Identification of Implementation Barriers of Building Information Modelling for Green Building Construction in Sri Lanka

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Abstract— *Green Building Information Modelling (Green BIM) is a novel approach to address the ever-growing need for sustainability in the built environment. It offers a more standardized way to create buildings, which in turn optimizes building performance while meeting green building requirements. However, BIM adoption still faces significant barriers, despite the fact that it could improve the efficiency of sustainable building projects. Hence, this study aims to determine the advantages of using Green BIM, as well as implementation barriers of BIM for Green Building construction in Sri Lanka. Mixed approach was followed in carrying out the study. A questionnaire was developed based on identified barriers from the literature review, to determine the most significant barriers. Identified barriers were analyzed using RII method. Semi structured interviews were also carried out to determine the significance of adopting BIM for Green Building construction. A content analysis was conducted for the qualitative data obtained through semi structured interview and RII (Relative Importance Index) analysis was carried out for quantitative data. Analysis of the responses demonstrated that " Not receiving enough client support and government support," followed by "Inadequate vision of BIM benefits" and "Lack of well-developed practical strategies for implementing Green BIM" were the most significant barriers. The study also presented possible solutions for Green BIM implementation barriers. Further, the study recommends some actions that the Government and educational institutes should take to overcome barriers in implementing Green BIM and is needed to identify to mandate BIM and to develop strategies in mitigating barriers of Green BIM implantation.*

Keywords— **Building Information Modelling, Green Building construction, Implementation barriers**

I. INTRODUCTION

Construction Industry plays a major role contributing 6.1% to the GDP (Gross Domestic Product) in Sri Lanka (Annual Report 2021, Central Bank of Sri Lanka). Most construction materials have traditionally been obtained through mining and quarrying from non-renewable natural resources. Natural resources are in greater demand with the increment of population for supply of needed construction materials. According to the Global Status Report (2020), CO_2 emissions from building operations have reached their greatest level yet, accounting for around 28% of total world energy-related CO_2 emissions. As a result, improving the

sustainability of the built environment is becoming increasingly important to obtain both economic and environmental benefits (Zhou & Shen, 2019). The concept of Green Building includes improved product design, resource reuse, and recycling (Dipta & Chowdhury, 2022). The imminent capabilities of Green BIM technology are concealed and undetectable in the Sri Lankan context because BIM has not yet been deployed in building construction, operation, and maintenance (Rathnasiri et al., 2017). Therefore, an effort is required to convince and showcase the significance of Green BIM technology for those who practice green construction. This research is aimed at supporting this effort, to determine whether Green BIM technology can be applied to Sri Lanka's construction industry. The integration of BIM with sustainable methods has given rise structures to Green BIM technology (Jalaei & Jrade, 2014), a significant advancement in BIM that helps to improve the performance of Green Buildings while also promoting the creation of sustainable.

The issues highlighted in studies so far, are primarily concerned with how Green BIM could more efficiently enhance design and building performance, particularly in dealing with environmental concerns, when compared to the use of standard techniques. But there were no studies carried out to discover the barriers in a developing country like Sri Lanka when adapting this new technology. The findings of the research will be limited to Green Building construction projects in Sri Lanka. Data collection will be limited since there are not a lot of professionals in the industry who are involved in BIM. This study is intended to improve Green BIM implementation in Sri Lanka and for improvement of status of Green Building construction with the combination of the BIM technology. The main objective of the research is to identify the implementation barriers of Building Information Modelling (BIM) for Green Building construction in Sri Lanka, which can be taken to mitigate the effect the construction has on the environment.

II. LITERATURE REVIEW

A. Building Information Modelling (BIM)

According to Emaminejad and Kalhor (2018), BIM represents actual buildings essentially throughout their whole life cycle as semantically enriched, reliable digital building models. BIM was primarily utilized during the building project's construction phase, but it is now also used for the operation and maintenance phases and also infrastructure such as stadiums and bridges (Liu et al., 2015). According to Becerik-Gerber et al. (2012) contractors mostly utilize BIM for as-built model generation, clash detection, and visualization. Furthermore, the author emphasizes that, the benefits of BIM technology also include the sustainability aspects and direct fabrication of buildings. Organizations lacking BIM skills will be at a competitive disadvantage when compared to organizations who have already deployed BIM on their projects and met an owner/sponsor requirement (Sahil, 2016).

B. Green Building Construction

As pointed out by Raza et al. (2018), the AEC industry is under constant pressure to reduce its energy usage to avoid GHG (Green House Gas) emissions and address the issues considering the severe difficulties of global warming, environmental degradation, a lack of energy resources, and rising energy costs. According to Zuo and Zhao (2014), one way to lessen the negative outcomes of building construction on the environment, society, and economy is through Green Building. Followings attributes are stated by Lu et al. (2017); Parvez and Srivastava (2021),

- Energy Consumption
- Thermal Comfort Analysis
- Day Lighting Analysis
- CO_2 Emission
- Natural Ventilation
- Water Usage
- Material waste
- Acoustic Analysis

As a yardstick of assess performance of buildings, Green Building Rating systems were implemented around the world and it has been estimated that there are approximately 600 green rating systems (Denagama, 2021).

C. Green BIM

The Green BIM integrates the structure model with simulations that reflect its environmental impact, improving analysis and minimizing data handling problems. (Araszkiewicz, 2016). Green BIM principles are often used to define Green Building design and construction that incorporates the usage of BIM technology. Shukra and Zhou (2021) have identified Green BIM is a new project design and delivery trend based on the integration of sustainable structures with BIM. As the Green BIM concept gains momentum, AEC practitioners have begun to make attempts to develop a Green Building with low energy consumption and little environmental effect (Wu et al., 2013; Zhou & Shen, 2019).

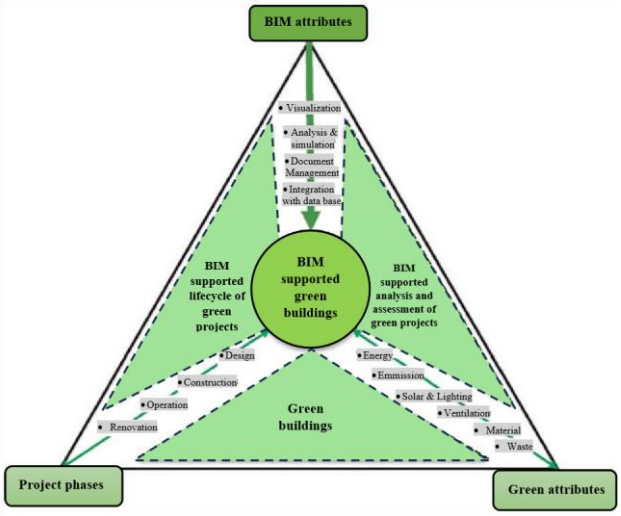

Figure 1: Green BIM triangle

Source: (Lu et al., 2017)

The above *Figure 1* shows interaction between "Green attributes", "Project phase" and "BIM attributes". As of the taxonomy, followings are encompassed by each dimension (Mohamed, 2019).

- Project Phase - project lifecycle aspect
- Green attributes - sustainability considerations like energy savings, thermal comfort, water savings, etc.
- BIM attributes - shows how BIM software contributed significantly to the two Green Building dimensions through visualization, analysis and simulation, document management, and interaction database.

According to Parvez & Srivastava (2021), BIM being involved in the construction sector has various advantages, particularly in terms of enhancing team performance and efficiency using coordinated digital models to eliminate errors and reworks. Moreover, following benefits have been identified on Green BIM by (Rathnasiri et al., 2021).

- An integrated Green BIM system promotes cooperation and communication amongst project teams to efficiently produce a well-performing building throughout operations.
- Facilitates sophisticated and complex sustainable design techniques such as day lighting and solar shading analysis, energy analysis, resource management, acoustic analysis, and cost analysis.
- Building performance evaluations and the selection of optimal ways that reduce waste of resources such as energy, water, and materials.
- Enhances safety by predicting problems, creates a better living environment, and contributes to lower primary and operational costs through greater material use and energy efficiency.

– Building performance might be examined for existing structures to determine cost reductions.

D. Sri Lankan Practices of BIM and Green Building Construction

As pointed out by Diaz et al. (2022), as Sri Lankan BIM in the early stages, there is very little national BIM initiative of government organizations for BIM adaption. The Green Building Council of Sri Lanka (GBCSL) serves as the primary organization committed to developing sustainable structures in Sri Lanka (Waidyasekra & Fernando, 2012). Waidyasekara and Sandamali (2012) revealed that there has been no notable result on local Green Building practices and there are numerous challenges in achieving Sri Lanka's sustainability goals. With the increasing development of construction activities, the adoption of green concepts has become a pressing demand in the Sri Lankan construction industry (Waidyasekra & Fernando, 2012). the inherent possibilities of Green BIM technology are concealed and undetectable in the Sri Lankan context because BIM is not still fully deployed in building construction, operation, and maintenance (Rathnasiri et al., 2017). According to (Abeywardhana, 2016), with the complexity of modern construction increasing, most of the present Quantity Surveyors have shifted to BIM tools to improve their efficacy and efficiency in delivering services. As recommended by Karunasena (2016), to promote the construction of Green Buildings in Sri Lanka, it is necessary to determine the probable mitigation strategies and barriers.

III. RESEARCH METHODOLOGY

The aim of the research was to identify the implementation barriers of BIM technology for Green Building construction. According to the characteristics of the above methods, research philosophy of this study is pragmatism, which is used for mixed approach since pragmatism. This study examines current practices of Green Building construction industry and their barriers and challenges in adopting BIM for Green building construction suggests steps that can be implemented to improve sustainable practices. The research was evaluated through a semi structure interview and questionnaire survey carried out. Here in the research, a questionnaire survey and semi structured interviews were carried out to collect data, in to achieve the objectives of the study following a mixed approach. For the questionnaire survey by using Stratified Random Sampling method, Construction professionals. The questionnaire was shared between 50 respondents. And, for the Semi- structure interview was conducted using purposive sampling targeting BIM users who involved in Green Building construction in Sri Lanka. A request for an interview was issued to 15 potential interviewees, and 8 of them agreed to take part in the study. The questionnaire has been sent to 50 professionals where 35 of them responded and participated in the questionnaire.

A. Data Collection Methods

Both the quantitative and qualitative data collection methods were used in collecting data. A literature survey and semi structured interviews as qualitative data collection methods and questionnaire survey as a quantitative data collection method were utilized in evaluating the research. In this study, semi-structured interviews and a questionnaire survey were conducted as the primary data collection.

The questionnaire was prepared based on factors identified as barriers in implementing BIM for Green Building construction through a literature survey. Accordingly, identified factors from the literature survey were presented as questionnaire to the participants through close ended questions to indicate to which extent the identified factors affect as barriers in implementing Green BIM in Sri Lankan context. The questionnaire comprised of two sections. First section was to collect demographic data and the second section was to collect the respondents' opinion on, to which extent the barriers identified affect Green BIM implementation.

In the interview, according to the appendix "A", first section of the interview was to collect general information of the interviewee regarding his/ her profession, years of experience in construction industry, areas of expertise etc. The second section consists open-ended questions regarding benefits of adopting BIM for Green Building construction and capabilities of Green BIM if implemented in Sri Lanka.

B. *Data Analysis & Presentation*

Through RII (Relative Importance Index) Analysis identified fifteen factors (barriers) affecting implementation of Green BIM in Sri Lanka, which given through questionnaire was sequenced according to the degree of relative importance scale ranging from 0 to 5. Qualitative data which was collected from semi- structured interviews were analyzed using the content analysis method. Frequency charts were used to quantify the qualitative data to rank. Data collected from the questionnaire's open-ended questions. By using this content analysis, the difference between actual content and the proposed content can be compared. It will explain the status of the research study.

IV. DATA ANALYSIS

The data for the analysis was gathered by a questionnaire survey with 35 responses and semi-structured interviews with 8 industrial professionals. To provide a perspective of results and for the comparison of the results, tabulated formats, diagrams, etc. were illustrated. Construction professionals who responded for the questionnaire are illustrated as given in the above *Figure 2*.

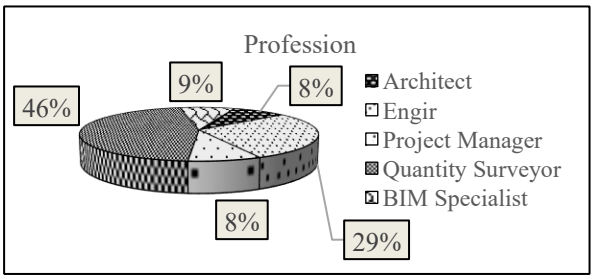

Figure 2: Respondents Profession

Based on the chart the majority of 46% of 35 respondents were quantity surveyors.

The table below illustrates the years of experience of the professionals who participated in the questionnaire survey.

Table 1: Respondents Years of Experience

Years of experience	No of Respondents	Percentage
0 - 5 years	25	71%
5 - 10 years	7	20%
10 - 15 years	1	3%
15 - 20 years	2	6%

For the interview 8 professionals were participated. 05 Quantity Surveyors, 01 Project Manager, 01 Engineer and 01 BIM specialist participated in this study.

A. Implementation Barriers of BIM for Green Building Construction in Sri Lanka

A detailed questionnaire was carried out for the purpose of identifying the barriers that mostly affect implementation of BIM for Green Building construction in Sri Lanka. The factors identified through literature survey associated to application of BIM for Green Building construction were ranked to meet the research objectives by utilizing Relative Importance Index (RII) Analysis. Using Microsoft Excel application, questionnaire feedbacks were analysed.

As shown in the Table 2, the most significant barrier to the use of BIM in Green Building construction projects in Sri Lanka has been identified as " Not receiving enough client support and government support," followed by "Inadequate vision of BIM benefits" and "Lack of well-developed practical strategies for implementing Green BIM". In terms of BIM adoption, many challenges have been highlighted in the current AEC scenario. The interviewees pointed out the most significant barriers were not receiving enough client support and government support, unawareness of benefits of BIM & insufficient practical strategies for implementing Green BIM. As pointed out the main reasons lack of demand is due to unawareness of Green Building codes and due to the instability of economy in Sri Lanka. Lack of initiation &

Barrier Code	Barrier	RII	Rank
B01	Lack of demand from clients and awareness about Green Building codes and regulations	0.8000	7
B02	The necessity for licensed software and hardware upgrades	0.8229	4
B03	Insufficient research on BIM and BIM implementation models	0.7771	11
B04	BIM standards are lacking for Green Building Assessment (GBA) applications	0.7943	8
B05	Project Stakeholders' resistance to change to the new technological advancements	0.8057	6
B06	Limited construction project budgets for the additional investment	0.8171	5
B07	High cost in training staff for the new software	0.6971	14
B08	Lack of management support due to unclear vision	0.7771	11
B09	Inadequate vision of BIM benefits	0.8457	2
B10	Do not receive enough client support and government support	0.8800	1
B11	Software diversity, inadequate information interchange formats, and a lack of tool and user compatibility	0.7257	13
B12	Contractual and legal limitations and BIM regulation	0.6514	15
B13	Lack of awareness of BIM technology and knowledge on sustainable practices	0.7886	10
B14	Lack of experts amongst industry professionals who practice BIM applications	0.7943	8
B15	Lack of well-developed practical strategies for implementing Green BIM	0.8286	3

support for the Green BIM implementation is also a great issue when it comes to the lack of strategies for implementing.

Apart from the questionnaire survey a semi structured interview was also carried out to identify any barriers other than the barriers identified from the literature review.
As pointed out by interviewees,

- Changes to the existing organizational structure and workflows when BIM implemented.
- Insufficient assistance from the software providers
- Incompatibility with the methods used to procure projects.
  Current procurement practices have not been properly adjusted or incorporated to fit the BIM process. It results in numerous scope gaps, delays, miscommunication, etc. Consequently, it should be standard practice for any subcontracts.
- Owners/clients have not made BIM mandatory. are some of the reasons for the barriers in the Green BIM implementation.

B. Possible Solutions for the Identified Issues to Adopt Green BIM for Sustainable Construction

Change is a part of the BIM implementation process. To overcome barriers of BIM implementation for Green Building construction it is essential to come up with proper solutions. The semi structured interview carried out were also intended to take opinion of the professional in mitigating barriers of implementing Green BIM.

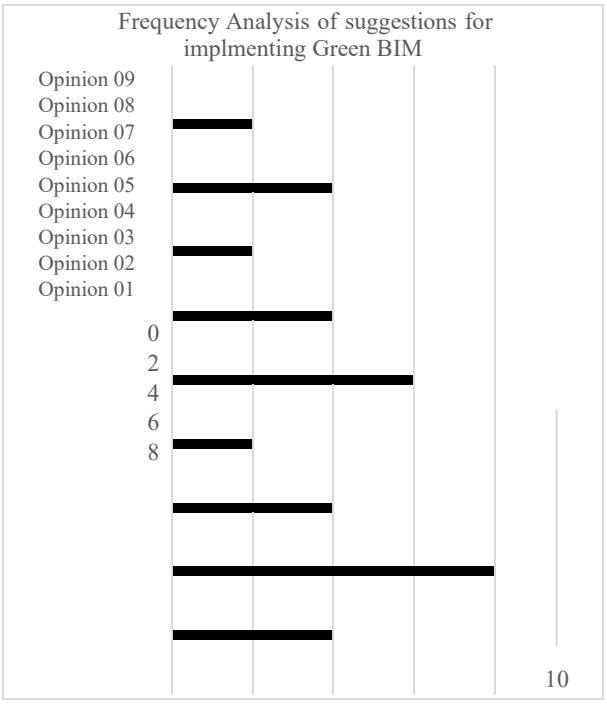

Figure 3: Frequency chart of suggested solutions

Table 3: Suggested Solutions

Opinion No.	Opinions
01	Before implementation of BIM for Green Building at least the industry should adopt to BIM technology, therefore BIM should be mandated.
02	Educational institutions should focus more on acknowledging students about sustainability concept and BIM.
03	Importance of application of BIM by giving different CPD (Continuing Professional Development) sessions or seminars and pressuring the
04	Create an information hub by using foreign working professionals then we can find solution for these matters.
05	Convince the government to introduce certain regulations to apply BIM and make arrangement to promote BIM and Green Building construction concepts.
06	Green Building Council Sri Lanka should mandate to use BIM in Green Building construction projects and standardize process
07	BIM success stories should be published so that the organization become more interested in adopting BIM
08	Higher level management should be educated about the benefits of BIM and Green concepts
09	Lower-level management should be provided with adequate training to use BIM tools

According to the responses highest frequency has got for the suggestion to provide adequate knowledge to the students by the educational institutions in using BIM and sustainable concepts to overcome barriers in implementing BIM for Green Building construction in Sri Lanka.

V. CONCLUSION

In terms of BIM adoption, many challenges have been highlighted in the current AEC scenario. Through a questionnaire survey and a semi structured interview, the main objective of the study was achieved. The data collected were analyzed using RII (Relative Importance Index) analysis and Content analysis. The most significant barriers were that, not receiving enough client support and government support, unawareness of benefits of BIM & Lack of well-developed practical strategies for implementing Green BIM. It was also studied that BIM workshops, courses, and seminars could improve and promote the BIM implementation culture. As most of the interviewees

emphasized the BIM and Green Building construction should be normalized to a certain extent before implementation of Green BIM in Sri Lanka.

VI. RECOMMENDATIONS

Following recommendations can be given based on the professionals' statements.

A. Government & Other Authorities

Being the largest client, the Government is responsible for BIM growth in the country.

- Implement rules and regulations in practicing Green BIM.
- Plan to make BIM usage mandatory in construction projects.
- Provide incentives for the organizations who are willing to adopt Green BIM tools in their projects.
- Partnering with BIM supportive organizations to support implementing BIM.
- Encourage AEC (Architectural, Engineering & Construction) firms to adopt BIM and Green Building concepts into their projects, by providing incentives, reduction of taxes, provide loans etc.
- Implementation of BIM in licensing authorities
- Collaboratively implement standards for BIM usage.
- Should implement a BIM committee.

B. Educational Institutions - Arrange CPD sessions, short courses, seminars etc. to spread awareness of Green Building construction concept and BIM.

- Give encourage practice of new software.
- Should motivate academics to carry out more research about BIM, sustainable construction, and Green BIM.

As emphasized by the interviewees the BIM and Green Building construction should be normalized to a certain extent before implementation of Green BIM in Sri Lanka. More focus should be given to that by the government and other organizations by taking necessary actions.

FUTURE RESEARCH DIRECTIONS:

It is suggested that researchers create a framework by using a combination of both quantitative and qualitative data. The sample size could be expanded for a more comprehensive understanding of the minimize of BIM implementation barriers. The subject area can be developed focused on identifying strategies on mitigating issues in implementing Green BIM in the eyes of each stakeholder in a project.

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ABBREVIATIONS

AEC	-	Architectural, Engineering and Construction
BIM	-	Building Information Modelling
CPD	-	Continuing Professional Development
GBA	-	Green Building Assessment
GBSCSL	-	Green Building Council Sri Lanka
GDP	-	Gross Domestic Product
GHG	-	Green House Gas
RII	-	Relative Importance Index

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