Assessment of barriers to the adoption of sustainable building materials (SBM) in the construction industry of a developing country

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Abstract

Purpose – Sustainable/Green building materials (SBMs/GBMs) offer a wide range of benefits which cut across the economic, social and environmental dimensions of sustainability. The incorporation of these materials in construction projects in most developing countries is still low owing to some factors. This study assessed the major barriers to the incorporation of SBMs in the delivery of construction projects in developing countries, with Nigeria as a case in point.

Design/methodology/approach – The well-structured quantitative questionnaire was used to gather data from the key players in the construction industry, using the snowball sampling method and electronic means of questionnaire administration. Frequencies, percentile, relative importance index, Kruskal–Wallis H test, Kendall's coefficient of concordance and exploratory factor analysis were used to analyse the gathered data.

Findings – The study revealed that the major constructs of barriers to SBM adoption in construction projects are: (1) resistance and information barriers (Eigenvalues = 5.237; % of V = 23.806), (2) regulation and funding of R&D (Eigenvalues = 2.741; % of V = 12.457), (3) cost and market barriers (Eigenvalues = 2.223; % of V = 10.105), (4) government incentive and suppliers' availability (Eigenvalues = 1.728; % of V = 7.852) and (5) GB experts and labour barriers (Eigenvalues = 1.307; % of V = 5.942).

Originality/value – This study assessed the view of construction experts in the five states of the south-eastern geo-political zone of Nigeria, particularly as regards the barriers to the incorporation of sustainable building materials in construction projects in the region.

Keywords Sustainable building materials (SBM), Green building, Sustainability, Barriers, Construction projects

Paper type Research paper

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1. Introduction

The construction industry globally is the most critical and leading carbon emitter (Huang *et al.*, 2018), and this is attributed to the processes and products adopted in the conventional, traditional approach to building production. One of the largest contributors to the endangering of the environment, particularly the imbalance that threatens the safety of the next generations, is the built environment (UCL Energy Institute, 2015; UKGBC, 2009). An estimate of about 25% of the world's logging activities are carried out in the construction industry, carbon dioxide emission is about 39%, emitted sulphur dioxide is 49%, emitted nitrous oxide is 25%, extraction of raw materials is 40%, other matters emitted constitute 10%, particularly in industrialised countries (Lim *et al.*, 2015).

The use of sustainable building materials (SBMs) has been advocated for minimising the impact of the construction activities on the environment, resource depletion, imbalance in the ecosystem and global warming and climate change (Eze *et al.*, 2021a). SBMs are regarded as 'friends of the environment because they are recyclable, reusable and have zero effect on the environment (Onyegiri and Ugochukwu, 2016). SBMs meet the need of the generation living now without denying the future generation the opportunities to meet theirs (Zhang *et al.*, 2017). According to Sheth (2016), SBMs are exceptional materials adopted with the aim of achieving sustainable construction. SBMs are environmentally responsive and they alleviate environmental problems like pollution, greenhouse gas (GHG) emission, imbalance in the ecosystem and other issues that evolve from the conventional building materials (CBMs). The traditional construction approach utilises eco-unfriendly and unsustainable materials and products that are averse to the environment (Eze *et al.*, 2021b).

In spite of the importance of SBMs, their selection and use are still limited in driving sustainability in building construction projects in most nations. Furthermore, what are still widely used are the traditional CBMs for building projects in both industrialised and emerging countries of the world (Gounder *et al.*, 2021). This is in spite of the importance attached to sustainable construction and the level of attention it has attracted in recent decades by both researchers and industry practitioners. The incorporation of SBM for attaining a sustainable built environment is low as it still faces some drawbacks to its widespread adoption, especially in developing countries (Baron and Donath, 2016). Nigeria is a developing country where there is a mismatch between the level of awareness and adoption of SBMs, and where the sustainable construction market is still largely "under-tapped and unsaturated" (Eze *et al.*, 2021a).

Extant literature has advanced reasons for the low level of adoption of SBMs in building projects. These range from awareness, knowledge and understanding issues, as well as poor attention to the sustainability concept and agenda (Aghimien *et al.*, 2018; Mohsin and Ellk, 2018; Baron and Donath, 2016). In the Nigerian context, in spite of the availability of studies on sustainable construction practices generally, there is the scarcity of studies on the barriers to the actual incorporation, adoption and implementation of SBMs or green building materials (GBMs). It is an area that has been underexplored in literature, particularly amongst researchers and academics in the south-east geo-political zone of Nigeria. Available studies either assessed small samples size (Umar *et al.*, 2021) or small variables on SBM selection (Akadiri, 2015), and these studies were carried outside the zone considered by this study.

Therefore, more studies are required in this aspect. It is based on this, that this study assesses the major barriers to the adoption of SBMs in construction projects, by sampling construction experts within the south-east geo-political zone of Nigeria. For construction experts and decision-makers in the construction sector to contribute to fighting the degrading effects of CBMs on the environment, and economic and social aspects of human existence, an understanding of the barriers to the use of SBMs is critical.

2. Barriers to SBMs/GBMs adoption

There is a mismatch between the awareness level of SBMs and their adoption in developing countries. For instance, in Ghana, the demand for GB is low (Addy *et al.*, 2021); in Nigeria, and by extension, other developing countries, the sustainable construction market is still largely under-tapped and unsaturated (Eze *et al.*, 2021a). Umar *et al.* (2021) reported that in spite of the growing local and international interest in sustainability, the level of awareness and knowledge of SBMs is still low amongst registered architects in Minna, Nigeria. According to Nikyema and Blouin (2020), developing countries in their efforts to implement sustainability agendas have always trailed developed nations as a result of various barriers. What are the factors that have prevented the sustainability market of these countries, especially as regards the use of SBMs/GBMs? A clear understanding of these factors will help shape decisions regarding the implementation of SBMs/GBMs (AlSanad, 2015).

Häkkinen and Belloni (2011) established a link between GBM knowledge, awareness and adoption of sustainable construction. Most stakeholders are either ignorant of or lack knowledge of GBMs and this impedes implementation. The lack of awareness and knowledge of GBM by professionals, misunderstanding of the sustainability concept, lack of client's awareness of the benefits of SBMs/GBMs and poor education of sustainable design are factors that inhibit the attainment of sustainability. Furthermore, the adoption of GBM and other technologies necessitates learning new methodologies, and the existing stock of the industry's experts lacks the experience. The scarcity of environmentally sustainable materials, lack of exemplar demonstration projects, a chronic shortage of skills and labour and lack of technical guidance are some critical impediments to the effective deployment of SBMs (Ofori and Kien, 2004). A firm grasp of the sustainability concepts is grossly lacking in the industrial designers and professionals (Rydin *et al.*, 2006), and the lack of locally manufactured SBM (Osaily, 2010) are some of the factors impeding the adoption and attainment of sustainability. In Sub-Saharan Africa, significant obstacles to sustainable development come mainly from the lack of education, lack of awareness, lack of a standard GB tool, no financial incentives from the government and excessive concentration on capital cost over the operating cost (Addy *et al.*, 2021). Similar observations were also made in other studies in Africa (e.g. Mpakati-Gama *et al.*, 2012; Nikyema and Blouin, 2020).

In Singapore and Australia, lack of proper communication by GB teams, lack of green practitioners, high initial cost, lack of government support, lack of interest and market knowledge of GB, uncertainty about GBMs' benefits and performance, lack of building codes and regulations and poor relationships amongst stakeholders, were the major barriers to GB (Hwang and Tan, 2012). In the US construction industry, Darko *et al.* (2017) reported that the major critical barriers to the adoption of green building technologies (GBTs) are: resistance to change from the use of traditional technologies, lack of knowledge and awareness GBTs and their benefits, high cost, lack of GB experts/skilled labour and lack of government incentives/supports. In the Australian construction sector, Gounder *et al.* (2021) examined the reasons for the low usage of sustainable materials for building projects are higher cost, possible cost overruns, lack of incentive, lack of government policies on promoting the use of SBMs and unwillingness to change at the industry level. These barriers must be overcome by stakeholders to improve the incorporation of SBMs in the future building project and in making existing buildings green.

The most rated barriers to SBMs in Iraq are: lack of sufficient awareness to deal with these materials during the occupancy and maintenance period, lack of coordination amongst stakeholders, lack of expertise required for the manufacture of environmentally friendly building materials, lack of trusted materials suppliers, lack the skills required to build with such materials and lack of adequate support for the implementation of the project (Mohsin and Ellk, 2018). In India, the top barriers to GB are: lack of expertise in life-cycle cost, lack of information on the benefits of green buildings, lack of labelling and lack of infrastructure and training (Abraham and Gundimeda, 2018). In Kuwait, the report of AlSanad (2015) shows that the top barriers to SBMs for achieving sustainable construction are the lack of awareness, lack of qualified staff, no existing rules to adopt GBM, lack of government support/no incentives and unwillingness to change. It was recommended that government initiatives are required to the introduction of standards, policies and incentives to guide and promote the attainment of sustainable construction. In a sustainable study by Aghimien *et al.* (2019), the major barriers are resistance to change, client preference, increased cost of investment and inadequate knowledge and understanding of the sustainability concept. Other reviewed studies that highlight the drawbacks to sustainability in the construction industry are (Chan *et al.*, 2018; Marsh *et al.*, 2020).

3. Research methodology

This study adopted a questionnaire survey to achieve the purpose of determining the major barriers to the adoption of SBMs in construction projects. The use of the questionnaire followed similar studies that contribute to the sustainability discussion (sustainable/green materials and sustainable construction) in the built environment (e.g. Abraham and Gundimeda, 2018; Gounder *et al.*, 2021). In addition, the questionnaire is widely used for social research (Blaxter *et al.*, 2001), it is simple to use and it can cover a large audience in a shorter period (Tan, 2011). This, therefore, makes it suitable for this study involving large targets such as clients, consultants, construction professionals and contractors that are engaged in public and/or private construction organisations within the five states in the south-east geo-political zone of Nigeria. These target participants were chosen because of their role in building construction generally and in achieving a sustainable built environment. The questionnaire was developed after a detailed review of relevant studies on the subject of this study.

To minimise response bias and improve the quality of collected data, some sample selection criteria were set: (1) the participants must have at least five years of industry practice experience, (2) have knowledge of sustainable construction/concepts and (3) must be actively involved in construction projects and working within the study area. These criteria were clearly stated in the questionnaire so that only qualified participants took part in the survey (Eze *et al.*, 2021a). A firm sample size could not be established as there was no separate database of construction practitioners and stakeholders with these criteria. Based on this, the snowball sampling technique was adopted. The snowball sampling technique depends on referral and it has the capacity to increase response rate (Heckathorn, 2011). A pilot survey was conducted to ensure questions on the questionnaire are intelligible. The feedback received from some selected participants helped to improve the questionnaire.

The questionnaire used was designed into two parts; the first part gathered information on the respondents' background, and the second part gathered information about the barriers to the adoption of SBMs/GBMs. The respondents were required to rate the variables according to the level of importance to the adoption of SBMs on a five-point Likert scale, with 1 = lowest rating scale and 5 = highest rating scale. Following a preliminary survey, the first sets of the participants were identified and the questionnaires were distributed via electronic means and the snowball sampling technique as it is respondent-driven. The electronic means of the survey is an economical way of reaching respondents who are difficult to reach, and it encourages the use of fewer papers (made from trees). Therefore, it is an eco-friendly means of survey (Nwaki and Eze, 2020).

After a survey period of three months, 135 filled questionnaires were received. The breakdown of the responses indicates that (19 (14.07%)) are from Abia state, 21(15.56%) from Anambra state, 15 (11.11%) from Ebonyi state, 41(30.37%) from Enugu state and 39 (28.89%) from Imo state). The gathered data were analysed using descriptive statistical tools (frequency, percentage, relative importance index (RII)), Kruskal–Wallis test and exploratory factor analysis (EFA). The nature of the data was first established through a normality test done using the Shapiro–Wilk test which is suitable for study with a sample size of fewer than 2000 (Ghasemi and Zahediasl, 2012). The significant values obtained were lower than 0.05, which confirms that the data were non-parametric. Furthermore, the reliability of the gathered data was determined using Cronbach's alpha test which gave an alpha value of 0.919 for the 22 variables assessed. This shows that the research instrument has very good reliability and the data obtained are of good quality. There is a tendency for the respondents to rank the variables differently since they are from different backgrounds and experiences. Kruskal–Wallis test was used to test if there is a significant difference in the perception of the respondents from the different states surveyed, as it is suitable for comparing views of three or more respondents group in a study. Kendall's coefficient of concordance (W) and chi-square were performed on the data. Kendall's W was used to determine the overall agreement of the participants regarding the ranking of the variables (Chan *et al.*, 2009). This test helps to establish whether or not there is consistency in the way the variables were ranked by the experts (Siegel and Castellan, 1988). The Kendall's W range from 0 to +1, the closer W is to 1 the better. Chi-square (χ^2) is suitable where the ranked variables are greater than seven and the sample size is larger than twenty. Significant considerations are given to the p-value and df in determining the groups' agreement in the ranking of variables (Siegel and Castellan, 1988). The assessed variables were ranked based on their relative weighting using RII and were further subjected to EFA. The EFA was used to scale down the variables into smaller and cohesive proportions of different constructs. Before proceeding with the EFA, the communality values, sample size, the Kaiser–Meyer–Olkin (KMO) value and the Bartlett test of sphericity with emphasis on the p-value, were considered. The entire methodological flow of the study is shown in Figure S1.

4. Results and discussion

4.1 Background information of respondents

The respondents' background information showed that 28.15% of the respondents are construction professionals, 16.30% are consultants, 20.00% are clients and 35.56% are contractors/subcontractors. This is a fair representation of the major stakeholders involved in building production and sustainability discussion. In terms of the respondents' years of experience in the construction sector, 31.85% have spent between 5 and 10 years in the construction industry, 28.89% have spent 11–15 years, 25.19% have spent 16–20 years and 14.07% have spent over 20 years in the sector. The average years of experience of the participants are 13.49 years. This is a good length of period to have gained considerable experience in the subject of this study. The participants are also well educated, as their academic qualification shows that those with HND are (9.63%), PGD (15.56%), BSc/B. Tech (39.26%), Master's degree (33.33%) and Doctorate are (2.22). This is an indication of sufficient education that is required to comprehend the questions contained in the questionnaire. Overall, the participants were qualified to participate and make a meaningful impact on the subject of this study.

4.2 *Barriers to incorporating sustainable building materials*

The ranking of the barriers to incorporating SBMs is shown in supplementary Table S1. The five major barriers are resistance/unwillingness to change (RII = 0.944, ranked 1st), lack of green building experts/skilled labour (RII = 0.920, ranked 2nd), high capital cost (RII = 0.911, ranked 3rd), lack of building code and regulations (RII = 0.907, ranked 4th) and lack of government incentives and support (RII = 0.893, ranked 5th). While, the least ranked barriers are poor education of sustainable design (RII = 0.761, ranked 18th), limited knowledge of GBM (RII = 0.757, ranked 19th), possible cost overruns (RII = 0.747, ranked 20th), lack of firm understanding of sustainability concept (RII = 0.733, ranked 21st) and lack of exemplar demonstration projects (RII = 0.726, ranked 22nd).

However, regardless of the relative ranking of the assessed barriers, they impede the implementation of SBMs in construction. This is based on the minimum and maximum RII scores of 0.726 (72.60%) and 0.944 (94.40%), respectively and the average RII of 0.843 (84.30%). The assessed variables have the capability to limit or hinder the widespread adoption and implementation of SBM in Nigeria and by extension other developing countries of Africa and beyond that have similar construction markets as Nigeria. The findings in this section is in consonance with what have been reported in previous studies (AlSanad, 2015; Ofori and Kien, 2004; Darko *et al.*, 2017; Abraham and Gundimeda, 2018; Addy *et al.*, 2021; Nikyema and Blouin, 2020; Gounder *et al.*, 2021).

The Kruskal–Wallis *H*-test was used to determine if there is a significant difference in the rating style and opinion of the different experts from the five states. Columns 5 and 6 of Table S1 indicate that the *p*-value of the assessed variables is higher than 0.05 significant levels. This implies a 100% agreement in the ways and pattern of ranking of the assessed variables by the participants. This is evidence of convergence of views. Based on this, it was concluded that no significant statistical difference exist between the construction professionals, consultants, clients and contractors/subcontractors from the five states regarding the barriers to the adoption of SBM in construction projects.

The Kendall's W test was carried out, and the test showed that W is > 0.05. Since the number of variables is higher than 7 and the sample size is 135, the significance of W should be established by making reference to the chi-square, df and *p*-value (Siegel and Castellan, 1988). The calculated chi-square value for the entire participants from the five states is (185.739). This is however greater than the critical chi-square value of (27.587) obtained from the statistical table. This shows relatedness in the ranking of the variables within the experts from the study area; therefore, disparity does not exist in the perceptions of the respondents. In addition, since the *p*-value is less than 0.05, a good agreement exists amongst the participants concerning the ranking of the assessed variables.

4.3 Factorability and suitability checks

Prior to carrying out the factor analysis (FA), data factorability and adequacy were determined. This was achieved through the consideration of the sample size, communalities, KMO test and Bartlett's test of sphericity (BTS). Researchers are yet to come to a consensus on what the ideal sample size for EFA should be. A high communalities value makes the sample size irrelevant in determining sample adequacy (Pallant, 2007; Tabachnick and Fidell, 2007). A communality value of 0.50 has been proposed (Hair *et al.*, 2016), while Pallant (2005) proposed a communality of at least 0.30. The communalities obtained in this present study range from 0.50 to 0.887. With regards to the KMO, a value of 0.735 was obtained, and this is closer to 1 than it is to 0. Kaiser (1974) states that the KMO value ranges from 0 to 1 and the data are suitable if it is nearer to 1 than 0. In addition, the KMO obtained in this study is quite above the suggested cut-off points (Field, 2005). Tabachnick and Fidell (2007) submitted that the *p*-value of BTS must be significant for data to be suitable for EFA. A *p*-value of 0.000 and a large chi-square (χ^2) of 1,333.93 were obtained for this study. This makes the data factorable. Furthermore, Xu *et al.* (2010) submitted that a large chi-square value and small *p*-value show that the correlation matrix is not an identity matrix; therefore, is suitable for EFA. It is therefore concluded that the sample size of 135, the communalities of at least 0.50, the KMO value of 0.735 and BTS of the *p*-value of 0.000 confirm that the data are sufficient and suitable for FA.

4.4 EFA of barriers to SBM incorporation in construction projects

The FA was carried out by properly using the principal component analysis (PCA) with varimax rotation as the methods of extraction and rotation, respectively. This was after the confirmation of the factorability of the gathered data. The underlying structure between variables was derived based on the FA, and five components having eigenvalues greater than 1 were extracted. The five factors accounted for a total cumulative variance (TCV) of 60.162%, and this met the recommended threshold for adequate construct validity (Pallant, 2007). The extracted factors that formed the five constructs explained a larger proportion of the variables observed than the remaining unextracted components. Furthermore, only variables with factors loading of at least 0.50 were retained under each component, thus, indicating a strong construct (See Table 1). This is in line with Spector's (1992) submission.

Factor 1: Resistance and information barriers: The 1st component structure accounted for about 23.806% of the total variance explained (TVE) of the extracted factors and has six variables that are loaded under it. The factors that are loaded under this component are: resistance/unwillingness to change, lack of information about green materials and products, low awareness of the benefits and other sustainability issues, lack of proper communication and coordination amongst stakeholders, poor education on sustainable design and the scarcity of environmentally sustainable materials. This component was named "*resistance and information barriers*" following an examination of the latest features of the variables loaded.

Resistance amongst the critical stakeholders regarding innovative approaches, techniques and materials in the construction industry is high, and it is one of the most cited barriers to the adoption of GBMs/SBMs (Marsh *et al.*, 2020; Darko *et al.*, 2017; Umar *et al.*, 2021; Aghimien *et al.*, 2019; Akadiri, 2015). Similar to resistance and unwillingness to change are overreliance and confidence on existing techniques and materials. This has negatively impacted the attainment of sustainable construction, as it cause serious drawback to the adoption of SBM in Nigeria and by extension other developing nations (Umar *et al.*, 2021; Aghimien *et al.*, 2019; Akadiri, 2015). Clients, construction experts and other stakeholders in the construction sector need to loosen up a bit and accept changes and new approaches and materials in the delivery of construction projects. This is central to attaining sustainability of the built environment and the upgrading of the existing buildings to sustainable ones. Therefore, awareness and information dissemination regarding the benefits of incorporating GBM will help in overcoming the resistance changes. When people know the actual benefits of a particular method or materials, there is a tendency that they would be interested in and support the use of such materials and techniques (Eze *et al.*, 2021a).

The absence of detailed information on green materials and products (Mpakati-Gama *et al.*, 2012), has an impact on the low awareness level of the benefits of GBM amongst stakeholders (Hwang and Tan, 2012). Poor information management is one of the major drawbacks to the speedy uptake of sustainability in the construction sector. Knowledge gained through education helps to improve the awareness of GBM and this could by extension impact the adoption level of the materials. This idea is supported by (Häkkinen and Belloni, 2011). Poor awareness, education on sustainability and poor information and communication amongst stakeholders can be attributed to the resistance and information barriers to GBM implementation. Reduction in the reluctance to take up new approaches and materials will help improve the adoption of GBMs. Having the right mix of information and knowledge on the green building are a key to attaining sustainability.

Factor 2: Regulation and funding of R&D: The 2nd component has three factors loading under it and accounts for about 12.457% of the TVE of the extracted factors. The factors that are loaded on this component are: lack of building code and regulations, lack of research funding for green building materials and technologies and lack of a standard GB tool. This component was named "*Regulation and funding of R&D*" after a critical inspection of the latent characteristics of the variables.

Component naming	Item loading	Factor loading	Eigenvalues	% of variance	Cum. %	Number of extracted factors
Factor 1: Resistance and information barriers	Resistance/ Unwillingness to change	0.797	5.237	23.806	23.806	6
	Lack of information about green materials and products	0.797				
	Low awareness of the benefits and other sustainability issues	0.769				
	Lack of proper communication and coordination amongst stakeholders	0.762				
	Poor education on sustainable design	0.684				
	The scarcity of environmentally sustainable materials	0.592				
Factor 2: Regulation and funding of R&D	Lack of building code and regulations	0.905	2.741	12.457	36.263	3
	Lack of research funding for green building materials and technologies	0.849				
	Lack of a standard GB tool	0.813				
Factor 3: Cost and market barriers	High capital cost	0.724	2.223	10.105	46.367	3
	Lack of client Knowledge/market demand	0.695				
	Lack of experience with GB methodologies	0.635				
Factor 4: Government incentives and Suppliers' availability	Lack of government incentives and support	0.822	1.728	7.852	54.220	3
	Limited availability suppliers of GBM, products and technologies	0.710				
	Poor relationships amongst stakeholders	0.578				
Factor 5: GB Experts and labour barriers	Lack of green building experts/skilled labour	0.753	1.307	5.942	60.162	3
	Limited training on local green building materials	0.680				
	Lack of firm understanding of sustainability concept	0.639				

Table 1.
Result of factor analysis of the barriers to adoption of SBM

Regulation and funding are critical to the introduction and sustenance of ideas in a new environment. Where this does not exist, existing techniques remain strong and the consequence is unguaranteed productivity. Regulations can give backing to training and education on GBMs. In addition, funding is central to the survival as well as the innovativeness of construction organisations. The finding here is supported by (Abraham and Gundimeda, 2018; Marsh *et al.*, 2020; Chan *et al.*, 2018; Gounder *et al.*, 2021). The lack of a clear building code and regulations guiding the incorporation of GBM is a critical factor inhibiting the speedy update of GBM in the construction industry of Nigeria and by extension other developing countries (Eze *et al.*, 2021a). The strict adherence to codes and regulations is amongst the measures proposed by (Aghimien *et al.*, 2018) for improving the use of SBM in Nigeria. If there are regulations on GBM adoption, the rate of growth in the use of GBMs would have improved. Funding of research on GBM and technologies is a function of having a workable regulation from the government. Chan *et al.* (2018) reported that the lack of adequate funding for research on innovative materials and technology is a key barrier to the adoption and incorporation of GBMs in construction projects.

Factor 3: Cost and market barriers: The 3rd component has three factors and they are: high capital cost, lack of client knowledge/market demand and lack of experience with GB methodologies. This component accounts for 10.105% of the TVE of the extracted factors, and is based on the latent features of the factors loaded on it was named "*cost and market barriers*". While capital is highly needed for driving innovation, the availability of adequate funds impacts the diffusion of new ideas. The high cost of investment in innovative materials and technologies is amongst the primary barriers to the implementation of GBMs. High cost of capital was amongst the barriers found by (Abraham and Gundimeda, 2018), that affect the adoption and incorporation of GBM by stakeholders. Another major issue is the lack of demand from clients/low market demand. This was acknowledged in literature such as Marsh *et al.* (2020), Hwang and Tan (2012) and Häkkinen and Belloni (2011). This result obtained also supports the findings of Aghimien *et al.* (2018) and Akadiri (2015). It was reported that extra cost and financial related factors are amongst the top challenges that the attainment of sustainable construction of education building projects faces in Nigeria (Aghimien *et al.*, 2018; Akadiri, 2015). Financial related issues have contributed to the low adoption of SBMs and the under-tapped and unsaturation of the sustainable construction markets of Nigeria and other developing nations (Eze *et al.*, 2021a). A lot is still left undone to change the narrative, and this could be the reason why Addy *et al.* (2021) submitted that the GB market in Sub-Saharan Africa is confronted by several significant factors.

Factor 4: Government incentive and suppliers availability: The 4th component structure accounts for 7.852% of the TVE of the extracted factors, and three factors are loaded onto it. The factors are: lack of government incentives and support, limited availability of suppliers of GBMs, products and technologies and poor relationships amongst stakeholders. A critical examination of the latent features of these variables led to the naming it *"Government incentive and Suppliers availability"*. Supports and incentives are necessary for the smooth adoption of innovations in organisations. This becomes even more interesting when it is coming from the government. The lack of such incentives and support has been reported to be a major barrier to the adoption of GBM and technologies (Nikyema and Blouin, 2020; Darko *et al.*, 2017; Aghimien *et al.*, 2018). Mohsin and Ellk (2018) found that the suppliers of GB materials, products and technologies are limited, and this inhibits the adoption of GBM in building projects. This barrier could be amongst the consequences of poor awareness and education on sustainable construction. When there is proper education on the usefulness of GBM and sustainable construction, there will be a trigger of demand and supply (Eze *et al.*, 2021a). The lack of government support, incentives and interest and the unavailability of suppliers of SBM, have negative impact on the delivery of green buildings in Nigeria and other developing countries. In Nigeria, limited suppliers of SBMs were ranked amongst the top six barriers to the use of SBMs (Akadiri, 2015). If the proportion of sustainable buildings is to be increased, government support is inevitable (Aghimien *et al.*, 2018). Government should be in the forefront of championing the sustainability course both in regulations, education and otherwise.

Factor 5: GB experts and labour barriers: The 5th component was named "*GB Experts and labour barriers*", and this component accounts for about 5.942% of the TVE of the retained factors. Three factors are loaded under this component and they are: lack of green building experts/skilled labour, limited training on local green building materials, and lack of firm understanding of sustainability concept. One of the factors that impede the implementation of GBM is the absence of experts/skilled labour on GB (Eze *et al.*, 2021b; Hwang and Tan, 2012). Sustainable construction is still an emerging area in developing countries; although efforts are being made to embrace sustainability in its entirety, the availability of experts on GB is a major drawback. This is even worsened by the limited training programme for the locals on the use of GBMs and the poor appreciation of the sustainability concept. In Nigeria, a study by (Eze *et al.*, 2021b) reported that the availability of technical skill and experts was amongst the top 10 determinants of SBM selection in building projects. Aghimien *et al.* (2018) posit that the use of competence and skilled contractors and experts is vital for improving sustainable construction in educational buildings in Nigeria.

Figure 1 below shows the relative weighting of the total factor loadings (TFL) of the major extracted factors which represent the critical barriers to SBM adoption in Nigeria. The TFL for the components is the effect of the individual factors loading. It can be seen that; *Factor 1: resistance and information barriers* (TFL = 4.400) is ranked 1st. This showed how critical stakeholders resistance to and information issues can be in hindering the adoption of SBMs/GBMs. *Factor 2: Regulation and funding of R&D* (TFL = 2.567) is ranked 2nd, followed by *Factor 4: Government incentives and suppliers' availability* (TFL = 2.110) ranked 3rd, then, *Factor 5: GB experts and labour barriers* (TFL = 2.072) and *Factor 3: Cost and market barriers* (TFL = 2.053) were ranked 4th and 5th, respectively.

5. Conclusion and recommendations

This study assessed the major barriers to the incorporation of SBMs in the delivery of construction projects in developing countries, with Nigeria as a case in point. A well-structured quantitative research questionnaire was used to achieve the aim of this study. Data were obtained from the key players in the construction industry using the snowball sampling method and electronic means of questionnaire administration. The gathered data were analysed, meaningful results are obtained and reported and a is conclusion drawn.

Based on the results of the RII analysis carried out, this study found that the major barriers to the adoption of SBMs/GBMs are: resistance/unwillingness to change, lack of green

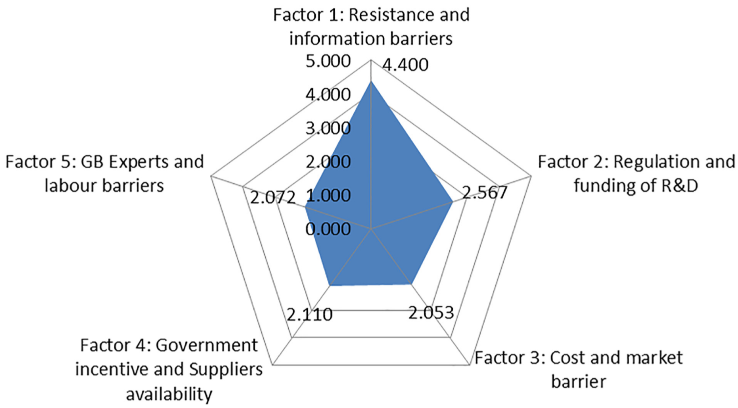

Figure 1.
Relative ranking by total factor loading (TFL) of extracted factors

building experts/skilled labour, high capital cost, lack of building code and regulations and lack of government incentives and support. Also, the result of the EFA showed that the five major constructs of barriers to SBM adoption in construction projects are; resistance and information barriers, regulation and funding of R&D, cost and market barriers, government incentive and suppliers availability and GB experts and labour barriers. Stakeholders' resistance and unwillingness to embrace change has been one of the primary issues confronting the diffusion and adoption of innovative ideas, methods and materials in the construction industry. The construction sector is regarded as laggards or late adopters of eco-friendly materials and technologies because of the high level of resistance and over-reliance on existing conventional materials and traditional means of delivery of construction projects. Of great impact in GB construction is the availability of skilled labour and experts and the high cost of investment. Even though the initial cost of implementing sustainable construction is high, the long term benefits make it cheaper compared to conventional buildings. Regulation and government support are vital to ensuring the speedy attainment of sustainability. However, this study showed that they are grossly lacking and that have impacted the adoption of GBMs. Therefore, efforts should be made to embrace GBMs in building projects. This will be achieved via awareness creation and education and training on GB methodologies. Government support is needed and appropriate regulations and policies should be made and monitored for implementation.

The implications of this study's outcome to the construction experts and decision-makers in the construction sector would be to further the discussions on sustainability subjects, especially as it concerns the major barriers to SBM adoption in the sector, and finding suitable solutions and strategies for overcoming the barriers. A proper grasp and understanding of the barriers to the use of SBMs/GBMs would lead to easier and better decisions from the industry players. This will lead to improved uptake and incorporation of these eco-friendly materials in building projects in Nigerian and beyond. SBMs improve occupants' comforts and health, thus, enhancing productivity and performance of employees. The corporate clients' organisations would find this study relevant in improving their overall labour performance and productivity. This is because having established and known the critical barriers to the use of SBMs/GBMs, their adoption are improved for enhance employees output per period. The construction industry contributes enormously to climate change issues, GHG emission and amongst other dangerous gaseous emissions. This study adds to climate change discussion by looking at the major factors that inhibit the curbing of the effects of the construction industry's contribution to climate change acceleration. Thus, existing body of knowledge on sustainable construction, particularly the barriers in Nigeria and by extension other developing countries of Africa, will experience an increase in numbers.

Notwithstanding the implications of this study, the number of variables assessed, sample size, study area, sampling method and analysis techniques adopted all limit the generalisation of the findings of this study. This is a caution on any attempt to generalise the results of this present study. Consequently, a further study to unravel more barriers and use a larger sample size and sampling techniques in other areas, zones or countries should be carried out. This will make comparison possible as more data would be available for that.

References

Abraham, P.S. and Gundimeda, H. (2018), "Greening' the buildings - an analysis of barriers to adoption in India", *Cities and the Environment (CATE)*, Vol. 10 No. 1, 10, available at: https://digitalcommons.lmu.edu/cate/vol10/iss1/10

Addy, M., Adinyira, E., Danku, J.C. and Dadzoe, F. (2021), "Impediments to the development of the green building market in sub- Saharan Africa: the case of Ghana", *Smart and Sustainable Built Environment*, Vol. 10 No. 2, pp. 193-207, doi: 10.1108/SASBE-12-2019-0170.

Aghimien, D.O., Adegbembo, T.F., Aghimien, E.I. and Awodele, O.A. (2018), "Challenges of sustainable construction: a study of educational buildings in Nigeria", *International Journal of Built Environment and Sustainability*, Vol. 5 No. 1, pp. 33-46.

Aghimien, D.O., Aigbavboa, C.O. and Thwala, W.D. (2019), "Microscoping the challenges of sustainable construction in developing countries", *Journal of Engineering, Design and Technology*, Vol. 17 No. 6, pp. 1110-1128, doi: 10.1108/JEDT-01-2019-0002.

Akadiri, P.O. (2015), "Understanding barriers affecting the selection of sustainable materials in building projects", *Journal of Building Engineering*, Vol. 4 No. 1, pp. 86-93.

AlSanad, S. (2015), "Awareness, drivers, actions and barriers of sustainable construction in Kuwait", *International Conference on Sustainable Design, Engineering and Construction. Procedia Engineering*, Vol. 118, pp. 969-983.

Baron, N. and Donath, D. (2016), "Learning from Ethiopia - a discussion on sustainable building", *Proceeding of SBE16 Hamburg International Conference on Sustainable Built Environment Strategies - Stakeholders - Success factors*, Hamburg, 7-11 March.

Blaxter, L., Huges, C. and Tight, M. (2001), *How to Research*, 2nd ed., Open University Press, London.

Chan, E.H., Qian, Q.K. and Lam, P.T. (2009), "The market for green building in developed Asian cities—the perspectives of building designers", *Energy Policy*, Vol. 37 No. 8, pp. 3061-3070.

Chan, A.P.C., Darko, A., Olanipekun, A.O. and Ameyaw, E.E. (2018), "Critical barriers to green building technologies adoption in developing countries: the case of Ghana", *Journal of Cleaner Production*, Vol. 172, pp. 1067-1079.

Darko, A., Chan, A.P.C., Ameyaw, E., He, B.-J. and Olanipekun, A.O. (2017), "Examining issues influencing green building technologies adoption: the United States green building experts' perspectives", *Energy and Buildings*, Vol. 144, pp. 320-332.

Eze, C.E., Ugulu, R.A., Egwunatum, S.I. and Awodele, I.A. (2021a), "Green building materials products and service market in the construction industry", *Journal of Engineering, Project, and Production Management*, Vol. 11 No. 2, pp. 89-101.

Eze, E.C., Ugulu, R.A., Onyeagam, O.P. and Adegboyega, A.A. (2021b), "Determinants of sustainable building materials (SBM) selection on construction projects", *International Journal of Construction Supply Chain Management*, Vol. 11 No. 2, pp. 166-194, doi: 10.14424/ijcscm110221-166-194.

Field, A. (2005), *Discovering Statistics, Using SPSS for Windows*, Sage Publications, London.

Ghasemi, A. and Zahediasl, S. (2012), "Normality test for statistical analysis: a guide for non-statisticians", *International Journal of Endocrinol Metab*, Vol. 10 No. 2, pp. 486-489.

Gounder, S., Hasan, A., Shrestha, A. and Elmualim, A. (2021), "Barriers to the use of sustainable materials in Australian building projects", *Engineering, Construction and Architectural Management (ECAM)*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/ECAM-10-2020-0854.

Häkkinen, T. and Belloni, K. (2011), "Barriers and drivers for sustainable building", *Building Research and Information*, Vol. 39 No. 3, pp. 239-255.

Hair, J.F., Hult, G.T.M., Ringle, C. and Sarstedt, M. (2016), *A Primer on Partial Least Squares Structural Equation Modeling*, Sage Publications, London.

Heckathorn, D.D. (2011), "Comments: snowballing versus respondent-driven sampling", *Sociological Methodology*, Vol. 41 No. 1, pp. 355-366, doi: 10.1111/j.1467-9531.2011.01244.x.

Huang, L., Krigsvoll, G., Johansen, F., Liu, Y. and Zhang, X. (2018), "Carbon emission of global construction sector", *Renewable and Sustainable Energy Reviews*, Vol. 81 No. 2, pp. 1906-1916.

Hwang, B.G. and Tan, J.S. (2012), "Green building project management: obstacles and solutions for sustainable development", *Sustainable Development*, Vol. 20 No. 5, pp. 335-349.

Kaiser, H.F. (1974), "An index of factorial simplicity", *Psychometrika*, Vol. 39 No. 1, pp. 31-36.

Lim, Y.S., Xia, B., Skitmore, M., Gray, J. and Bridge, A. (2015), "Education for sustainability in construction management curricula", *International Journal of Construction Management*, Vol. 15 No. 4, pp. 321-331.

Marsh, R.J., Brent, A.C. and De Kock, I.H. (2020), "An integrative review of the potential barriers to and drivers of adopting and implementing sustainable construction in South Africa", *South African Journal of Industrial Engineering*, Vol. 31 No. 3, pp. 24-35, doi: 10.7166/31-3-2417.

Mohsin, A.H. and Ellk, D.S. (2018), "Identifying barriers to the use of sustainable building materials in building construction", *Journal of Engineering and Sustainable Development*, Vol. 22 No. 2, pp. 107-115, (Part-6), doi: 10.31272/jeasd.2018.2.87.

Mpakati-Gama, E.C., Wamuziri, S.C. and Sloan, B. (2012), "The use of alternative building materials in developing countries: addressing challenges faced by stakeholders", *World Construction Conference 2012 – Global Challenges in Construction Industry*, 28-30 June 2012, Colombo, pp. 266-275.

Nikyema, G.A. and Blouin, V.Y. (2020), "Barriers to the adoption of green building materials and technologies in developing countries: the case of Burkina Faso", *IOP Conference Series: Earth and Environmental Science*, Vol. 410, 012079, doi: 10.1088/1755-1315/410/1/012079.

Nwaki, W.N. and Eze, C.E. (2020), "Lean construction as a panacea for poor construction projects performance", *ITEGAM- Journal of Engineering and Technology for Industrial Applications (ITEGAM-JETIA)*, Vol. 6 No. 26, pp. 61-72, doi: 10.5935/jetia.v6i26.723.

Ofori, G. and Kien, H.L. (2004), "Translating Singapore architects' environmental awareness into decision making", *Building Research and Information*, Vol. 32 No. 1, pp. 27-37, doi: 10.1080/09613210210132928.

Onyegiri, I. and Ugochukwu, I.B. (2016), "Traditional building materials as a sustainable resource and material for low cost housing in Nigeria: advantages, challenges and the way forward", *International Journal of Research in Chemical, Metallurgical and Civil Engineering*, Vol. 3 No. 2, pp. 247-252, doi: 10.15242/IJRCMCE.U0716311.

Osaily, N.Z. (2010). The key Barriers to Implementing Sustainable Construction in West Bank –Palestine. MSc Thesis, submitted to the Robert Kennedy College/Zurich University of Wales/UK, March – 2010. available at: http://osaily.com/portal/wp-content/uploads/2017/05/The-Dissertation-Was-About-The-Key-Barriers-to-Implementing-Sustainable-Construction-In-West-Bank-Palestine.pdf

Pallant, J. (2005), *SPSS Survival Manual: A Step By Step Guide to Data Analysis Using SPSS for Windows (Version 12)*, 2nd ed., Allen & Unwin, Crows Nest NSW 2065.

Pallant, J. (2007), *SPSS Survival Manual: A Step-by-step Guide to Data Analysis Using SPSS Version 15*, 3rd ed., Open University Press, Milton Keynes.

Rydin, Y., Amjad, U., Moore, S., Nye, M. and Withaker, M. (2006), "Sustainable construction and planning", The Academic Report, Centre for Environmental Policy and Governance, the LSE SusCon Project, CEPG, London School of Economics, London.

Sheth, K.N. (2016), "Sustainable building materials used in green buildings", *The 9th International Conference on Engineering and Business Education (ICEBE) & 6th International Conference on Innovation and Entrepreneurship (ICIE)*, pp. 23-26.

Siegel, S. and Castellan, N.J. (1988), *Nonparametric Statistics for the Behavioral Sciences*, 2nd ed., McGraw-Hill, New York.

Spector, P.E. (1992), *Summated Rating Scale Construction: An Introduction*, Sage Publications, Newbury Park, CA.

Tabachnick, B.G. and Fidell, L.S. (2007), *Using Multivariate Statistics*, 5th ed., Pearson Education, Boston, MA.

Tan, W.C.K. (2011), *Practical Research Methods*, Pearson Custom, Singapore.

UCL Energy Institute (2015), "Buildings", available at: https://www.bartlett.ucl.ac.uk/energy/research/themes/buildings

UK Green Building Council (UKGBC) (2009), *Making the Case for a Code for Sustainable Buildings*, UKGBC, London.

Umar, I.A., Lembi, J.J. and Emechebe, L.C. (2021), "Assessment of awareness of Architects on sustainable building materials in Minna, Nigeria", *American Journal of Construction and Building Materials*, Vol. 5 No. 2, pp. 50-56, doi: 10.11648/j.ajcbm.20210502.12.

Xu, Y., Yeung, J.F.Y., Chan, A.P.C., Chan, D.W.M., Wang, S.Q. and Ke, Y. (2010), "Developing a risk assessment model for PPP projects in China – a fuzzy synthetic evaluation approach", *Automation in Construction*, Vol. 19 No. 7, pp. 929-943, doi: 10.1016/j.autcon.2010.06.006.

Zhang, H., Peng, Y., Tian, G., Wang, D. and Xie, P. (2017), "Green material selection for sustainability: a hybrid MCDM approach", *PLoS ONE*, Vol. 12 No. 5, pp. 1-26.

Supplementary material

The supplementary material for this article can be found online.

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