Advancing Lean Implementation for Improving Sustainability in Sub-Saharan Africa: A Literature Review

Evelyn Lami Ashelo Allu and Fidelis Emuze

Abstract

This article aims to synthesize relevant literature underpinning the implementation of lean principles in the Architecture, Engineering, and Construction (AEC) sector. The focus is on the challenges and benefits to promoting lean application and sustainability efforts within the AEC sector in the sub-Saharan African region. The discourse centers on a descriptive analysis of the selected articles that specifically relate to the challenges and prospects of lean implementation in the AEC sector within the last six years. Findings from the literature review suggest that the prospects of lean applications by far surpass the challenging barriers. The limitations are mainly due to lack of appropriate knowledge on the specific application techniques for the construction tasks/processes. Furthermore, findings suggest that the implementation of lean principles promotes environmental sustainability, allows for refining construction processes to suit peculiarities, and encourages continuous improvements of processes, services, products, and stakeholders' development. Specific contextual adaptations to address regional-based requirements for lean implementation are recommended.

Keywords: AEC sector; lean implementation; lean principles; sub-Saharan Africa; sustainability

Introduction

Sub-Saharan Africa comprises developing countries whose Architecture, Engineering, and Construction (AEC) sector is known for its fast growth and significant share of the economy. Yet, from a sustainability lens, the sector is saddled with many challenges, such as inadequate knowledge and/or slow implementation of sustainable innovations in the field. This article presents an overview of the challenges and benefits of the applications of lean principles to the AEC sector via a literature review. Literature abound on the applications of lean principles[1] but are limited for the AEC sector.[2,3] Furthermore, not much is known about the challenges and prospects for the implementation of lean principles in sub-Saharan African countries. Thus, an agenda to transform lean implementation in the African region was formed.[4] Due to this implementation, it is necessary to know what the challenges are in order to address them; knowledge of the benefits will help to advance the implementation of lean and sustainable construction in the AEC sector in this African region.

Theoretical Background

The application of lean principles in the AEC sector allows the sector's professionals to implement and improve on their project delivery activities. Although this innovation has not always been common practice within the AEC sector,[5] in recent times, its success in the sector has been acknowledged in some studies. Successes within the AEC sector include promoting environmental sustainability,[6–8] reduction in construction waste and time,[9] strategies for resource control,[9] and continuous improvement in the overall efficiency of the processes.[10]

The main objective of lean in construction is to meet the needs of the client and to simultaneously improve the products and processes of development within the AEC sector.[11] By this objective, the management and the application of innovations in

Department of Built Environment, Central University of Technology, Free State, South Africa.

construction is significant for the developmental growth and efficiency of the AEC sector. In some countries, particularly in developed economies, lean applications have advanced in this sector in order to improve productivity and efficiency[12] while also promoting environmental sustainability.[13,14]

Sustainable construction has been defined and summarized by the International Council for Research and Innovation in Building and Construction (CIB), by Vieira de Carvalho et al.[15] as: "The conception and development of a healthy construction process based on resource efficiency and ecological design." (p. 2)

Given this definition, there is a strong correlation between lean construction and environmental sustainability. Elsewhere, as aforementioned, the efforts toward environmental sustainability through lean applications have been widely acknowledged. However, in the sub-Saharan African countries, little is known about strategies adopted by the AEC sector toward the reduction of environmental waste and the promotion of environmental sustainability.[16]

Due to the advantages offered by lean principles/concepts, the AEC sector is expected to adopt, advance, and implement these concepts into its processes.[2,17] In this regard, the AEC sector has been identified to have the potential for sustainable innovations through lean principles strategized applications.[18]

Roelandt[19] recognized three main approaches as phases to implementing lean as:

- Diagnostic: The main activities are communication to site management and personnel describing the purpose and process of the program, mapping of relevant work processes and the execution of loss and waste analyses to determine technical limits and improvement targets. During all these phases, site personnel are actively involved and engaged to create buy in during the implementation phase.
- Implementation: A number of basic Lean construction tools are implemented such as visual boards, toolbox talks, performance management dashboards, etc. Site personnel, including the site manager, are coached to recognize the different kinds of waste and the corrective actions to eliminate them via problem solving sessions and techniques. A number of frequent wastes factors identified include: Waiting Periods, Over Processing, Material Movement (lag times), Period of Inventory and Motion (time wasted to correcting omissions).
- Sustainability: The production output is monitored and necessary ad hoc assistance is given to site management if required. Regular site assessments versus a list of best practices take place and improvement actions are undertaken. (p. 260)

However, the challenges for implementation have also been recognized by some researchers to include: lack of adequate understanding, communication problems, lack of managerial commitments, lack of lean culture, and the misapplication of tools.[20]

On the other hand, the application of innovations, particularly the lean concept for improving the efficiency of project delivery in the construction sector, also has some challenges for its applications or implementations.[21,22] Another important challenge is how to channel the strategies in the AEC sector toward sustainable actions.[23,24] Additionally, the lack of measurement tools is also seen as a missing link.[25,26] Despite the acknowledgement of some of these challenges, research is still ongoing regarding how best to tackle these challenges[27] with particular references to regional suitability.[4,28]

Consequently, this study investigates the global regional attempts by countries that have adopted and applied the lean principles into the processes in their construction sector. Revelations from the investigations provide insights into the potentials and the challenges therein and recommendations for the AEC sector in the sub-Saharan Africa are suggested.

Literature Review

For the purposes of this article, search terms were limited to *barriers* or *challenges* and the *prospects* or *benefits* of *lean application within the AEC* or the *construction sector*. The literature review was sought from articles published in construction-related or lean construction journals and conferences. Only articles written in English within the last six years were selected for meta-analysis with the sub-Saharan context. Meta-analysis allows for a profile overview or a landscape assessment of a specific research domain in order to identify the different perspectives for a narrative summary.[29]

Relevance of the Sub-Saharan African Region

The sub-Saharan African region lies south of the Sahara in the African

continent and is made up of 46 of the 54 countries in Africa, as shown in Figure 1. This region is important to this study for many reasons. The region has a rapid population growth and is expected to reach 1.2 billion people by 2025.[30] The region's high population drives the increasing demand for infrastructure and construction activities,[22,31] thus, making the AEC sector a very busy one. Arif et al.[31] further observed that the rapid population growth and increased construction activities in these developing countries raise much concern for environmental sustainability.

Additionally, the construction sector of the sub-Sahara region contributes a significant 7 to 10 percent of their GNP growth.[22] The sector's growth rate has been on the incline.[32] In addition, the construction sector contributes significantly more than other sectors to employment and development in the region[33] and beyond.[34] Yet, poor infrastructural, unsustainable development, poor workflow, poor performance of people in construction, and cost of construction are recognized as some of the region's biggest challenges.[35,36]

Given the relevance of the AEC to the sub-Sahara region, it is increasingly important to apply best international practices for its continued growth.

Lean Principles and Implementation to the AEC Sector

The concept of lean principles has provided practical ways for implementation into the AEC or construction sector,[37] and the implementation has had a positive impact on environmental sustainability.[6] As such, the successes of lean are conceptualized in lean strategies via the application of the five basic lean principles. Researchers have suggested that the implementation of lean techniques are through the identified lean principles.[11] Table 1 presents each of the five principles, explains the expectations to be derived from the principles, and offers descriptive summaries on how the principles can be applied to the AEC sector.

For implementation of lean principles for the improvement of the AEC sector, there must some consideration of technique for implementation. Although the client's role drives the entire construction process,[39] the onus lies with practitioners who are to ensure the implementation of every process leading to the desired product delivery.[40,41] It is therefore important for practitioners to have basic knowledge of the expectations and how to apply the lean principles in order to meet these expectations.

Table 1 enumerates the basic lean principles, describes the expectations in a question format, and highlights the many ways to implement their applications in the AEC sector.

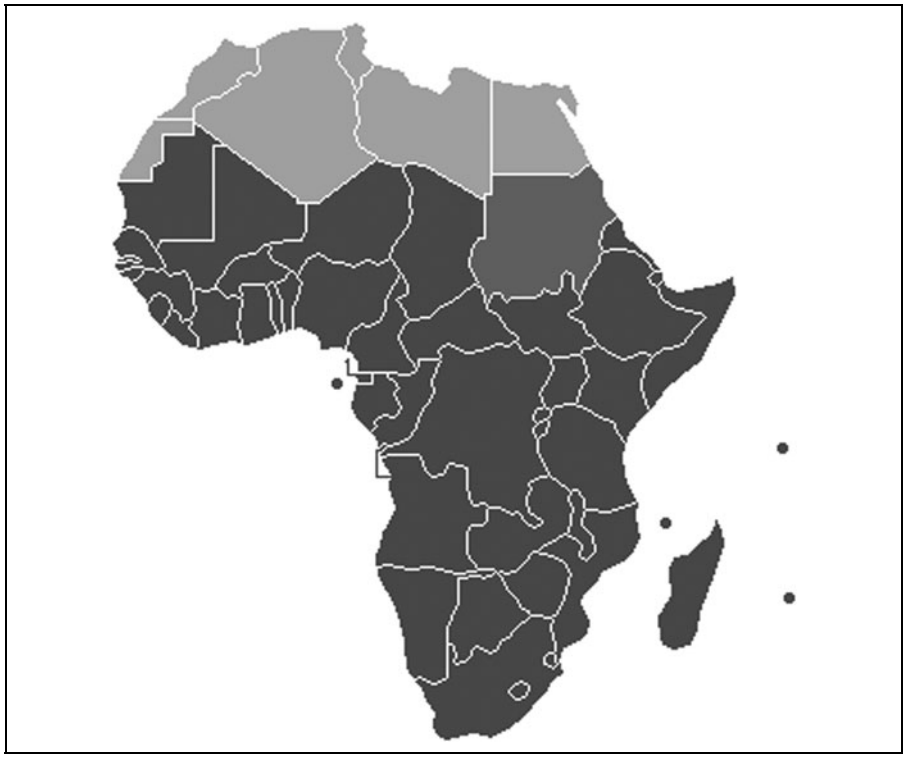

Figure 1. Shaded areas are "Sub-Sahara Africa" as used in the statistics of many UN institutions, with the exception of Sudan, which is often classified as North Africa.

Prospects of Lean Implementation and Drivers

The benefits of lean implementation have been the focus of attention by many researchers in the AEC sector, as indicated by numerous studies.[26,42–44] The prospects for lean implementation in the AEC sector are targeted toward improvement of labor efficiency and production processes[45,46] and the promotion of environmental sustainability.[8,47] In addition, the implementation of lean principles has a positive impact on safety concerns.[48,49] Thus, when lean principles are implemented in the AEC sector, it is a win-win strategy because it incorporates improvement for both human and production

Table 1. Lean Principles—Expectations and Implementations

No.	Principles	Expectations/Questions	Associate Principles and Implementation Techniques
1	Specify or Define Value	• What is the perception of value? • What does the client expect or want to accomplish?	• Reduce the uncertainty through the clear understanding of the client's expectations from the start • Reduce the production task • Minimize the cost of all tasks • Minimize resource consumption • Remove non-value adding activities
2	Identify and Map the Value Stream	• How to implement the principles into the AEC sector • At what stage do you implement?	• Compress lead time • Reduce variability • Simplify • Increase transparency • Increase variability • Ensure every task or process is compliant to value adding
3	Allow value **Flows**	• How to ensure continuous flow from processes, services, and products • How to eliminate or reduce wasteful tasks in the AEC processes	• Ensure requirements are captured • Ensure customer requirements are met • Take requirements for all deliverables into account • Ensure production system capacity • Measure value
4	**Pull** value	• In what ways do you allow AEC practitioners to pull knowledge at the right time and for better understanding of application of lean principles to construction processes?	• Allow transparency in all production process activities • Provide information anytime for all employees and participants • Apply holistic monitoring and controlling of the production process • Ensure real-time feedback of the process
5	Perfection	• What are the adoptions for continuous refining of tasks/processes for continuous improvement of the AEC sector's activities?	• Improve both flow and conversion of activities • Ensure a well-defined sequence of events and allow for stock taking • Study and set standards based on contextual and global best practices • Set up self-evaluation mechanisms for construction

Adopted and modified from Biton and Howell[38] (p. 126), and Khodeir and Othman[2] (p. 2).

efficiency, environmental sustainability, and construction safety. Accordingly, the drivers for implementing lean principles in construction, enumerated by McGraw,[48] are as follows:

- Client's needs and influence
- Reduced project schedule
- Increased profit margins and decreased costs
- Promotion of sustainability
- Work safety
- Competition concerns
- Leadership concerns
- Work force concerns

These drivers provide the basis for pursuing the successful implementation of lean principles in order to improve the gains in the AEC industry. However, the road to actualizing these is not without some challenges.

Challenges for Lean Implementation in the AEC Sector

Lack of understanding of the underpinning challenges or barriers for implementation of lean poses a great obstacle to implementation in the construction sector.[50] The question of what constitutes the underpins and the way forward for the sub-Saharan countries are discussed in the following section in order to advance the implementation of lean within the AEC sector in the sub-Saharan region. Liker[51] notes that there are differences in the applications of lean from different perspectives, while Abdullah et al. [52] opined that the implementation of lean principles should be tailored to suit contextual needs. Radhika and Sukumar[54] support Liker[51] and Abdullah[52] by going further to suggest that addressing the causes for the barriers in the implementation of lean are surmountable when identified. As such, the discourse of this article and its attempt to uncover the sub-Saharan peculiarities makes it relevant.

Challenges and barriers for implementing lean principles have been acknowledged in research. According to McGraw[48] and supported by later research conducted by Smith and Ngo,[44] there are 13 broad areas that constitute challenges, which also serve as barriers to the implementation of lean principles in the AEC sector, as follows:

1. Lack of industry support due to fragmentation

2. Lack of proper competence/ knowledge or educational issues
3. Lack of commitment from top management/non-participative management style for workforce
4. Lack of exposure on the need for lean construction/ experience
5. Lack of measurement tools/ standards
6. Lack of client and supplier involvement
7. Difficulties in understanding the concept of lean construction
8. Negative attitudes and inability to work in group
9. Cultural differences and human attitudinal issues (mind-set issues)
10. Uncertainty in the supply chain/procurement/contract-related issues
11. Tendency to apply traditional management
12. Lack of planning/long-term philosophy
13. Overall lack of support/ government support

Contextualization of the Challenges

Based on the selection criteria for the literature sought, as identified and discussed in the Literature Review section, only five countries outside the sub-Saharan region and only four countries within the sub-Sahara region met the conditions. The challenges posed by lean implementation are presented in contextual specifics in Table 2.

Table 3 presents the challenges to countries in the sub-Saharan region based on primary research findings using the same identified challenges cited in Table 2. Although the articles cited for selecting the four sub-Saharan countries identified more than 13 challenges, the related items were merged and grouped into the 13 groups identified in Table 2, with the exception of cost-related barriers.

Discussion

Table 2 suggests that fragmentation of the construction sector is a common barrier to all five countries. The next-most common barrier is the lack of commitment from top management, followed by the lack of proper competence/knowledge or educational issues. Table 2 also reveals that for developed countries (United States and United Kingdom), items 4, 5, 11, 12, and 13 (lack of exposure to the lean

Table 2. Challenges for Lean Implementation in the Selected Global Regions (2013–2017)

	Challenges or Barriers	Source and Country/Region				
		Gao and Low[42]	Hussain et al.[53]	Limon[26]	Smith and Ngo[44]	Sarhan and Fox[50]
		China	India	Norway	USA	UK
1	Fragmentation and subcontracting	X	X	XX		XX
2	Lack of proper competence/knowledge/ or educational issues	X	X	X	X	X
3	Lack of commitment from top management/non-participative management style for workforce	XX	XX	XX	X	XX
4	Lack of exposure on the need for lean construction/experience	X	XX			
5	Lack of measurement tools/standards		X	XX		
6	Lack of client and supplier involvement		X	X	X	
7	Difficulties in understanding the concept of lean construction	X	X			X
8	Attitude and inability to work in group	X	X		X	
9	Culture & human attitudinal issues (mind-set issues)	XX	X	X		XX
10	Uncertainty in the supply chain/procurement/ contract-related issues	X	XX			X
11	Tendency to apply traditional management	X	XX	X		
12	Lack of planning/long-term philosophy	XX		X		
13	Overall lack of support/government support	X				

Note: X represents an identified challenge or barrier from each country.
XX represents top-three barrier with strong influence from each country.

Table 3. Challenges for Lean Implementation in Selected Sub-Saharan African Countries (2013–2017)

S/N	Challenges or Barriers	Source and Country/Region			
		Ayalew et al.[56]	Djokoto et al.[22]	Adegbembo et al.[57]	Emuze[58]
		Ethiopia	Ghana	Nigeria	South Africa
1	Fragmentation and subcontracting	X	X	X	
2	Lack of proper competence/knowledge or educational issues	XX	XX	XX	XX
3	Lack of commitment from top management/non-participative management style for workforce/industry	XX	X	X	XX
4	Lack of exposure on the need for lean construction/experience	XX	XX	XX	X
5	Lack of measurement tools/standards	X	X	X	X
6	Lack of client and supplier involvement	X	X	X	X
7	Difficulties in understanding the concept of lean construction	X	X	XX	X
8	Negative attitude and inability to work in group	X	X	X	X
9	Culture & human attitudinal issues (mind-set issues)	X	X	X	X
10	Uncertainty in the supply chain/procurement/ contract-related issues	X	X	X	XX
11	The tendency to apply traditional management	X	X	X	X
12	Lack of planning/long-term philosophy	X	X	X	X
13	Overall lack of support/government support	X	X	X	X
14	Cost related (higher investment cost and final cost of implementation)	X	XX	X	X

Note: X represents an identified challenge for a particular problem.
XX represents top-three barrier with strong influence from each country.

concept, lack of measurement tools, application of traditional methods, lack of planning, and lack of government support, respectively) are not listed as barriers. This is perhaps due to the fact that the implementation of lean principles within the AEC sector started earlier in some Western countries.[55]

In the sub-Saharan countries presented in Table 3, more than 90 percent of the possible barriers were recorded for all four countries. The following factors were found to pose the greatest obstacles to influencing implementation of lean principles in the AEC sector, in order of strength from strongest to weakest:

- Item 2: Lack of proper competence/knowledge or educational issues
- Item 4: Lack of exposure to the need for lean construction/experience
- Item 3: Lack of commitment from top management/non-participative management style for workforce/industry

The following were found to be strong impeding factors:

- Item 7: Difficulties in understanding the concept of lean construction
- Item 10: Uncertainty in the supply chain/procurement/ contract-related issues
- Item 14: Cost related (higher investment cost and final cost of implementation)

The overview of impeding factors shown in Table 3 validates all 13 barriers that pose a challenge to the implementation of lean principles in the AEC sector as identified by McGraw.[48] The additional barrier noted, cost, is a common factor to the sub-Saharan countries. This also validates the Mina study,[35] which found cost to be a very significant factor in the construction activities of the sub-Saharan countries.

Given the many benefits of implementing lean principles in construction, it is a worthwhile strategy that should be considered within the sub-Saharan region. The way forward for the AEC sector in this context calls for industry and government to collaborate in order to advance the implementation of lean principles, not just for infrastructural development but for positive sustainable impact on the environment, continuous improvement of its practitioners, the sector in general, and the safety of its workers.

In summary, commitments by the regional governments would well be

able to advance the implementation of lean practices and, in the long run, solve or minimize some of the barriers identified in Table 3.

Conclusion and Recommendations

In recent times, the expectations for the AEC sector to act sustainably by adopting lean principles into its developmental activities cannot be ignored. The prospects for the advancement of lean principles and implementation have been acknowledged in research and practical activities in the AEC sectors of many countries globally. Yet, very little is known about implementation in the sub-Saharan African countries. In addition, some barriers have continuously challenged the implementation of lean principles into construction activities in general and specific to the sub-Saharan region.

The research cited in this article identified some major, common challenging barriers to the implementation of lean principles in the AEC sector within the sub-Saharan region. This identification was aimed at contextualizing the barriers by region and enabling promotion of regional collaborative strategies for advancing the implementation of lean principles into AEC activities. These activities could drive development in this region.

Though this article contributes to the research discourse on the implementation of lean in the AEC sector, it is not without some limitations. The foundational discourse has a global outlook, but its outcomes are limited and directed to the sub-Saharan African region.

As can be deduced from the discourse, the following recommendations are suggested to pave the way forward in contextualizing the implementation of lean principles as a strategy for sustainability:

1. Formulate a blueprint and develop policy for the actualization of lean implementation.
2. Adapt international best practices and measurement standards with modifications to suit the sub-Saharan regional requirements.
3. Encourage sub-Saharan countries to support a common institute for the promotion of lean implementation within the region.
4. Provide support and possible reward for compliance practices within the AEC sector.

Author Disclosure Statement

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Address correspondence to:
Evelyn Lami Ashelo Allu
Postdoctoral Research Fellow
Department of Built Environment
Central University of Technology (CUT)
Bloemfontein, South Africa

E-mail: eallu@cut.ac.za