Lean construction: an approach to achieving sustainable built environment in Nigeria

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O Babalola[1] , E O Ibem and I C Ezema

Department of Architecture, Covenant University, Ota, Ogun State, Nigeria

E-mail: meettbabs@yahoo.com

Abstract. The Nigerian building industry (NIB) is faced with numerous challenges. Chief among these is how best to manage the different kinds of wastes generated during the building procurement process and by so doing improve the sustainability record of the industry. Cost overrun, time overrun, and waste of building materials are the major problems crippling the industry. However, lean approach has been established in western world such as the USA, UK and others as an approach that helps in attaining sustainability in the building projects. This paper presents result of a study conducted to identify benefits derivable from the adoption of lean practices (LPs) by firms in the NIB. The approach adopted for this study was the review of literature to identify the benefits of Lean Practices (LPs) adoption and a questionnaire survey of architecture, building consulting and contracting and quantity surveying firms in Abuja, Lagos, Port-Harcourt, Enugu and Kaduna. In all, 446 valid responses were obtained and the data analyzed using descriptive statistics. The result revealed that stakeholders in the Nigerian building industry perceived LPs adoption as very helpful in the reduction of time and cost overrun on projects. Thus, the study has established that the adoption of LPs is one of the ways stakeholders in the industry are using to achieve economic sustainability in the procurement of building projects and ensuring that clients and end-users get value for money in such projects.

Keywords: Nigerian Building industry; Building Procurement; Lean practices; Sustainable Environment; Nigeria

1. INTRODUCTION

The construction industry has been identified as one of the industries with the ability to contribute significantly towards social and economic growth of any country especially the developing countries. On the one hand, the construction process has been identified as being very complex, fragmented and unique in nature, as it involves the inputs of different categories of professionals and non-professionals specializing in different phases of the work. Whereas, construction projects have been associated with complex problems such as time overrun with 70% of projects extending beyond the planned time and cost overrun with most projects running over contracts cost with about 14% of the contract cost and about 10% of the material cost on each projects ending up as material waste [1]. In addition, the

construction industry has also been identified as a major polluter of the environment [1]; and thus regarded as one of the industries working against the attainment of the sustainability goal.

In view of the fact that the construction industry is faced the challenges of managing the aforementioned issues, it is imperative to identify specific strategies and approaches that can help in reducing the quantum of waste generated from construction process. The built environment is a major product of the construction industry and therefore, there is an urgent need to make it sustainable. Lean construction has been identified as an approach that can help in the reduction of all kind of wastes and at the same time ensures that clients and end user have value for money spent on projects. For instance, in the UK, Ogunbiyi [2] observed that firms in the construction industry have made significant progress towards achieving sustainable construction through the adoption of lean practices or tools. This is because lean construction is believed to have the same goal with sustainability in the area of waste reduction [2].

Sustainability has been defined as an economic growth targeted towards meeting the presents generation's needs without compromising future generations' potentials and opportunity of meeting their need [3]. Therefore, sustainable construction involves achieving sustainability goals in the construction industry by addressing ecological, socio-economic and cultural challenges posed by construction activities and the use of constructed facilities. Its major goal is the creation and operation of a healthy built environment through efficient use of available resources, building to suit the environment/ecology and meeting the needs of the present and future generations without any form of comprise [2,3].

Lean construction is a concept that originated from the manufacturing industry, whose main principles are the elimination of wastes in any production process and activities to cause a reduction in the process cycles, an improvement in product quality and increment in efficiency of projects [2; 4]. However, waste from the lean concepts does not only include material waste but all kinds of wastes that can be generated in the production process. Such wastes include delay; over-processing and ordering, excess motion, labour and inventory, defects and so on [2; 4].

It is noteworthy that lean construction and sustainable construction have been well investigated especially in developed countries and literature have gone ahead to link the two concepts through the benefits attained from the implementation of lean construction on projects [3; 5]. However, there is insufficient literature to establish the benefits derivable from the adoption of LPs within the context of building projects in the Nigerian construction industry. Therefore, this study sought to investigate the benefits of lean construction as an approach to sustainable built environment from the perspectives of stakeholders in the Nigerian building industry, which is a subsidiary of the construction industry. The benefits of lean in this study were measured using cost and time parameters. Therefore, this study makes valuable contribution in identifying the economic and ecological benefits of LC from the perspective of stakeholders in the building industry of a developing country.

2. REVIEW OF LITERATURE

This section covers review of published literature on the link between lean construction (LC) and sustainable Construction (SC) and the benefits associated with the adoption of lean practices (LPs) in the construction industry.

2.1. Lean Thinking and Sustainable Construction

Lean construction and sustainability have been identified as the different approaches in the construction industry that achieve same objectives of waste reduction for different purposes, thus showing that they are intertwined [7]. According to Khodeir and Othman [6], LC has been identified as a short-term approach because it aids in process performance, while SC is considered a long term approach because it majors on the entire building cycle. Khodeir and Othman [6] further explained that LC's main focus is on the construction process while SC's main focus is on the product. This suggests that LC has been identified as an approach that manages the entire construction process thereby helping the construction industry to achieve a sustainable built environment.

Futhermore, LC is believed to match sustainability objectives because the adoption of its principles and practices has potentials to eliminate all kinds of waste that can be generated in the construction process. SC objective is to achieve a built environment where material wastes that are supposed to end up in landfills are reduced and thus, its impacts on the environment through pollution and use of available resources is reduced. While LC aimed at the reduction of all kinds of wastes in order to increase efficiency of the process and as well improves satisfaction of construction clients [6;7]. LC helps in achieving sustainable built environment from the three angles of sustainability. Lean construction fosters the social angle of sustainabilty by ensuring the safety and health of the working environment and wokers and also through the maintanannce of a long and standing relationship among construction stakeholders. In addition, LC helps to achieve the economic angle of sustainability through reduction of raw materials, delivery time and the cost of delivery of construction products, while it aids the achievement of the environmental perspective through elimination of waste in the entire process thereby reducing its impacts on the environment through pollution and the presevation of environmental resources [6,7,8].

2.2. Benefits of Lean Practices (LPs) Adoption in construction

Research literature has revealed several benefits derivable from the adoption of LPs on projects in the construction industry [see 5, 9, 10]. In fact, in a recent study, Babalola, Ibem and Ezema [5] categorised the benefits of lean construction into economic, social and environmental benefits. That research identified the economic benefits of LPs as covering cost, time and quality advantages driveable from LPs adoption. Some of the benefits in this category include project time reduction, project cost reduction, project quality improvement, continuous improvement in the project process, better control of inventory, minimization of risk among several others In addition to this, some of the social benefits of LPs identified include those associated with the relationship and satisfaction of stakeholders involved in the projects. Some of the benefits in this category are customers' satisfaction, satisfaction of employee, cooperation among stakeholders, establishment of long-term relationships, consideration of workers' health safety and others. Furthermore, the environmental benefits of LPs adoption identified are related to those associated with the attainment of green construction and reduction in the generation of material waste that are detrimental to flora and fauna in the ecological environment.

3. RESEARCH METHODS

The data presented in this article is part of those used for a larger research work investigating the adoption of lean practices (LPs) in the Nigerian building industry. The research design and approach used for the study was survey and quantitative research, respectively. Structured questionnaires were used for data collection. The questionnaire was designed and administered by the researchers to architecture, building consulting and contracting, and quantity surveying firms in selected cities of Abuja, Lagos, Port-Harcourt, Enugu and Kaduna. The aforementioned cities were purposively selected as cities as they are the key urban centres within five out of the six geo-political Zones excluding the Northeast zone of Nigeria (due to Boko Haram insurgency in this zone). These cities were also selected for the survey because these have the highest population of building industry firms location in each of the identified zone in Nigeria.

The sample for the study was drawn out of a population consisting of all the consulting and contracting firms operating in the Nigerian building industry. At the time of the survey 1116 registered firms in the selected five cities constituted the sample frame for the study as recorded in the various directory of firms published by professional and regulatory bodies in the Nigerian built environment [11;12;13]. To determine the sample size for the study, Leslie Fisher's formula

$$(n= Z^2P\ (1-P)/\ d^2) \quad (1)$$

This was multiplied by an adjustment factor for non-response given as

$$(q = 1/\ (1-f)) \quad (2)$$

In applying these formulae, "Z" was taken to be 1.96 at a confidence level of 95%, "P" represents the proportion of sample characteristics of interest and this was assumed to be 50% and sampling error was taken as 0.05. This resulted to a minimum sample size of 404 firms. However, to ensure even distribution of the sample size (404) within the sample frame, 40% of the sample was selected in each category stakeholders in the building industry in Nigeria. This translated to 446 firms because the sample size was increased by 42 firms (9% increase). This was allowable as Alreck and Settle [14] indicated that in selecting sample size, 40% or more can be selected if the population is a few hundreds, while if many hundreds, 20% of the population is appropriate. In addition, if the population is a few thousands 10% of the population can be selected and if several thousands, 5% or less will do for the sample size. This aforementioned practice has been identified as well practiced among social scientist by [14]. Therefore, for the purpose of the study a sample size of 446 firms was used.

The study also adopted a multi-stage sampling method that involved cluster-sampling procedure for identifying natural clusters of firms in the aforementioned five cities and random sampling for the selection of participants within each city chosen for study. In each selected firms, a staff was randomly selected to represent the firms for the purpose of questionnaire administration. In all, 670 copies of the questionnaire were administered by hand to the selected participants. However, 462 representing about 69% were retrieved and 446 representing around 96.5% of the retrieved questionnaires was correctly filled by the respondents and were subsequently included in the analysis.

The questionnaire used was designed by the researchers and had six sections classified sections A, B, C, D, E and F covering 6 thematic issues. However, only data collected from two sections of the questionnaire were included in this paper. The data used here were drawn from Section A of the questionnaire, which covers the respondents' personal profiles and Section F, which covers perceived impacts of LPs adoption. In Section F of the questionnaire, respondents were asked to indicate based

on a 5-point Likert type scale ranging from "1" for *Very Low Extent* to "5" for *Very High Extent*, the extent to which LPs adoption on building projects by their firms has helped in the achievements of 11 benefits of LPs as identified from the research literature.

The Statistical Package for the Social Sciences (SPSS) software package was used in analysing the data obtained from the survey. Due to the nature of the research objectives, the principal type of analysis the data were subjected to was descriptive statistics, which involved the calculation of percentages and frequency distribution. The results were presented using tables and charts.

4. RESULTS AND DISCUSSION

4.1. Respondents Profiles

Respondents' profiles are presented in Table 1. Table 1 revealed that majority of the respondents for this study were male within age bracket of between range of 16 years and to 35 years, working in architectural firms and having a minimum of bachelor's degree and with industry working experience of over 11 years. The result further revealed that a majority of the respondents' worked in architectural firms in Lagos. It can be inferred from the respondents' personal profile as displayed in Table 1 a majority of the Nigerian building industry stakeholders encountered in the survey are relatively young adults males employed in firms located in Lagos and Abuja. It also evident in Table 1 that a high majority of these professionals who participated in the survey are also well educated and have a reasonable number of years of experience in the Nigerian building industry and thus qualified to be key informants in this research.

Table 1: Respondents' Profile.

Variables	Frequency (n=446)	Percentage (%)
A. Gender		
Male	324	72.6
Female	122	27.4
B. Age Group in years		
16-25	125	28.0
26-35	192	43.0
36-45	77	17.3
46-55	35	7.8
56 and above	17	3.8
C. Cities of Firms location		
Abuja	147	33.0
Lagos	185	41.5
Port-Harcourt	38	8.5
Kaduna	47	10.5
Enugu	29	6.5
D. Type of firms		
Architectural	310	69.5
Building Consulting and Contracting	21	4.7
Quantity Surveying	115	25.8
E. Role of respondents		
Architect	256	57.4
Builder	34	7.6
Engineer	37	8.3
Project Manager	24	5.4
Quantity Surveyor	95	21.3

F. Academic qualification		
Diploma	97	21.7
Bachelor	252	56.5
Master	85	19.1
Doctoral	12	2.7
G. Work experience in years		
1-5	200	44.8
6-10	149	33.4
11-15	71	15.9
16-20	7	1.6
21-25	15	3.4
25 and above	4	0.9

Source: Adapted from [15]

4.2. Perceived Benefits of LPs Adoption in Building Projects in Nigeria

Figure 1 is a display of the result on the extent to which the participants in the survey rated cost effective and timely delivery of building projects as benefits derivable from LPs adoption in the Nigerian Building Industry. The result presented in Figure 1 revealed that stakeholders in the Nigerian Building Industry were of the view that the adoption of LPs on past projects helped them to achieve cost effectiveness and timely delivery of projects without compromising the quality of the projects. This implies that lean practices adoption in building projects handled by a majority of those sampled in the firms have been highly beneficial both to the clients and firms in terms of elimination of cost overrun and time overrun. These have earlier been identified as major problems crippling the Nigerian building industry.

This result also indicates that the adoption of LPs on building projects can help achieve sustainable built environment through the reduction or elimination of wastes that contribute to cost and time overruns on building projects in Nigeria. Time and cost overruns have been identified to manifest through over ordering of materials, unclear design and drawings, lack of understanding of clients' brief, increase in material cost due to inflation and lot more in the building procurement process [1]. According to Babalola, Ibem and Ezema [15], most of these wastes lead to delay which resultantly causes problems like litigations and total abandonment of government or individually funded projects. This in a long run results to an unsustainable built environment as uncompleted projects litter the cities with the associated dilapidation and unkempt cityscape.

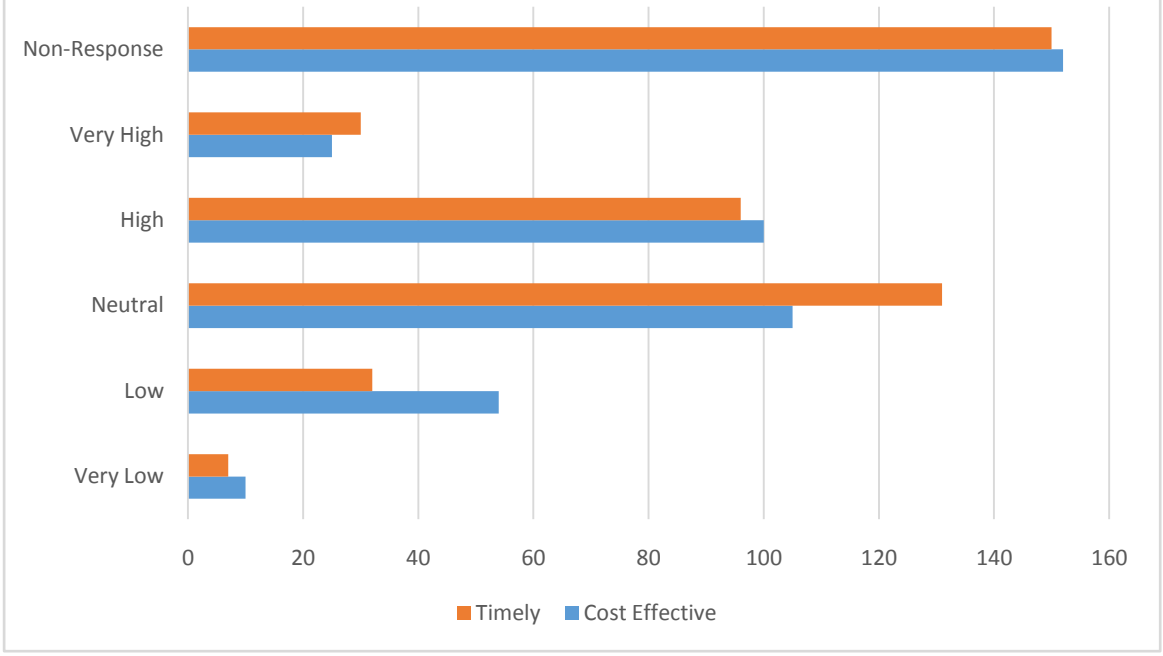

Figure 1: Benefits of Cost-effectiveness and Timely Delivery of Building Projects in LC.

However, in order to get an in-depth perception of the sustainable benefits derivable from LPs adoption in building projects by firms, the respondents were asked to respond to 11 questions as they relate to LPs adoption and benefits derivable from their adoption on pasts projects executed by their respective firms. The result is presented in Table 2.

Table 2: Benefits of LPs Adoption in the Procurement of Building Projects.

Benefits derivable from LPs adoption	Scale	Frequency	Percentage	Mean Score	SD
Reduce generation waste of materials	Very Low Extent	27	6.1	3.37	0.994
	Low Extent	48	10.8		
	Neutral	81	18.2		
	Extent	129	28.9		
	Very High Extent	48	10.8		
	Non-response	113	25.3		
Reduce over ordering of materials	Very Low Extent	15	3.4	3.43	0.990
	Low Extent	40	9.0		
	Neutral	98	22.0		
	Extent	140	31.4		
	Very High Extent	35	7.8		
	Non-response	118	26.5		
Stay within quoted project material	Very Low Extent	19	4.3	3.35	1.016
	Low Extent	41	9.2		
	Neutral	107	24.0		
	Extent	127	28.5		
	Very High Extent	33	7.4		
	Non-response	119	26.7		
Reduce project variations	Very Low Extent	7	1.6	3.26	0.854
	Low Extent	47	10.5		
	Neutral	145	32.5		
	Extent	106	23.8		

	Very High Extent	19	4.3		
	Non-response	122	27.4		
Reduce project errors	Very Low Extent	11	2.5	3.32	0.945
	Low Extent	49	11.0		
	Neutral	126	28.3		
	Extent	116	26.0		
	Very High Extent	30	6.7		
	Non-response	114	25.6		
Reduce defects	Very Low Extent	17	3.8	3.29	0.980
	Low Extent	43	9.6		
	Neutral	128	28.7		
	Extent	112	25.1		
	Very High Extent	30	6.7		
	Non-response	116	26.0		
Stay within project budget	Very Low Extent	53	11.9	2.96	1.161
	Low Extent	53	11.9		
	Neutral	111	24.9		
	Extent	98	22.0		
	Very High Extent	23	5.2		
	Non-response	108	24.2		
	Very Low Extent	13	2.9	3.16	0.994
Spend less than project budget	Low Extent	67	15.0		
	Neutral	140	31.4		
	Extent	77	17.3		
	Very High Extent	35	7.8		
	Non-response	114	25.6		
Reduce cost over head	Very Low Extent	19	4.3	3.24	0.996
	Low Extent	42	9.4		
	Neutral	144	32.3		
	Extent	91	20.4		
	Very High Extent	34	7.6		
	Non-response	116	26.0		
Timely complete and deliver projects at expected time	Very Low Extent	13	2.9	3.42	1.007
	Low Extent	35	7.8		
	Neutral	124	27.8		
	Extent	112	25.1		
	Very High Extent	46	10.3		
	Non-response	116	26.0		
Timely complete and deliver projects before expected delivery time	Very Low Extent	21	4.7	3.32	1.088
	Low Extent	51	11.4		
	Neutral	101	22.6		
	Extent	121	27.1		
	Very High Extent	40	9.0		
	Non-response	112	25.1		

Table 2 reveals the benefits derived from the adoption of LPs on building projects previously handled by the respondents'' firms. The result presented in Table 2 reveals that the respondents were of the views that asides the fact that LPs adoption helps in achieving cost effective project delivery and delivery of project in line with the project time schedule, it also helps in the reduction of over ordering of material thereby resulting in waste of unused materials. In addition, they also indicated that LPs adoption helped in elimination of waste generation in the entire process, and reduces the incidences of errors, defects and variability that are very common in building projects delivery in Nigeria. The result presented further shows that LPs adoption positively enabled stakeholders' stays within quoted materials for projects. Findings of this study appear to be consistent with findings from [2], which identified reduction of waste generation, project cost and so on as sustainable benefits derivable from LPs implementation.

Therefore, it is established from the result presented in Table 2 that LPs adoption in the Nigerian building industry is perceived by stakeholders based on their experiences from past projects as being able to help in the elimination of the major problems facing the Nigerian building industry such as

time overrun, cost overrun and material waste. In that light, the study has also been able to establish that if the aforementioned wastes are eliminated a sustainable built environment is achievable in Nigeria. This is because a sustainable built environment is achieved when the environment is free from pollution resulting from building construction waste, non-abused and overused of natural resources used as construction materials, and the present and future generations are not affected from the negative consequences of building projects.

5. CONCLUSION

In this study, the adoption of LPs as a sustainable approach to the procurement of building projects in the Nigerian building industry was examined. Based on the findings, it can be conclude that lean construction is indeed an approach in the building industry can help in achieving a sustainable built environment. It can also be concluded that the benefits derivable from LPs adoption in the Nigerian building industry cut across the three pillars of sustainability: economic, environmental and social sustainability but at different degrees. Specifically, evidence in this study seems to point to that fact that stakeholders in the Nigerian building industry are inclined to benefits associated with cost effective and timely delivery of building projects than the environmental benefits of lean construction adoption. It is therefore suggested that more awareness of the environmental benefits of LPs among stakeholders in the industry is required to maximise the benefits of lean practices in achieving a sustainable built environment in Nigeria.

REFERENCES

[1] Assaf, S.A. and Al-Hejji, S. (2006). Causes of delay in large construction projects. *IJPROMAN, **24***, 349-57. doi:10.1.016/j.ijproman.2005.11.010

[2] Ogunbiyi, O. (2014). *Implementation of the lean approach in sustainable construction: a conceptual framework.* UK: University of Central Lancashire.

[3] Marhani M.A., Jaapara, A., Ahmad Baria N. A. & Zawawib, M. (2013). Sustainability through lean construction approach: A literature review. *Procedia - Social and Behavioral Sciences, **103***, 90-9.

[4] Womack, J. and Jones, D. (2003). *Lean thinking: banishing waste and create wealth in your corporation.* New York: Free Press.

[5] Babalola, O., Ibem E.O., Ezema, I.C. (2019). Implementation of lean practices in the construction industry: A systematic review. *Building and Environment, **148***, 34-43. doi:https://doi.org/10.1016/j.buildenv.2018.10.051

[6] Khodeir, L.M. and Othman, R. (2018). Examining the interaction between lean and sustainability principles in the management process of AEC industry. *AIN SHAMs Engineering Journal*, 1627-34. doi:http://dx.doi.org/10.1016/j.asej.2016

[7] Abd-Jamil, A.H. and Fathi, M.S. (2016). The integration of lean construction and sustinable construction: a stakeholder perspective in analyzing sustainable lean construction strategies in Malaysia. *Procedia Computer Science, **100***, 634-643.

[8] Saieg, P., Sotelino, E.D and Caiado, R.G.G. (2018). Intercations of building information modeling, lean and sustainability on architectural, engineering and construction industry: a systematic review. *JCLEPro, 174*, 788-806.doi:https://doi.org/10.1016/j.jclepro.2017.11.030

[9] Sarhan, J.G., Fawzia, S. and Karim, A. (2017). Lean construction implementation in the Saudi Arabian construction industry. *Construction Economics and Building, 17*(1), 46-69. doi: 10.5130/AJCEB.v17i1.5098

[10] Anderson, B., Belay, A.M. and Seim, E.M. (2012). Lean construction practices and its effects: a case at St. Olav's integrated Hospital, Norway. *LCJ*, 122-49. Retrieved from www.leanconstructionjournal.org

[11] Architects Registration Council of Nigeria (ARCON). (2016). *Register of architectural firms entitled to practice in Nigeria.* Abuja: Architects Registration Council of Nigeria.

[12] Council of Registered Builders of Nigeria (CORBON). (2017). *List of registered builders in the federal republic of Nigeria.* Abuja: Council of Registered Builders of Nigeria.

[13] Nigerian Institute of Quantity Surveyors. (2017, November 18). *NIQS.* Retrieved from Registered Quantity Surveying Firms in Nigeria: https://niqs.org.ng/

[14] Alreck, P.L. and Settle, R.B. (1985). *The survey research handbook.* Home-Wood: Irwin.

[15] Babalola, O. D, Ibem, E. O. and Ezema I. C. (2018). Assessment of awareness and adoption of lean practices in the Nigerian building industry. *IJERT,* ***9*****(3)**, 1626-40. Retrieved from http://www.iaeme.com/IJCIET/issues.asp

[16] Sambasivan, M. and Soon, Y.N. (2007). Causes and effects of delays in Malaysian construction industry. *IJProman, 25*, 517-526. doi:10.1016/j.ijproman.2006.11.007