Investigating the Barriers Involved in the Sustainable Implementation of LC and BIM Approaches in Qatar's Construction Industry

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Abstract

The construction industry has never been as open to welcoming new ideas and strategies from other industries as it is now. Excessive waste in the three pillars of the construction industry, time, cost, and quality, led to adopting certain concepts tried and proven to work successfully in other sectors. Lean is one of such ideas that made its way to the construction industry after years of success in the manufacturing sector. Building Information Modelling (BIM), on the other hand, has been around for quite a while in the construction industry. Imagine how amazing it would be for the construction professionals and designers to live in what is yet to be constructed. BIM made it possible to foresee the future of the project. The question is not how successful these two strategies are, as this has already been proven through numerous studies, but how sustainable would that project be if both Lean and BIM are used concurrently. Qatar construction industry has embraced Lean and BIM concepts and Sustainability measures on its own, owing to a multitude of external and internal factors. Through a mixed-method approach of research strategy, an in-depth review of the literature helped explore the synergies between Lean Construction, BIM and Sustainability. However, the survey questionnaire and interviews led to identifying the two main barriers to implying Lean and BIM in Qatar's construction industry, "Culture and Attitude" and "Commitment & Support from Top Management". The survey results also indicated the interaction of Lean, BIM and Sustainability at different project stages and helped identify misunderstandings about Sustainability among the industry professionals. The proposed performance measurement strategy also received an overwhelming response.

Keywords: Sustainability; BIM; Lean Construction; Barriers; Construction

1 Aim

The aim of this research is to look into the effects of LC and BIM in achieving Sustainability objectives on infrastructure projects in the state of Qatar.

1.1 Objectives

- To investigate the barriers involved in the implementation of LC and BIM in achieving sustainable project delivery.
- To analyse the synergies between LC, BIM and Sustainability.
- To propose the framework for performance measurement of Sustainability with the support of tools like Lean and BIM.

2 Literature Review

2.1 Sustainability and the Emerging Technologies

The construction industry has started realising to change the way of thinking. In the Netherlands, for instance, one cannot build anything unless 20% of the demolished building is utilised in the new building (ICE, 2020).

Large construction companies have started investing in R&D (Research & Development) to come up with innovative technologies to achieve sustainability goals. BIM & LC are two of those technologies that have emerged so quickly (Memon, 2022).

2.2 BIM & LC for Sustainable Design and Construction

2.2.1 Synergies between Lean Principles and BIM to achieve Sustainability Goals

No much work is carried out to report the synergies amid Lean principles and BIM to achieve sustainability objectives on the projects. Moakher & Pimplikar (2012) suggest that the application of BIM in an integrated and collaborative work environment helps achieve sustainability goals like energy efficiency, reduction in operational costs, reduction in water consumption, and improvement in building air quality.

Clash detection is an effective tool that BIM provides, which directly contributes to the Lean goals of waste reduction at an early stage of design. BIM also offers a collaborative tool of 4D planning, which is considered an effective tool in LC. Cost management and Carbon footprint management carried out through auxiliary information system provided by BIM may reduce the waste produced by the environmental issues by early design iterations (Bhargav, *et al*., 2013).

Based on the literature analysis and evidence from various researchers, Rafael et al. (2010) in their matrix of interactions identified fifty-six interactions amid Lean and BIM.

Although, Lean and BIM, both with all their benefits, contribute to sustainable construction individually, however, blend of both is the need of the time (Ritu, *et al*., 2017).

2.2.2 Barriers Involved in the Application of Lean and BIM Practices in Qatar

Eastman *et al*. (2011) classified four challenges that the construction industry is facing to implement BIM standards. These challenges include Collaborative teamwork, legislations, Information communication and Operational issues.

Apart from the challenges as mentioned above, the main barriers to the implementation of the BIM by (Atif, *et al*., 2015) and (NBS, 2018) are availability of skilled staff, availability of training, no client demand.

Other barriers identified by (Saad, 2011) through an extensive study conducted in the UK and with the recommendation to test these barriers globally in different countries are, lack of commitment to change and continuous improvement (Saad, 2011), fragmentation and subcontracting (Saad, 2011), procurement and contracts type (Saad, 2011), culture and attitude (Saad, 2011), adherence to traditional management concepts due to time and commercial pressure (Saad, 2011), financial issues (Bashir, *et al*., 2010) cited in (Saad, 2011), lack of top management commitment and support (Bashir, *et al*., 2010) cited in (Saad, 2011), design/construction dichotomy (M, *et al*., 1998) cited in (Saad, 2011), lack of awareness (Memon, 2022), lack of customer-focused and process-based performance measurement systems (Saad, 2011)

2.2.3 Sustainable Development in Qatar

Sustainability has been considered as a pivotal element of QNV 2030 in terms of Qatar's future development, considering the "needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

Qatar's response to the UN's Sustainability Development Goals (SDGs) is overwhelming. The

formation of the CSD is a significant step of Qatar towards the achievement of SDGs. CSD is currently working on five major areas; food and water security, natural resources governance, renewable energy, waste management, algal technology program (CSD, 2020).

As mentioned in section 2.8, the sustainability rating system GSAS in Qatar only deals with building construction. However, some project-tailored international rating systems like CEEQUAL (International), Green Roads, Envision TM and INVEST are jointly used on Qatar's major infrastructure projects as per QHDM.

3 Analysis of Results & Discussion

The outline and the approaches adopted for this research are illustrated below. Figure below shows the outline of the different steps adopted.

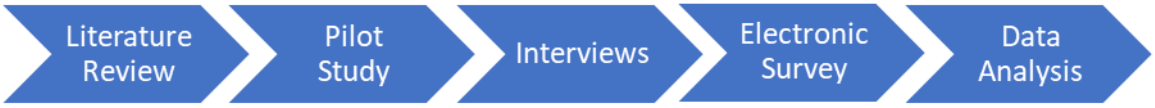

Table 1: Data Collection Source, Type and Nature of the Data and Approaches to Collecting the Data with the Scale of the Sample

Mixed-Method Approach for the research					
	Data Collection	**Nature**	**Data Type**	**Data Collection Approach**	**SampleTarget**
1	In-depth Literature Review	N/A	Secondary	N/A	N/A
2	Pilot Study of Survey Questionnaire	Structured	Primary	Qualitative	10
3	Survey Questionnaire (Google Forms)	Structured	Primary	Quantitative and Qualitative	150
4	Interviews through phone call	Semi-Structured	Primary	Qualitative	3

3.1 Survey Questionnaire

In survey questionnaire to study and analyze the objectives of the paper, the participation constituted of 60% of the post graduate & 8% of PhD scholars with 27% at the managerial level from large scale companies of both private and public sector. Pertaining to a question related to Sustainability, around 67% of the participants agreed that the design on the infrastructure projects follows the international Sustainability standards as mentioned in QHDM (Qatar Highway & Design Manual) which is alarming.

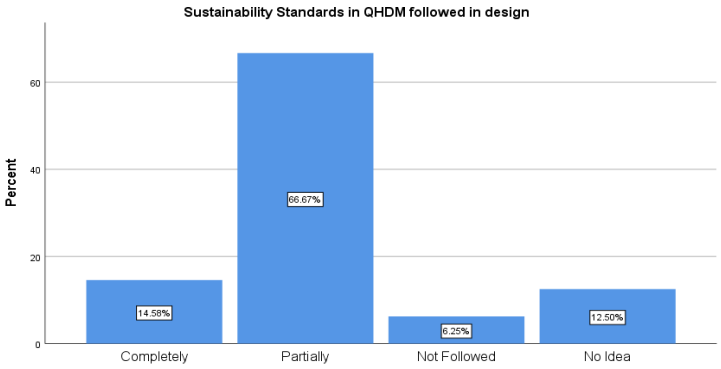

Fig. 1: Sustainability Standards in QHDM followed in Design

Considering, Qatar's construction industry, the Author, shortlisted some barriers for the survey questionnaire to test their impact on sustainable project delivery. Friedman's non-parametric test of ranking was conducted to check these barriers based on the participant's response. The test indicates that the top barrier with the highest mean rank is "Culture and Attitude." "Lack of Top Management Commitment & Support" is second in the ranking. "Lack of Commitment to Change", "Financial Issues", "Lack of Customer Focused and Process-Based Performance Measurement System" and "Adherence to the Traditional Management Concepts Due to Time and Commercial Pressure" can be considered of the same rank due to their mean rank values almost the same.

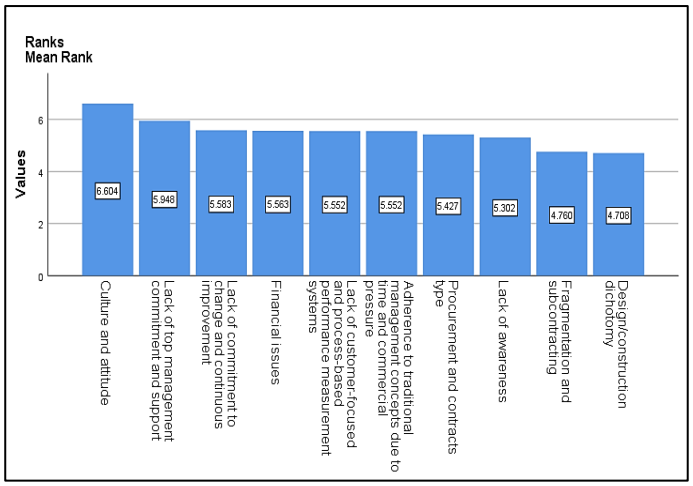

Fig. 2: Ranking of Barriers based on Survey responses through Friedman's non-parametric test of ranking

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Lack of commitment to change and continuous improvement	48	3.54	1.383	1	5
Fragmentation and subcontracting	48	3.29	1.202	1	5
Procurement and contracts type	48	3.44	1.319	1	5
Culture and attitude	48	3.77	1.403	1	5
Adherence to traditional management concepts due to time and commercial pressure	48	3.56	1.382	1	5
Financial issues	48	3.50	1.353	1	5
Lack of top management commitment and support	48	3.62	1.378	1	5
Design/construction dichotomy	48	3.25	1.158	1	5
Lack of awareness	48	3.44	1.382	1	5
Lack of customer-focused and process-based performance measurement systems	48	3.52	1.353	1	5

Fig. 3: SPSS - Friedman's non-parametric test of ranking

SPSS software was used to analyze the results of the study questionnaire. Approaches used for the analysis of each question are given in the table below:

Table 2: Data Analysis Approaches

Data Analysis Approaches			
Q. No.	**Data Type**	**Statistics Type**	**Approach**
1	N/A	N/A	N/A
2-3	Nominal	Descriptive	Frequency Distribution
4	Ordinal	Descriptive	Frequency Distribution
5-8	Nominal	Descriptive	Frequency Distribution
9	Ordinal	Exploratory	Frequency Distribution
10-12	Nominal	Descriptive	Frequency Distribution
13	Ordinal	Inferential	One Sample t-Test
14	Nominal	Exploratory	Frequency Distribution
15	Ordinal	Descriptive	Frequency Distribution
16-18	Nominal	Descriptive	Frequency Distribution
19	Ordinal	Descriptive	Mean & Mode
20	Ordinal	Inferential	Friedman's non-parametric test of ranking
21	Nominal	Descriptive	Frequency Distribution
22	Ordinal	Descriptive	Central Tendency (Mean, Median, Mode)
23	Nominal	Descriptive	Frequency Distribution
25-26	Ordinal	Descriptive	Frequency Distribution / Mean

Another objective of the study was to analyze the synergies between Lean, BIM and their impact on Sustainability. The literature review shows the different studies where the synergies between these Three aspects have been discussed. However, the participants were asked if the implementation of BIM and Lean construction (LC) help in achieving the following;

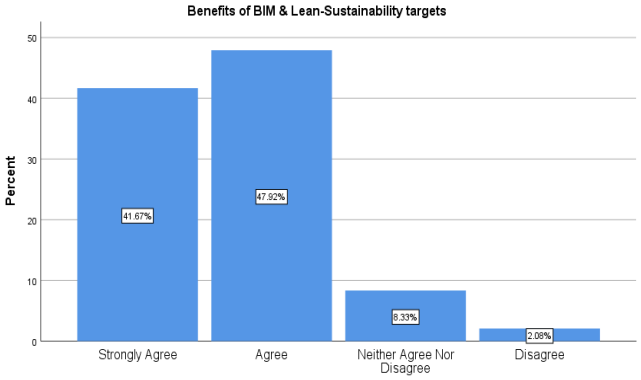

Fig. 4: Benefits of BIM & lean - Sustainability Targets

Sustainability targets, Increased Profit, Increased certainty of cost and schedule, Reduced risks, Competitiveness, Reduction in waste, Improvement in Health & Safety objectives, Improvement in Quality, Reduction in project or process completion time. Around 42% of the participants strongly agreed & 48% agreed that implementation of Lean and BIM combined help in achieving the above targets, which strongly indicates that there are synergies between Lean, BIM and Sustainability.

The author proposed the framework for performance measurement of Sustainability with the support of tools like Lean and BIM in the study and the participants were asked if they agree to a "Compatible re-alignment of the business process" is required for the performance measurement of BIM and Lean practices in line with sustainability objectives on infrastructure projects. Around 48% of the participants strongly agreed and 42% agreed to the proposal. Refer to the contents of the proposal modified by the author to suit the infrastructure projects;

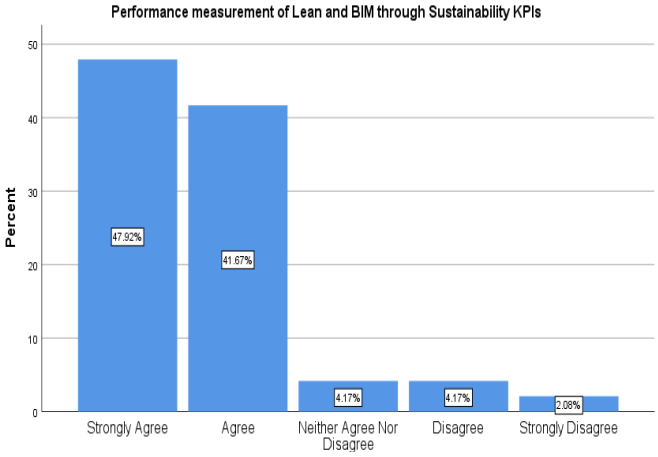

Fig. 5: Performance Measurement of Lean and BIM Through Sustainability KPIs

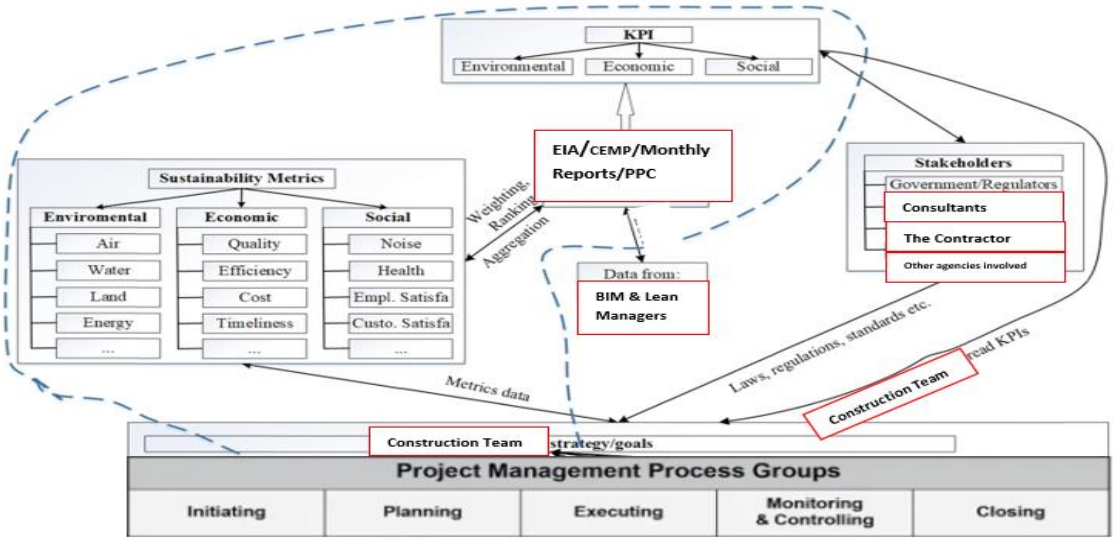

Fig. 6: Ardian, et al. (2018)'s conceptual framework for measuring sustainability performance of Supply Chains Modified by the Author to suit infrastructure projects

4 Conclusion and Recommendations

4.1 Impact of LC and BIM on Sustainable Project Delivery

The main objectives of the study were thoroughly investigated by conducting a thorough review of the literature previously available. However, the available literature is not enough to provide a concrete basis for the combined use of BIM with LC on infrastructure projects to achieve Sustainability objectives. The literature review, survey questionnaire and interviews somehow answered the questions of whether or not LC and BIM have an impact on Sustainability and are there any synergies between these three terminologies or not. A correlation between LC and Sustainability "LC = waste elimination = sustainability" as explained by Claire & BRE (2013, p. 10) is a partial answer to the questions. Nevertheless, a thorough review of various other studies and the survey helped in concluding and updating this synergy with a modified version of it, **"LC+BIM = waste elimination = sustainability."**

4.2 Barriers to the Implementation of LC and BIM for Sustainable Project delivery

Adapting the new innovative solutions to replace the old systems eventually end up with new challenges and barriers. The primary data collected through a survey questionnaire and the interviews helped in understanding the viewpoint of the industry regarding the objectives of this research. One of the objectives of this research was to point out the barriers involved in implementing LC and BIM to achieve Sustainability objectives. The survey results show that "Culture and Attitude" and "Lack of Top Management Commitment & Support" are the top barriers identified, indicating that Qatar's construction industry requires a strategic transformation from traditional project management techniques to new solutions like IPD.

4.3 Performance Measurement

The survey results revealed participants' strong agreement on the proposed modified performance measurement procedure by receiving Lean and BIM practitioners' feedback into the Sustainability KPIs and generating new streamlined KPIs. Figure 5 refers (Ardian, *et al*., 2018)'s conceptual framework for measuring sustainability performance of Supply Chains Modified by the Author to suit infrastructure projects. As mentioned in the previous section, the survey participants welcomed this new proposal by the Author and encouraged to have a system of performance measurement in the current KPI system.

4.4 Other Findings and Recommendations

A very strong opinion came about the need of producing a new rating system along with the legislation system separate for infrastructure projects, which may also consider the impacts of Lean and BIM on project Sustainability objectives. International Sustainability standards mentioned in QHDM are partially followed in design, indicating that the organizations need to be serious towards Sustainability. There is a lack of awareness about LC, BIM and Sustainability among the industry professionals. Specifically, there is a perception that Sustainability is all about the environment and recycling. Aspects of Sustainability from a Social and Economic perspective need to be highlighted or investigated. Further investigation on the case study basis is recommended for investigating the impact of LC and BIM on Sustainability. The questionnaire was distributed equally to Lean, BIM,

Sustainability practitioners and the rest of the industry. Yet, the results show a disproportion of the data gathered as not 100% of the people responded from each category.

More interviews from the industry professionals are recommended to be conducted for any studies in future.

4.5 Limitations of the Research

The Author could have conducted a further secondary analysis, but it was not possible due to the time limit. Further secondary analysis of this subject is highly recommended for future studies. Interviews were conducted from a limited sample due to the limited time frame. The limit of words did not allow the Author to dig down the literature review and conduct further secondary analysis.

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