufficient exposure to meet the requirements for implementation of lean construction is also considered as barriers (Marhani et al., 2013).

Environmental Dimension

Despite the importance of environmental dimension, there are not enough research studies concentrating on the identification of factors that hinders the improvement of the environmental dimension of the construction industry through lean construction principle and techniques, therefore, this paper has attempted to present some of these barriers. The low price of energy, low price of material, and low price of water consumption can be considered as barriers since low price does not encourage companies to have the motivation to seek and implement a new method like lean construction for waste reduction. Lack of adequate laws on waste reduction and environment protection is another barrier which makes companies deliberately pollute the environment since they are not motivated nor enforced to use the modern method such as lean construction for waste reduction. Waste is inevitable and has been a part of strategy and culture of some companies which lead companies to accept that waste is a part of a production,

and they lack the initiative and effort to find and apply a new method for waste removal and protect the environment. Lack of awareness on the benefits of waste reduction is a barrier that is related to the insufficiently trained and educated companies on how lean construction principle and techniques is capable to eliminate wastes during project life cycle and ultimately help to decrease the overall cost of a project.

Conclusion and Recommendations:-

This paper was able to present a list of all important barriers in adopting lean concept within the construction industry that would facilitate the successful lean construction implementation with a sustainability approach. All the barriers were explored, identified and defined through the survey from previous publications in the context of lean construction and barriers of lean construction implementation. A large number of 69 barriers were identified and through a semi-structured format of Delphi interview, these were verified and classified into seven main groups of management, awareness and educational, financial drivers, resource, technical, people and culture, and environmental. Since the objective of this study was to help in carrying out a successful and sustainable lean construction implementation, all possible means were ventured with an intent to collect all the barriers within the three aspects of sustainability. The results showed that the proposed hierarchical structure model of barriers to lean construction implementation can guide and help to achieve a successful lean construction implementation with a sustainability approach. It was also explained how each of the barrier classification groups affects the dimensions of sustainability.

The outcome of this paper can be useful to both academic and practice. This paper can help researchers in the field of lean construction as it presents a checklist of all important barriers to the successful and sustainable lean construction implementation. In addition, the result of this study can provide an overview and guidance to managers and decision makers for them to distinguish the most important barriers during lean construction implementation and at the same time on the selection of the best strategy that can aid in dealing with these barriers effectively.

Future studies should consider using these barriers as a basis for identifying the key barriers according to the type of project, environment, culture, and other related factors. Furthermore, additional efforts must be exerted to identify other barriers related to the environmental aspect other than the proposed barriers in this study.

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