Article Title

Sustainable Construction Practice in Nigeria: Barriers and Strategies for Improvement.

Abstract:

Purpose: Amidst all solutions posited to address sustainable construction practices in Nigeria, the implementation plans are repudiated by sustainable barriers. This study examines and confirms the strategy with the most significant impacts on the identified barrier to Sustainable Construction Practice (SCP).

Design/Methodology/Approach: The study deployed a questionnaire survey to evaluate the perspective of 100 construction actors on the barriers and strategies of sustainable construction practice in Nigeria. Factor Analysis was employed to categorize key barriers and strategies into their underlying clusters for further analysis. Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to confirm the construct's significant relationship and magnitude, thereby establishing the strategies with the highest impacts on the barriers to sustainable construction practices.

Findings: The findings revealed three clusters of barriers and four groups of strategies to SCP , including technopolitic barrier, perception and awareness barrier, and sociocultural barrier. For the significant strategies, education and training, stakeholder regulation, incentive support and government and legislative support strategies were established. Overall, education and training strategy was identified as the most dominant and effective strategy to mitigate the barriers of SCP in Nigeria.

Originality/Value: The paper establishes education and training as the key strategy to achieving sustainable quest in the AEC industry. The practical implication is that policy makers, educators and professional bodies can harness sustainable knowledge transfer through education and training to improve sustainable construction practices in Nigeria.

Keywords: Sustainable construction practice, , Sustainability, Nigeria, Sustainability education; Climate literacy

Article Type: Research paper.

1. Introduction

Over time, the Nigerian construction sector has proven to uplift the economy through infrastructural project delivery across board, making huge economic impacts (Oke *et al*., 2018). The growth of the sector has significantly enhanced the national GDP, creating considerable employment, and opportunities for the citizenry (Saka and Lowe, 2010). In contrast, its activities have also been found to cause negative impacts through waste generation, water impoverishment and other forms of damage to the environment (Toriola-Coker *et al*., 2021). These adverse effects on construction cannot continue without curbing it through sustainable approaches in the construction industry. The construction industry has been an essential division for sustainable development because of its impacts on the environment (Ofori, 2007). Thus, this sustainable development has led to a critical change in building construction, providing an excellent economic standing to support social well-being in a conservative environment (Davies and Davies, 2017). These have become a necessary aspects of construction globally, as sustainability is related to achieving eco-friendliness (Aigbavboa *et al*., 2017).

According to Agenda 21 for Sustainable Construction Industry in emergent nations, the goal of sustainable construction is perceived to be a holistic concept striving toward rebuilding and harmonising the environment and the economy (Du Plessis, 2002). The concept focused on efficient resource utilisation and reduction of environmental impact, whilst the initial approach is concerned with technical issues than social-economic sustainability (Shafii *et al*., 2006). However, the effect on developing countries caused a low level of achievement, affecting the implementation of SCP. The implementation of this practice is affected by the barriers surrounding sustainability in the construction domain (Toriola-Coker *et al*., 2021). These barriers are vital to the adoption of SCP within the construction industry in Nigeria.

Previous studies on SCP in Nigeria are focused on the abilities of construction firms (Dania *et al*., 2014), sustainable health and safety practices in construction (Okoye and Okolie, 2013) and recognised barriers of sustainable construction (Daniel *et al*., 2018). Likewise, several barriers, such as poor knowledge, inadequate perception and awareness, and lack of legislation and government support to sustainable construction practice, have been identified by some authors as vital impediments to full implementation of sustainable construction practice in Nigeria. For example, the study of Osuizugbo *et al*., (2020) revealed poor government support and irrelevant laws and regulation as some of the barriers to sustainable construction.

However, amid the identified number of barriers enlisted from existing studies, several studies have failed to identify the strategies for engendering SCP within the same study. Also, many strategies were explored without confirmation of the most efficient measures. Hence, this study has taken a holistic approach by identifying the key barriers to sustainable construction practices, while also establishing the requisite measures for engendering SCP practices within the Nigerian construction industry. Thus, the ultimate goal of the study is to establish the most efficient strategy for tackling the barriers to sustainable construction practices in Nigeria. The study fulfils its aim through the following objectives:

1) To establish the major barriers impeding sustainable construction practices and establish strategies for driving its implementation.
2) To establish the most efficient measure for addressing the barriers to sustainable construction practice in Nigeria.

In order to understand the barriers and strategies of sustainable construction practice, the first phase of the study employs a quantitative approach to enquiry, using a questionnaire survey and exploratory factor analysis.. This helps to establish the key barriers and strategies ahead of estimating the impacts of the key strategies on the barriers to sustainable construction practices using Structural Equation Modelling (SEM) for confirmatory factor analysis. The following section reviews extant literature in SCP as a theoretical insight for this study. The methodological approach employed, which included data collection and analytical procedures, is justified, and described. The study’s literature review is presented before the design, research process, findings, and discussion.

The paper offers insight into factors and the key measure to be considered to overcome the barriers impeding the improvement of SCP. The relationship between various construct and latent factor are also presented. The study will assist policymakers and construction actors to understand the key strategy to improve SCP.

2. Literature Review

2.1 Barriers of Sustainable Construction Practices Implementation

In line with the concept of sustainable development, sustainable construction is an engineering construction process that assures basic human requirements and optimally utilises the available resources, mitigating negative impacts to realise environment protection of saving materials, energy and land (Hasan and Zhang, 2016). For effective implementation of sustainable construction, it is important to pin down possible retarding variables at the inception, so that stakeholders in the industry can successfully act professionally. One prominent barrier to SCP in developing countries is the lack of historical data and prototypes from which construction stakeholders can learn and build on (Oke *et al*., 2019). Studies from different countries identified this barrier and linked it to learning requirements (Aigbavboa *et al*., 2017; Oke *et al*., 2018). Ametepey *et al*. (2015) argued that lack of knowledge of construction actors stands as a hindrance to implementing sustainable construction, for example, in Ghana. This barrier affected the level of awareness and understanding of sustainability in the construction industry. Consequently, sustainability education was identified as the key to the adoption of sustainable practices in the built environment (Toriola-Coker *et al*., 2021).

Djokoto (2014) posited that resistance to change is also a crucial barrier inhabiting sustainable construction within the building industry. This barricade is placed by cultural background within the related environment, causing a barrier in adopting new ideals such as sustainable construction. Olawumi *et al*. (2018) identified resistance to change as one of the key barriers to adopting sustainability in the construction industry; this has caused the industry to operate in a one-way paradigm for a long time; thus, adopting changes might look unachievable especially when the approach in use is traditional. Nejati *et al*. (2017) suggested that resistance to change has a key moderating effect between green supply chain management and green human resource management, as this tends to hinder sustainable culture. Overall, there is resistance to change in any organisation, and managers must survive it (Graves *et al*., 2013).

Across the developed nations, governments are the major drivers of sustainability across sectors, including the construction industry (Ajayi and Oyedele, 2017). For instance, the United Kingdom government encourages waste minimization as an element of SCP through landfill tax as a penalty and green subsidy as an enabler (Ajayi and Oyedele, 2017). However, studies from Nigeria suggests that there is a dearth of government support. For instance, in Nigeria, there is no regulation on the quantity of waste sent to landfills and no proper context to guide and implement SCP (Osuizugbo *et al*., 2020).

2.2 Strategies for Enhancing Sustainable Construction Practices

For sustainability to be rooted in the construction industry, a sustainable plan must be driven by strategy within the industry stem, integrating sustainability into core business (Elmualim *et al*., 2012). The implementation of industrial strategy starts from the management to operational staff. According to Ikediashi *et al*. (2012), sustainable construction practices are achievable only by executives in top level management, providing requisite resources to mitigate challenges arising from adopting sustainable construction practices (Osaily, 2010). Mohammed and Abbakyari (2016) proposed strategies for achieving sustainable construction, focusing on the principle of sustainable design and construction. The principle revolves around conserving materials and resources, energy and environment, water conservation and quality. These principles improve sustainable practices, create awareness within the sector to benefit sustainable construction (Aigbavboa *et al*., 2017). Similarly, AlSanad (2015) and Opoku et al. (2015) stated that general cognizance and proper knowledge of sustainability command success and promote SCP. This is also echoed by an Indonesian study Fitriani and Ajayi (2022b), which posits that raising awareness through education and benchmarking is requisite to enhancing sustainable construction practices.

Regulation by the government is a requisite strategy in guiding construction practice, whilst implementing sustainable regulatory policies to improve SCP in the Nigerian construction industry (Aghimien *et al*., 2018; Fitriani and Ajayi, 2022b). Nwokoro and Onukwube (2011) posited that total compliance with sustainable policies is essential for attaining SCP in Nigeria. Through government collaboration with higher institutions and support (Daniel *et al*., 2018), sustainable regulation policies are enforced for sustainable construction (Oke *et al*., 2019). According to Aghimien *et al*. (2018), stringent government and legislative support on sustainability would propagate and enhance successful projects. Popularization and adoption of sustainable drivers through government intervention improve construction process productivity (Osuizugbo et al., 2020). Therefore, the implication of this action enhances proactive measures through the provision of strict government policy on sustainable construction (Osuizugbo *et al*., 2020). Considering incentive support through financial and non-financial support, Davies and Davies (2017) identified financial incentives as the main driver to sustainable construction practice. In the same vein, Daniel *et al*. (2018) suggested that incentives are vital for improving the practice of sustainability in the built environment. Conversely, Khalil *et al*. (2021) identify stakeholders' support as one of the key drivers to push sustainability in the construction industry to its climax. These stated drivers have their uniqueness in contributing to the improvement of SCP, as government impact through policies and laws enhance the quality of education and training for all construction actors in sustainable construction.

3. Methodology

3.1 Data collection

A quantitative research method was adopted using empirical questionnaire survey, which is an effective method to attain "quantifiability and objectiveness" (Ackroyd and Hughes, 1992). The barriers and drivers of SCP established from the literature review, as presented in Tables XXX, were used in developing the questionnaire, which was in three sections. The first section was the respondents' particulars, whilst the second section was the barriers to SCP, and the third section contained the strategies for driving SCP in the Nigerian construction industry. The respondents were asked to rate the criticalities of these barriers and strategies for SCP using a 5-point Likert scale (1= strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree). The questions were put on a scale to ensure the responses are summarised, averaged, and further analysed using different statistical methods (Nunnally and Bernstein, 2007). Hence, the questionnaire was administered through Google form to the experts whilst one hundred (100) questionnaires were returned by construction professionals who were sampled using random sampling method. Overview of the respondents, all of whom are members of registered professional bodies, is presented in Table 1.

Table 1: Overview of the respondents

3.2 Reliability Analysis

When employing the Likert scale on a questionnaire, the research instrument need to be verified using Cronbach's alpha coefficient (Nunnally and Bernstein, 2007). Using SPSS, the Cronbach's alpha coefficient for barriers is 0.864, while that of the strategies is 0.918. With the value, the data used for this study shows good reliability and internal consistency of the criteria, as Field (2013) posited that a Cronbach alpha value of 0.7 is valid.

3.3 Factor Analysis Technique

As a technique to reduce items, Factor Analysis (FA) was used to identify the underlying constructs, barriers, and strategies for SCP in this study. FA is a statistical method whose reason is to identify a relatively small number of item grouping that can be used to represent relationships among sets of many interrelated variables Field, 2013). To achieve the first objectives of establishing the major barriers and strategies for engendering sustainable construction practices, Factor Analysis was employed in this study. Doing this provides inputs for achieving the second objectives, which is aimed at establishing the strategies with the highest potentials of addressing the barriers.

According to Field (2013), the fitness of data for factor analysis is usually accepted using a few measures, including Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. With KMO, the sample adequacy is measured, representing the squared correlation between the variables to the squared correlation (Field, 2013). The KMO value ranged from 0 to 1. For a satisfactory FA to proceed, the KMO value should be above the threshold of 0.50 (Field and Miles, 2009). Bartlett's test of sphericity is a statistical test that accentuates the correlation between the variables. The value of the test is expected to be below 0.05 to be significant (Taherdoost *et al*., 2014). Hence, this shows whether the original correlation matrix is an identified matrix, which would indicate that there is no relationship among the variables, and hence FA would be unsuitable (Pett *et al*., 2003). Through this, 13 variables from both constructs; barrier and strategies that caused multicollinearity problem were excluded to meet the stated thresholds.

Once the suitability of the data for factor analysis was ascertained, with reduced data containing 24 barriers of sustainable construction practices in Nigeria, with the aid of SPPS, the KMO value for the construct is 0.709 significant at 0.001 respectively, confirming the suitability of the data for factor analysis. The data extraction and rotation were carried out using Principal Component Analysis and varimax respectively, requiring an Eigen value of 1 to be retained. The Factor Analysis resulted in seven-factor component explaining the significant measure that impede the improvement of sustainable construction practice in Nigeria. Based on the component factors, the seven underlying measures were labelled, and their Eigen factors and percentage of variance were taken as their measure of significance. The results are shown in Table 2. indicating the seven-factor solution that accounted for 62.739% of the total variance.

In the same vein, for strategies engendering sustainable construction practices, 25 strategies were suitable, whilst the KMO value for the construct is 0.836, significant at 0.001, confirming the suitability of the data for factor analysis (Field, 2013). The results produced five-factor components explaining the major drivers of SCP in Nigeria. Considering their component factors, five extracted factors were labelled, and their Eigen factors and percentage of variance were taken as their measure of significance. The result presented seven-factor solution accounted for 60.773% of the total variance, as further shown in Table 3.

3.4 Partial Least Squares-SEM

Structural Equation Modelling (SEM) is a generally used multivariate technique for testing the relationship between variables, and it encompasses factor analysis, regression analysis and path analysis (Hair et al., 2006). Aside from its combination of those sets of analysis, SEM estimate multiple interrelated relationships while considering measurement errors (Kline, 2010). It is also helpful in understanding model performance algorithms, as it provides a virtual representation of complex relations between constructs (Chen *et al*., 2012). In this study, PLS-SEM was adopted to estimate the impacts of the different strategies on the barriers to sustainable construction practices, as established through factor analysis. This helped to determine the most efficient strategies to be implemented towards engendering sustainable construction practices in Nigeria.

4. Data Analysis and Results

The barriers to sustainability practice refer to hindrances to the process and structure that lead to the failure of sustainability objectives in construction organizations. Identifying the barrier helps stakeholders adopt better strategies in integrating sustainability in various construction projects. Therefore, factor analysis is employed to identify the key variables and significantly reduce items into fewer dimensions to determine the main barriers and strategies of SCP. Tables 2 and 3 show the results of factor analysis for both barriers and strategies respectively.

Table 2: Exploratory factor analysis, means test and reliability analysis results

Table 3: Exploratory factor analysis, means test and reliability analysis results

The established barriers and strategies, as identified through exploratory factor analysis and presented in Tables 2 and 3 were then employed in the confirmatory factor analysis to establish the strategies with the highest potentials of mitigating the barriers to sustainable construction practices.

4.1 Assessment of Measurement Model

The model assessment aims to calculate the convergent validity of the variables. This was examined through factor loadings, composite reliability (CR), and the average variance extracted (AVE) (Hair et al., 2017). Internal consistency of the constructs was measured using composite reliability (CR). According to Herath and Rao (2009), 0.70 is the threshold criterion, and all the items (variables) involved in this study exceeded the threshold criterion. Moreover, the convergent validity of the constructs was assessed by the factor loadings and the average variance extracted (AVE). Barclay *et al*. (1995) noted that factor loadings are acceptable at 0.5 and above. The construct's item lower than 0.5 were deleted in the model and the deleted items were indented under the following constructs: managerial barrier, knowledge and information barrier, government-related barrier, content-related barrier and social awareness strategy. Likewise, the AVE value above 0.5 suggests an adequate convergent validity (Hair *et al*., 2017). All the items involved in this study had factor loadings and AVEs values above their recommended thresholds, as shown in Table 4.

Table 4: The result of measurement model (Loading and reliability)

4.2 Measurement Model for Sustainable Construction Practices

The study adopted a formative measurement model to examine the significant barriers of sustainable construction practices. According to Hair et al. (2017), measurement model helps the researcher measure how latent variables fit in regardless of their links with the indicators. Formative Measurement Model was used to weigh the collinearity among indicators (VIF<5) and also the weight significance (i.e., whether p-value is less than 0.05), threshold value of VIF less than 5 (Hair et al. 2017). The results from Table 5 and Figure 1 shows the value of VIF of all constructs which was less than 5. Therefore, collinearity is not an issue between the constructs and variables, and all formative constructs and p-value of the constructs are all significant at intervals.

In addition, in terms of the significance of each construct, the analysis reveals the importance and the path coefficient as well as bootstrapping to evaluate the significance (Hair et al., 2011) Smart PLS was used to examine the level of importance and the relevance of the construct (Ringle *et al.*, 2015). The greater the coefficient, the stronger the effect of the exogenous construct on the endogenous constructs (Hussain *et al*., 2018). Table 5 and Figure 2 reveal that all formative constructs' weights had significant t-value that provided empirical support to retain all the constructs (Hair *et al*., 2011). Table 5 also provides the confidence interval and p-values for the formative construct, providing additional evidence on the significance of the constructs. The result showed that education and training had the topmost path coefficient of 0.601 compared to other values in the model. It has a more excellent value of variance and a high effect on barriers to sustainable construction practice.

Table 5: Formative Indicator Constructs for Sustainable Construction

Figure 1: PLS Algorithm result for the sustainable Construction Constructs

Figure 2: PLS complete bootstrapping for the sustainable barrier and strategy

5. Discussion

5.1 Barriers to Sustainable Construction Practice

According to the findings of the present paper, three highly dominant groups of barriers hinder the achievement and promotion of SCP in Nigeria. The first set of barriers is technopolitics, which is related to politics and technical ideology of a group of construction professionals concerned about lack of technological knowledge and alternatives to advance political goals. Consequently, this was contextualised during worldwide adoption in the late 1990s. Furthermore, other barriers were perception and awareness centred on lack of sustainability knowledge in the built environment. Consequently, this barrier was spotted among the three most inhibiting barriers of sustainable practice in Indonesian (Fitriani and Ajayi, 2022). These barrier was considered deficient among professionals and most critical to sustainable construction implementation in Nigeria (Daniel *et al*. 2018). Thus, this aligns with the finding of AlSanad, (2015), who argued that most stakeholders are inexperienced in sustainable practice, this was identified as the key barrier to sustainable practices in Nigeria (Toriola-Coker *et al.*, 2021). Conversely. this barrier has regressively affected the economic and reportedly posed a threat to climatic literacy of sustainability.

5.2 Education and Training as the Key Strategy for Driving Sustainable Construction Practice.

With the path coefficient value of 0.601 at 95% confidence level shown in Table 5, education and training are the key strategies for driving SCP. This implies that by addressing sustainable education and training, the barriers to sustainable construction practices would be addressed. This is in line with the earlier findings that education and training are suitable divers for equitable economic growth (Omopariola *et al.*, 2019). Moreover, stakeholder perception and passion for learn and unlearning through conferences and workshops promote and improve the knowledge of sustainability practices in the built environment (Aigbavboa *et al*., 2017). Opoku *et al*. (2015) buttress the findings stating that the key and way to a successful implementation of sustainable construction practice is through proper education. In the same vein, Omopariola *et al*. (2019) identified education and training as the suitable driver to achieving SCP; this develops expertise for sustainable construction creating a driving force for awareness and transformation in the construction industry (Darko *et al*., 2018). Therefore, with the strength of this strategy, the barriers of sustainable construction have been traced to knowledge acquisition (Oke *et al*., 2019). For example, lack of perception and awareness, resistance to change and rigid ideology of actors to technological application all have the traits of knowledge that impact SCP.

5.3 The Nature of Sustainable Education and Level of Awareness in Nigeria

Education has gained the trajectory man has devised to shape his own future and establish a critical foundation for national growth and social-economic transformation (Okeke, 2014). Moreover, the transformation through education and adoption of sustainable tools have been recognised and used to drive sustainability in many developed countries where positive progress has been made. For instance, code of sustainable homes and several sustainable education programs have been used to drive sustainable construction practices in the UK (Ajayi *et al*., 2015). Considering sustainable tools, BREEAM, LEED and GBRS are widely used tools and assessment methods to measure the sustainability and building performance in the UK and USA. The categories in the BREEAM, LEED and GBRS include different types of environmental categories such as water, energy, pollution, material, maintenance, and management. Consequently, BREEAM, LEED and GBRS offer a reliable reporting measurement for sustainability, which support construction organisation in fulfilling their targets. However, despite the usability of these tools and methods in various developed countries, the awareness and the applicability of the Green Building Rating System (GBRS) is yet to be fully embraced by the public in Nigeria (Ade-Ojo, 2022).

The low level of sustainability awareness has become a significant barrier in developing countries like Nigeria (Tunji-Olayeni *et al*., 2018). Even by having sustainable tools, there is still a need to raise sustainability awareness through education. Shutaleva *et al*. (2020) highlighted the need for environmental education as all-time learning towards sustainable development practices. Alsaati *et al*. (2020) investigated sustainability awareness and conduct among college students and found that there is a lack of knowledge about sustainability. Therefore, it is critical to promote sustainability awareness among stakeholders through education. The pathway to realizing this sustainable awareness starts with acquiring knowledge from the institution. Education institutions are recognised as the principal agent of knowledge generation and transfer through teaching (United Nations 2012). Thus, there should be an active commitment from university management to lead the way toward sustainability practices. This will improve the adoption of the sustainability concept in universities, enhancing public awareness and understanding.

Furthermore, the professional bodies play a vital role in propelling the concept of sustainability within the built environment by providing educational routes and setting curricula of degree programs (Martin and Hall, 2002). In the UK, professional bodies like the Engineering Council have been actively updating the code of professional practice by adding sustainability standards into the course accreditation requirements. Through professional bodies involvement and support, practitioners are required to perform their functional roles according to sustainable guideline standards while performing their duty. Moreover, the professional association also engaged in developing a framework and organising international symposiums to build professional capacity for sustainable practices. For example, the UK's Chartered Institute of Building (CIOB) offers professional development programs in sustainability as part of their incentive for the Continued Professional Development (CPD) program for members. Green Building Council Nigeria (GBCN) promotes green, safe, and sustainable human settlements and industrial infrastructure in Nigeria (Abisuga and Okuntade, 2020). By using GREENSHIP grading systems, GBCN will give developers, professionals, and construction businesses context-based recommendations and criteria.

Apart from the GBCN, other professional bodies within the Nigerian construction sector are expected to champion the leadership for sustainable construction practices. For example, The Council for the Regulation of Engineering in Nigeria (COREN) is a regulatory body that practices and control the engineering personnel training i.e., Engineers, Engineering Technologist, Technicians, and consulting firms wishing to practice engineering. The professional bodies and GBCN are expected to promote sustainability practices and intensify awareness of sustainable development through national workshops and training, supporting and motivating stakeholders as they work towards the achievement of sustainable practices for long-term future. Furthermore, professional bodies are also expected to set minimum requirements for sustainability knowledge and competencies for new members, create case studies, and develop professional guidelines and best practices scenarios.

6. Conclusion

In an emergent nation like Nigeria, the rush to meet the massive need to build more buildings has increased the inherent adverse struggles of the construction sector in recent times. Consequently, this struggle has activated the urgent need for improving sustainability practices in the country. In the face of these efforts, the potent and workable strategy that can overcome the inherent barrier related to sustainability in the construction sector is expedient in promoting the full adoption of sustainable construction practices. To this end, this study aimed to examine and confirm the strategy with the most significant impact on the barrier to sustainable construction practices in the Nigerian construction industry. To achieve the aims, barriers and strategies related to sustainable construction were identified and grouped, by employing factor analysis on questionnaire responses received from 100 construction professionals . The factor analysis revealed that the underlying barriers for the 24 critical barriers were technopolitics, perception and awareness, sociocultural-related, managerial, knowledge and information, government-related and content-related barriers. In addition,, the underlying strategies for the 25 critical strategies were education and training, stakeholder regulation and support, social awareness, incentive support, and government and legislative support strategies. SMART PLS-SEM was then used to analyse the data to ascertain the most significant and dominant construct among the factorized underlying barriers and strategies of sustainable construction practices. The results reveal that technopolitics, perception and awareness and sociocultural barriers negatively influence SCP. Also, the results revealed that incentive support, education and training, stakeholders support, and government and legislative have a positive influence on SCP. Finally, the overall result revealed education and training as the most dominant and efficient measures for engendering sustainable construction practices in Nigeria, as it has the most significant impacts on the barriers to sustainable construction practices. The implication is that education and training are keys to promoting sustainability practice.

Along with the engagement of universities and professional bodies in building the awareness that will encourage the adoption of sustainable construction by industry actors, it is essential to address environmental concerns through framework enhancement and capacity building. To maintain sustainable development, capacity building should focus on knowledge transfer through education and training, which is essential for adopting sustainable approaches to construction. Also, the government as a supporter should prioritise policy that would help stakeholders develop capacity in sustainability especially, in the construction industry. The government and stakeholders should also set up strategic goals involving professional institutes and organisations to integrate sustainable development as requisite criteria into their professional accreditation and developmental plans. In addition to the strategies, the availability of a market is important to drive awareness, adoption, and improvement of sustainable construction. Green marketing could stimulate the use of tools and systems by emphasizing the potential environmental benefits through advertisement and promotion.

Due to the need for subduing the impacts of global warming and facilitating a healthy built atmosphere, adopting sustainable construction practices is an essential measure for the future of construction industry. Consequently, it is vital for the Nigerian construction industry to actively promote and provide support to the implementation of sustainability through the most significant confirmed strategies. This study has explored the underlying strategies for engendering and improving sustainability practices based on professionals' perspectives within the Nigerian context and is expected to fill knowledge gaps and provide the key strategy to promote sustainability practices. However, the finding of this study is limited to the Nigerian context only, with the finding emanating from Nigerian construction stakeholders. Future research could estimate the significance of education and training as a vehicle for driving sustainable construction practices in other nations.

Disclosure statement

No potential conflict of interest to report.

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Table 1: Barriers identified from previous studies

(Table by authors)

Barriers	**References**
Lack of alternative prevailing technology	Gupta *et al*. (2020), Djokoto et al. 2014
Lack of administrative policies ideology	Zhang et al. (2018)
Lack of business case understanding	Davies and Davies (2017) , Pitt et al. (2009)
Poor understanding of sustainable construction	Fitriani and Ajayi (2022) Aigbavboa *et a*l. (2017), Oke *et al*. (2019)
Poor perception of sustainable construction	Fitriani and Ajayi (2022)
Lack of resources barriers	Gupta et al. (2020), Choon Hua et al. (2005), Tai et al. (2009)
No role for initialising and leading sustainability	Toriola-Coker *et al*. (2021)
Ignorance of lifecycle cost benefits	Aigbayboa *et al*. (2017)
Poor skills among construction craftsmen	Toriola-Coker *et al*. (2021)
Lack of client demand	Pitt et al. (2009)
Lack of assessment method of sustainability	Häkkinen and Belloni, (2011)
Lack of commitment from professional bodies	Tunji-Olayemi *et al*. (2018), Aghimien *et a*l. (2019)
Missing of data required for sustainability	AlSanad (2015), David and Davies (2017)
Lack of knowledge to consider alternatives	Aigbayboa *et al*. (2017)
Lack of resource supervise building requirement	Toriola-Coker *et al*. (2021),
Lack of methods for sustainable building	Shafii et al. (2006), Dzokoto and Dadzie (2013)
Clients' preference for the traditional materials	Olawumi *et al.* (2018)
Lack of time to address sustainability issues	Sourani and Sohail (2011)
Lack of sustainability measurement codes	Davies *et al*. (2017), Fitriani and Ajayi (2022) Darko et al. (2018)
No method to verify compliance sustainability	Toriola-Coker *et al*. (2021)
Poor sustainability education in institutions	Aigbayboa *et al*. (2017), Tunji-Olayemi *et al*. (2018)
No input tariff for generation of renewable energy	Lu *et al*. (2020), Toriola-Coker *et al*. (2021),
Low priority on sustainability issues	Toriola-Coker *et al*. (2021)
Insufficient research and development	Sourani and Sohail (2011), Gan *et al*. (2015)

Table: 2: Strategies identified from previous studies

(Table by authors)

Strategies	**References**
Promotion of passive design approach	Gooroochurn *et al*. (2022)
Definition of stockholder roles in construction	Lam *et al*. (2010)
Team working approach to project delivery	Liu *et al*. (2019)
Sustainability development of client's awareness	Karvonen (2020), Fitriani and Ajayi (2022), Häkkinen and Belloni (2011)
Training on designing with materials	AlSanad (2015)
Environmental impact assessment	Aysin (2009)
Sustainability education at institutions	Fitriani and Ajayi (2022), Dahiru *et al*. (2013), Tunji-Olayemi *et al*. (2018),
Increase knowledge among politicians	Fitriani and Ajayi (2022)
Update existing regulation of sustainability	Pitt et al. (2009), Serpell et al. (2013)
Rating schemes to assess practitioners	Toriola-Coker *et al*. (2021)
Demonstration project and case studies	Toriola-Coker *et al*. (2021)
Creation of a new chartership route	Toriola-Coker *et al*. (2021)
Development of sustainable design appraisal standard	Small and Al Mazrooei (2016), Bond & Morrison-Saunders (2009)
Implementation of labelling and benchmarking	Lam *et al*. (2010)
Market creation for sustainable construction materials	Calkins (2008), Fitriani and Ajayi (2022),
Facilitating client awareness and commitment	Fitriani and Ajayi (2022)
Sustainability knowledge requirement for membership	Fitriani and Ajayi (2022),
System/tools to enable procurement as sustainability	Davies *et al*. (2017)
Introduction of levies on non-sustainable materials	Pitt *et al*. (2009)
Introduction of legislation to limit carbon	Toriola-Coker *et al*. (2021)
Introduction of subsidy for renewable energy	Kim (2021)
Subsidy for renewable energy resource	Kim (2021)
Improved construction with sustainability	Ayarkwa *et al*. (2017)
Integrating sustainability regulation	Serpell et al. (2013)
Introductions of pay policy	Davies *et al*. (2017), Hwang *et al*. (2017)

Table 3: Overview of the respondents

(Table by authors)

Roles	**Frequency**	**Academic qualifications**	**Frequency**
Architect	12	Graduate Degree (HND and BSc)	75
Builder	12	Master of Science (MSc)	18
Civil/ Structural Engineer	36	Doctorate Degree (PhD)	7
Construction Operative	2		
M & E Engineer	8	**Years of Experience (years)**	**Frequency**
Project Manager	8	1-5yrs	26
Quantity Surveyor	8	6-10yrs	26
Material Supplier	8	11-15yrs	24
Site Manager	4	16-20yrs	12
Others	2	21-25yrs	10
TOTAL	**100**	Above 25yrs	2
		TOTAL	**100**

Table 4: Exploratory factor analysis, means test and reliability analysis results

(Table by authors)

Extracted and Rotated Constructs/Items	Eigen value	% of variance	Factor loading	Mean value	Cronbach alpha	Cronbach alpha if item deleted
Technopolitics barriers	3.747	15.611			0.812	
Lack of alternative prevailing technology			0.844	3.40		0.723
Lack of administrative policies ideology			0.816	3.54		0.710
Lack of business case understanding			0.801	3.22		0.790
Perception & Awareness barriers	2.353	9.804			0.712	
Poor understanding of sustainable construction			0.791	3.38		0.723
Poor perception of sustainable construction			0.704	3.30		0.671
Lack of resources barriers			0.654	3.12		0.632
No role for initialising and leading sustainability			0.617	3.36		0.584
Ignorance of lifecycle cost benefits			0.569	3.58		0.694
Managerial barriers	2.202	9.177			0.663	
Poor skills among construction craftsmen			0.748	3.36		0.560
Lack of client demand			0.706	2.92		0.645
Lack of assessment method of sustainability			0.681	3.14		0.629
Lack of commitment from professional bodies			0.578	3.48		0.539
Knowledge/Information barriers	1.988	8.282			0.714	
Missing of data required for sustainability			0.860	3.44		0.658
Lack of knowledge to consider alternatives			0.753	3.20		0.536
Lack of resource supervise building requirement			0.713	2.96		0.684
Sociocultural barriers	1.758	7.325			0.635	
Lack of methods for sustainable building			0.760	3.28		0.467
Clients' preference for the traditional materials			0.707	3.52		0.469
Lack of time to address sustainability issues			0.637	3.40		0.649
Government-Related barriers	1.631	6.797			0.638	
Lack of sustainability measurement codes			0.680	2.60		0.620
No method to verify compliance sustainability			0.579	3.16		0.535
Poor sustainability education in institutions			0.578	3.70		0.527
Content-Related barriers	1.378	5.743			0.571	
No input tariff for generation of renewable energy			0.794	3.56		0.633
Low priority on sustainability issues			0.771	3.24		0.544
Insufficient research and development			0.522	3.58		0.562

Overall Cronbach's Alpha = 0.716

Table 5: Exploratory factor analysis, means test and reliability analysis results

(Table by authors)

Extracted and Rotated Constructs/Items	Eigen value	% of variance	Factor loading	Mean value	Cronbach Alpha	Cronbach's alpha If item deleted
Education and Training	6.849	27.398			0.887	
Promotion of passive design approach			0.770	3.94		0.864
Definition of stockholder roles in construction			0.763	3.47		0.861
Team working approach to project delivery			0.715	4.30		0.868
Sustainability development of client's awareness			0.699	3.91		0.873
Training on designing with materials			0.639	4.16		0.874
Environmental impact assessment			0.639	4.15		0.878
Sustainability education at institutions			0.612	4.13		0.879
Increase knowledge among politicians			0.610	4.35		0.886
Stakeholder Regulation/Support	2.256	10.025			0.815	
Update existing regulation of sustainability			0.814	3.64		0.767
Rating schemes to assess practitioners			0.734	3.84		0.769
Demonstration project and case studies			0.695	3.77		0.776
Creation of a new chartership route			0.612	3.62		0.797
Development of sustainable design appraisal standard			0.570	4.11		0.798
Implementation of labelling and benchmarking			0.569	3.72		0.808
Social Awareness	2.057	9.227			0.599	
Market creation for sustainable construction materials			0.642	4.00		0.513
Facilitating client awareness and commitment			0.619	4.01		0.581
Sustainability knowledge requirement for membership			0.609	3.96		0.500
System/tools to enable procurement as sustainability			0.603	3.37		0.598
Introduction of levies on non-sustainable materials			0.574	3.40		0.536
Incentive Support	1.869	7.476			0.689	0.612
Introduction of legislation to limit carbon			0.808	3.76		0.500
Introduction of subsidy for renewable energy			0.726	3.38		0.662
Subsidy for renewable energy resource			0.612	3.23		0.542
Government/Legislative support	1.662	6.647			0.629	
Improved construction with sustainability			0.770	3.94		0.524
Integrating sustainability regulation			0.639	4.37		0.510
Introductions of pay policy			0.633	3.62		0.566

Table 6: The result of measurement model (Loading and reliability)

(Table by authors)

Constructs	Item	Loading	λ	CR	AVE
Education and Training	Sustainability education at institutions	0.695	0.871	0.890	0.602
	Team working approach to project	0.737			
	Sustainability development of clients	0.752			
	Promotion of passive design approach	0.813			
	Training on designing with materials	0.682			
	Increase knowledge among politicians	0.533			
	Definition of stockholder roles	0.855			
	Environmental impact assessment	0.718			
Government /Legislative	Integrating sustainability regulation	0.839	0.680	0.704	0.608
	Introductions of pay policy	0.729			
	Improved construction with sustainability	0.767			
Incentive Support	Legislation to limit embodied carbon	0.780	0.686	0.717	0.615
	Subsidy for renewable energy resource	0.703			
	Financial incentives for energy resource	0.858			
Perception and Awareness	Poor understanding of sustainability	0.806	0.736	0.744	0.655
	Poor perception of sustainability	0.813			
	Lack of sustainable financial resource	0.801			
Sociocultural	Lack of time to address sustainability	0.818	0.649	0.731	0.740
	Client's preference for building service	0.872			
	Lack of method for sustainable building	0.519			
Stakeholder Regulation	Sustainable design appraisal standards	0.700	0.749	0.765	0.572
	Creation of a new chartership route	0.716			
	Update regulation of sustainability	0.743			
	Rating schemes to assess practitioners	0.857			
Technopolitics barriers	Lack of policies and support	0.815	0.812	0.883	0.727
	Lack of business awareness understanding	0.885			
	Lack of alternative prevailing technology	0.840			

Table 7: Formative Indicator Constructs for Sustainable Construction

(Table by authors)

Formative Construct/Variables	**Path Coefficient**	**T-Value**	**P-Value**	**Sig <p 0.05**	**95% Confidence intervals**	**VIF**
Perception & Awareness->Barrier	0.526	6.677	0.000	Yes	0.306(0.652)	1.136
Techno-politics->Barrier	0.532	6.429	0.000	Yes	0.365(0.683)	1.092
Sociocultural->Barrier	0.339	6.412	0.000	Yes	0.221(0.444)	1.209
Incentive->Strategy	0.225	5.929	0.000	Yes	0.158(0.292)	1.323
Government->Strategy	0.176	5.683	0.000	Yes	0.119(0.221)	1.187
Education & Training->Strategy	0.601*	15.531	0.000	Yes	0.527(0.651)	1.548
Stakeholders Regulation->Strategy	0.302	9.244	0.000	Yes	0.248(0.362)	1.403

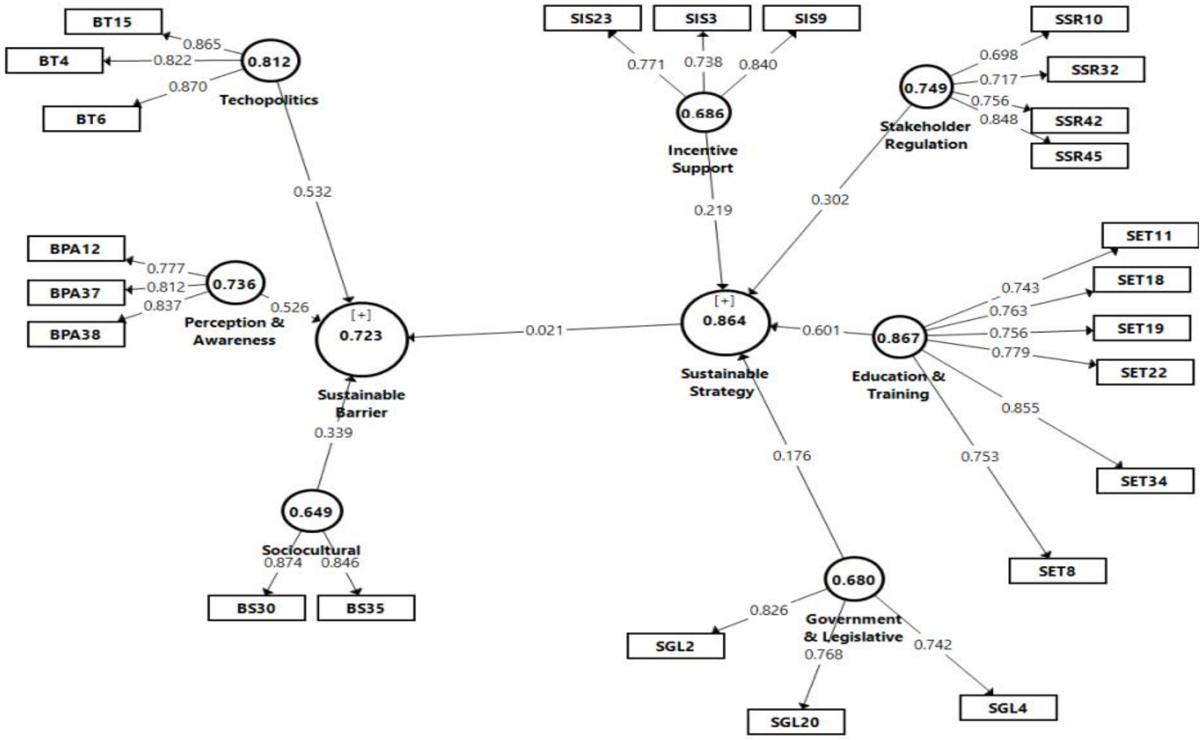

Figure 1. PLS Algorithm result for the sustainable Construction Constructs

(Figure by authors)

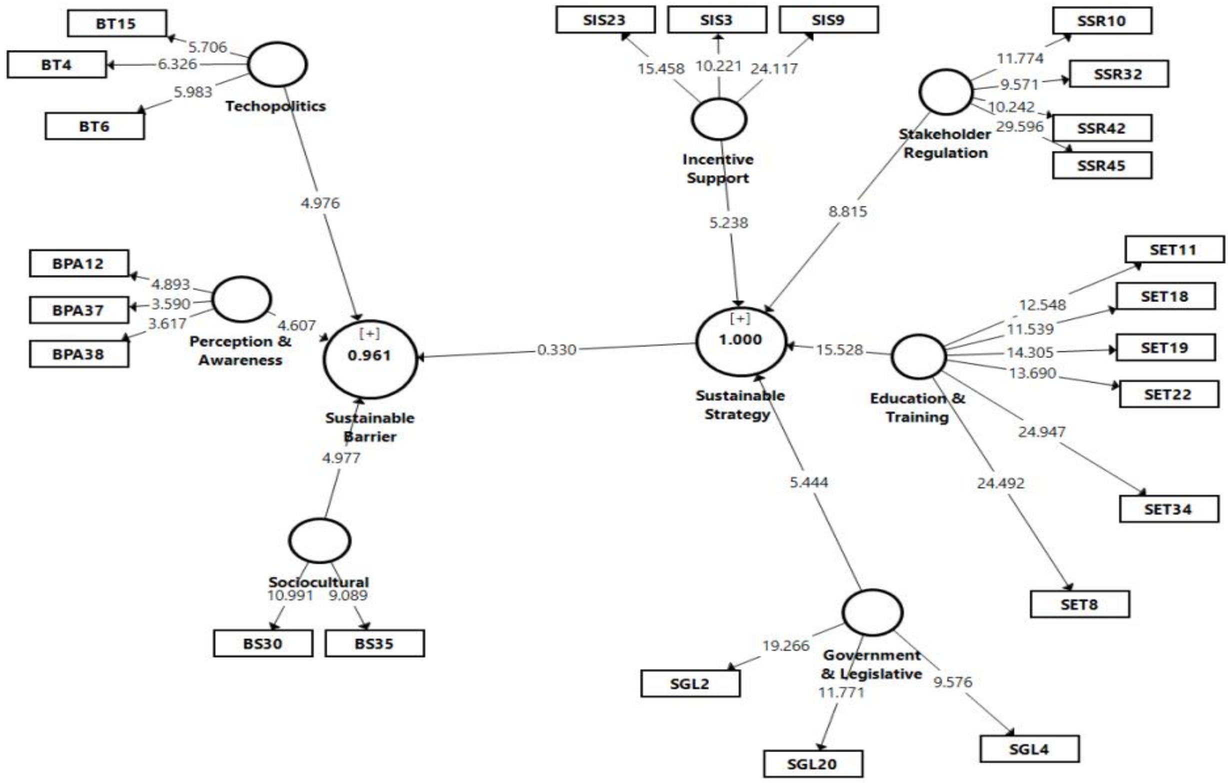

Figure 2. PLS complete bootstrapping for the sustainable barrier and strategy

(Figure by authors)