Barriers to implementing GreenBIM in the construction industry: a developing country study

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Abstract

Overcoming the hurdles to achieving GreenBIM is critical to achieving its implementation. This is not an isolated case, as the construction industry is known to be slow to attain digital adoption due to various challenges. This study is important for identifying and overcoming the various barriers to achieving sustainability in the construction industry. The study collected randomly through well structured questionnaires. The collected data was analysed, and the study findings reveal, among others, that there is lack of GreenBIM guide, a lack of incentives to adopt GBIM, lack of BIM training, and business changes are some of the barriers to GBIM adoption in developing countries.

Keywords

GreenBIM, hurdles, sustainability

1. Introduction

The construction industry is actively adopting various innovations and technologies to improve industry products (Adekunle et al., 2021; Ejohwomu et al., 2021). Also, the adoption of these new approaches as opposed to the traditional methods is also beneficial to achieve sustainability and provide environmentally friendly construction industry products. Sometimes, these innovations and emerging technologies are adopted separately, while some are combined. The concept of Green Building information modelling(GreenBIM/GBIM) involves the fusion of green technology and Building information modelling(BIM). Although still a budding area as compared to BIM, it has been adopted in both large construction projects and residential buildings (Ekasanti et al., 2021), although not without shortcomings and areas for improvement.

Shukra & Zhou, (2021) viewed Green Building information Modelling as a concept that adapts green building and Building Information Modelling practices towards achieving a sustainable design and objectives in a construction project. For Liu and Wang, (2022), it involves a process of improving the building performance while creating and managing the lifecycle information using Building Information Modelling without compromising the achievement of the project goals. Akmal *et al.*, (2019) revealed the importance of combining green building and Building Information Modelling in the process of all phases of the project, including maintenance, renovation, and demolition, ensuring that the project results meet the standard of Green Building Information Modelling. This combination integrates sustainability and effective information management. Consequently, the importance of BIM in achieving GreenBIM cannot be overemphasised as it plays a critical role. GBIM, among other uses, provides for the reduction of waste, reduction of environmental impacts while improving quality, improves collaboration, and real-time information management, among others, as it fuses the advantages of green building and BIM. (Cassino et al., 2010) views GreenBIM as the adoption of BIM tools to achieve sustainability and improved building performance on a construction project. Basically, GreenBIM consists of three components, BIM, Green Building certification protocol and environmentally sustainable design(Gandhi & Jupp, 2013).

GreenBIM is used to achieve energy performance analysis, acoustic analysis, building performance analysis, carbon emission analyses, natural ventilation system analyses, solar radiation and lighting analyses, and water usage analyses, among others (Chang & Hsieh, 2020; Lu et al., 2017). Some other benefits of using BIM for sustainability practices in the built environment include achieving real-time sustainable design and multi-design alternatives and reduction of project environmental impact, among others (Olawumi & Chan, 2019).

Actualising these benefits has been difficult in the construction industry, especially in developing countries. This study aims to identify the barriers to implementing GreenBIM in the south African construction industry.

2. Barriers to Green BIM implementation

Despite the inherent benefits of the implementation of GBIM in the construction industry, achieving it has been a tedious task. This is due to the various barriers that have made it impossible. According to (Cassino et al., 2010), one of the challenges faced in the construction industry when it comes to the adoption of GreenBim is the lack of tools and the complexity of developed models. Some other barriers include lack of experts ((Akmal et al., 2019) (Sehrawy et al., 2021)), lack of knowledge (Akmal et al., 2019; Araszkiewicz, 2016), high implication cost (Araszkiewicz, 2016; Sehrawy et al., 2021; Zhabrinna et al., 2018), lack of GreenBIM awareness (Akmal et al., 2019), culture resistance (Adekunle et al., 2022; Sehrawy et al., 2021), lack of standard workflow (Sehrawy et al., 2021), deficient BIM libraries (Sehrawy et al., 2021) among others. Most of these barriers are context specific, hence the study to determine the barriers specific to the South African construction industry regarding GreenBIM implementation.

3. Research Methodology

This research was aimed at identifying the barriers to the implementation of GreenBIM in the construction industry. Construction industry professionals in the South African construction industry (architects, construction managers, Quantity surveyors, town planners, civil engineers, electrical engineers, mechanical engineers, and safety managers) were sampled. Sampling these professionals is essential due to the various roles they perform in the construction industry, especially in the era of innovations is considered very important. A quantitative approach was adopted through the use of well-structured questionnaires; this has been well adopted in built environment research to generalise outcomes (Akinradewo et al., 2022; Aliu & Ohis Aigbavboa, 2020) using numerical data. A total of sixty-four data was collected. The administered questionnaire adopted a five-point Likert scale to provide a quantitative measure (Boone & Boone, 2012). The five scales adopted are strongly disagree, disagree, Neutral, agree and strongly agree. Firstly the reliability of the items making up the scales was measured using the Cronbach Alpha. According to Pallant, (2010), the value range between 0 to 1, and good reliability should be above 0.7. the Cronbach alpha for this study achieved 0.949. This means the instrument measurement items are reliable. The data collected was analysed using the Mean item score and Kruskal Wallis H test. This is to determine the average of responses and differences in respondents opinions.

4. Research findings

4.1 Background information of respondents

The respondents for the study consist of 60% possessing bachelors degree, 20% of the respondents have diploma, 9.2% of the respondents have Masters degree, followed by 7.7% possessing Matric certificate and 1.5% having PhD. Table 1 also shows the profession of the respondents to be 33.8% Quantity surveyors, 21.5% construction managers, 16.9% electrical engineers, and 12.3% of the respondents are civil engineers. Other professions in the respondents are Architects (7.7%), Mechanical engineers (3.1%), safety managers and town planner (1.5% respectively). Respondents possess various degree of industry experience; the majority of the respondents have between 0 – 5 years (67.7%). Other respondents possess between 5- 10 years of experience (26.2%), 15-20 years (3.1%) and 1.5% possess experience above 20 years in the construction industry. Furthermore, the respondents are predominantly working with contracting organisations (32,3%), followed by those working with government parastatals (27.7%), 20% work with private organisations/clients, and 18.5% are consultants.

Table 1: Respondent background information

Highest educational qualification	Frequency	Percent
Matric certificate	5	7.7
Post certificate or Diploma	13	20

Bachelors degree	39	60
Masters degree	6	9.2
Doctorate	1	1.5
Profession		
Construction Manager	14	21.5
Quantity Surveyor	22	33.8
Town Planner	1	1.5
Civil Engineer	8	12.3
Electrical Engineer	11	16.9
Mechanical Engineer	2	3.1
Safety Manager	1	1.5
Architect	5	7.7
Years of experience		
0-5	44	67.7
05-10	17	26.2
15-20	2	3.1
More than 20 years	1	1.5
Institution/organisation		
Consultant	12	18.5
Government	18	27.7
Private Organisation	13	20
Contracting organisation	21	32.3
Familiarity with Green BIM		
Not at all familiar	13	21.5
Slightly familiar	16	24.6
Somewhat familiar	18	27.7
Moderate familiar	12	18.5
Extremely familiar	5	7.7

Meanwhile, it is worth noting that respondents are familiar, although to different degrees with the GreenBIM concept. Only 13% claim not to be familiar with the concept, and this study serves as a source of awareness to the professionals. It does mean the concept is fairly new in the South African construction industry.

4.2 Barriers to implementing GreenBIM

Table 2 presents the mean item score of each of the presented variables to the respondent. The mean item score was adopted to get the average of the responses collected from the industry professionals based on a five Likert scale. The table presents the variables and the MIS, and the SD. From the table, all variables presented are significant. However, according to the data collected, the most significant variable is the lack of a GreenBIM guide, with a score of 3.64; this is followed by a lack of incentives for promoting GreenBIM (MIS = 3.61). Other barriers to the implementation of GreenBIM include the lack of BIM training (3.56), business changes (3.55) and lack of BIM demand (3.53) and the lack of government support (3.47). The study also checked if there is a significant statistical difference in response based on the professionals grouping; the Kruskal-Wallis test (Table 3) was employed. According to (Pallant, 2010), a significance level of above .05 signifies that there is no statistically significant difference in the responses across the groups. For this study, all variables achieved a significant level above 0.05 except for the high implementation cost, which has a value of 0.019.

Table 2: Barriers to the implementation of GreenBIM

Barriers	Mean	Std. Deviation
Lack of Green Building Information Modelling guides	3.64	1.213
Lack of incentives for promoting Green Building Information Modelling	3.61	1.149
Lack of Building Information Modelling training	3.56	1.180
Business changes	3.55	1.053
Lack of Building Information Modelling demand	3.53	1.195
Lack of experts on Building Information Modelling	3.47	1.195
Lack of government support	3.47	1.247
Culture resistance	3.44	1.167
Shortage of skills	3.39	1.341
Lack of knowledge	3.39	1.280
High implementation costs	3.39	1.242

Table 3: KWH test for responses

	Kruskal-Wallis H	Asymp. Sig.
Lack of experts on Building Information Modelling	8.138	0.321
Lack of knowledge	11.901	0.104
High implementation costs	16.693	0.019
Lack of Green Building Information Modelling guides	6.445	0.489
Culture resistance	3.860	0.796
Lack of incentives for promoting Green Building Information Modelling	6.919	0.437
Lack of government support	6.848	0.445
Shortage of skills	12.960	0.073
Lack of Building Information Modelling training	11.413	0.122
Lack of Building Information Modelling demand	10.567	0.159
Business changes	7.615	0.368

The results suggest a lack of GreenBIM guides and structure, which can be linked to a lack of awareness, lack of legal structures necessary for implementation, and stakeholders not fully aware of the full benefits or how to implement GreenBIM among other factors. These factors are not isolated to GreenBIM implementation as they have been identified, especially lack of adequate awareness or clarity to be a critical barrier to the diffusion of technology and innovations in the construction industry (Adekunle et al., 2020; Akinradewo et al., 2022; Ikuabe et al., 2022; John et al., 2022). This might also be a likely reason for the diverse ranking of the high cost of implementation by the respondents, as they might not have full clarity on the implementation of GreenBIM; hence they cannot determine the cost of implementation.

Considering the critical role played by BIM in achieving GreenBIM, it is not surprising to find it as a barrier to the actualisation of GreenBIM. The lack of BIM training, demand and skills must be overcome to achieve BIM. Kekana et al., (2014) and Olugboyega & Windapo, (2021) identified this as some of the challenges facing BIM adoption in the South African construction industry. Consequently, to achieve GreenBIM implementation, there is a need to achieve BIM diffusion.

5. Conclusion

The study identified the barriers to GreenBIM implementation in the south African construction industry through the perception of industry professionals. A quantitative approach was adopted through the random distribution of well-structured questionnaires to achieve this aim. Considering that Green BIM is a fusion of BIM, sustainability and green certification, it thus implies that achieving its implementation cannot be possible without achieving the components. It is thus not surprising from the results that professionals opined that there is a lack of GreenBIM guide in the south African construction industry. This is because the South African construction industry is still struggling with the adoption of BIM. Furthermore, the study result shows that there is a lack of government support, lack of incentives, and lack of BIM training, among others, to achieve GreenBIM. Thus there should be a conscious effort towards achieving GreenBIM by first addressing the barriers to BIM adoption and then creating awareness and clarity on the benefits of GreenBIM to the industry stakeholders. Also, the government must support and create incentives to motivate the adoption of GreenBIM, especially in the achievement of sustainable infrastructures. Overall, there must be a structure guiding the implementation of GreenBIM for a seamless implementation process.

References

Adekunle, S. A., Aigbavboa, C. O., & Ejohwomu, O. A. (2020). BIM Implementation: Articulating the hurdles in developing countries. *8th International Conference on Innovative Production and Construction (IPC)*.

Adekunle, S. A., Aigbavboa, C. O., Ejohwomu, O., Adekunle, E. A., & Thwala, W. D. (2021). Digital transformation in the construction industry : a bibliometric review. *Journal of Engineering, Design and Technology*, *2013*. https://doi.org/10.1108/JEDT-08-2021-0442

Adekunle, S. A., Aigbavboa, O. C., Ejohwomu, O. A., Oyeyipo, O., & Thwala, W. D. (2022). Unravelling the encumberances to better information management among Quantity surveyors in the 4IR: A qualitative study. In S. M. Ahmed, S. Azhar, A. D. Saul, & K. L. Mahaffy (Eds.), *12th international conference on construction in the 21st century (CITC-12)*.

Akinradewo, O. I., Aigbavboa, C. O., Edwards, D. J., & Oke, A. E. (2022). A principal component analysis of barriers to the implementation of blockchain technology in the South African built environment Principal component analysis of barriers. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-05-2021-0292

Akmal, N., Ismail, A., Ramli, H., Dewiyana Ismail, E., Raja, R., Rooshdi, M., Sahamir, S. R., & Idris, N. H. (2019). A Review on Green BIM Potentials in Enhancing the Construction Industry Practice. *MATEC Web of Conferences*, *266*, 01023. https://doi.org/10.1051/MATECCONF/201926601023

Aliu, J., & Ohis Aigbavboa, C. (2020). Employers' perception of employability skills among built-environment graduates. *Journal of Engineering, Design and Technology*, *18*(4), 847–864. https://doi.org/10.1108/JEDT-06-2019-0162

Araszkiewicz, K. (2016). Green Bim Concept- Scandina Vian. *Construction Innovation*, *LXII*(2), 134–150. http://www.sciencedirect.com/science/article/pii/S0926580515001661%0Ahttp://dx.doi.org/10.1108/CI-01-2014-0002%5Cnhttp://www.emeraldinsight.com/doi/abs/10.1108/CI-01-2014-0002

Boone, H. N. J., & Boone, D. A. (2012). Analyzing Likert Data. *Journal of Extension*, *50*. http://www.joe.org/joe/2012april/tt2p.shtml[8/20/20129:07:48AM]

Cassino, K. E., Bernstein, H. M., Asce, F., Ap, L., Gudgel, J., Advisor-Bim, E., Jones, S. A., Laquidara-Carr, D., Messina, F., Partyka, D., Lorenz, A., Buckley, B., & Fitch, E. (2010). *SmartMarket Report Produced with support from Green BIM McGraw-Hill Construction Green BIM SmartMarket Report Executive Editor SmartMarket Report*. www.analyticsstore.construction.com

Chang, Y.-T., & Hsieh, S.-H. (2020). *A REVIEW OF BUILDING INFORMATION MODELING RESEARCH FOR GREEN BUILDING DESIGN THROUGH BUILDING PERFORMANCE ANALYSIS*. *25*(2). https://doi.org/10.36680/j.itcon.2020.001

Ejohwomu, O., Adekunle, S. A., Aigbavboa, O. C., & Bukoye, T. (2021). Construction industry and the Fourth Industrial Revolution. In *The Construction Industry: Global Trends, Job Burnout and Safety Issues.*. Nova Science Publishers.

Ekasanti, A., Dewi, O. C., & Putra, N. S. D. (2021). Green BIM potential in assessing the sustainable design quality of low-income housing: A review. *IOP Conference Series: Materials Science and Engineering*, *1098*(2), 022078. https://doi.org/10.1088/1757-899X/1098/2/022078

Gandhi, S., & Jupp, J. R. (2013). Characteristics of green BIM: Process and information management requirements. *IFIP Advances in Information and Communication Technology*, *409*, 596–605. https://doi.org/10.1007/978-3-642-41501-2_59/COVER

Ikuabe, M., Aigbavboa, C., Akinradewo, O., Adekunle, S., & Adeniyi, A. (2022). Hindering factors to the utilisation of UAVs for construction projects in South Africa. *Modular and Offsite Construction (MOC) Summit Proceedings*, 154–160. https://doi.org/10.29173/MOCS277

John, B., Adekunle, S. A., & Aigbavboa, C. (2022). Construction Industry and the Fourth Industrial Revolution: the Key Impediments in Developing Countries. *Proceedings of International Structural Engineering and Construction*, *9*(1), CON-29-1-CON-29-6. https://doi.org/10.14455/ISEC.2022.9(1).CON-29

Kekana, T. ., Aigbavboa, C. ., & Thwala, W. . (2014). Building Information Modelling (BIM): Barriers in Adoption and Implementation Strategies in the South Africa Construction Industry. *International Conference on Emerging Trends in Computer and Image Processing, Dec. 15-16*.

Liu, Q., & Wang, Z. (2022). Green BIM-based study on the green performance of university buildings in northern China. *Energy, Sustainability and Society*, *12*(1), 1–17. https://doi.org/10.1186/S13705-022-00341-9/FIGURES/12

Lu, Y., Wu, Z., Chang, R., & Li, Y. (2017). Building Information Modeling (BIM) for green buildings: A critical review and future directions. *Automation in Construction*, *83*(June), 134–148. https://doi.org/10.1016/j.autcon.2017.08.024

Olawumi, T. O., & Chan, D. W. M. (2019). An empirical survey of the perceived benefits of executing BIM and sustainability practices in the built environment. *Construction Innovation*, *19*(3), 321–342. https://doi.org/10.1108/CI-08-2018-0065

Olugboyega, O., & Windapo, A. O. (2021). Structural equation model of the barriers to preliminary and sustained BIM adoption in a developing country. *Construction Innovation*, 1471–4175. https://doi.org/10.1108/CI-04-2021-0061

Pallant, J. (2010). *SPSS Survival Manual* (4th ed.). McGraw-Hill Companies.

Sehrawy, A. Al, Amoudi, O., Tong, M., & Callaghan, N. (2021). A review of the challenges to integrating BIM and building sustainability assessment. *AIP Conference Proceedings*, *2428*. https://doi.org/10.1063/5.0071055

Shukra, Z. A., & Zhou, Y. (2021). Holistic green BIM: a scientometrics and mixed review. *Engineering, Construction and Architectural Management*, *28*(9), 2273–2299. https://doi.org/10.1108/ECAM-05-2020-0377

Zhabrinna, Davies, R. J., Abdillah Pratama, M. M., & Yusuf, M. (2018). BIM adoption towards the sustainability of construction industry in Indonesia. *MATEC Web of Conferences*, *195*, 06003. https://doi.org/10.1051/MATECCONF/201819506003