Barrier Factors Affecting Adoption of Green Building Technologies in Nigeria

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ABSTRACT

Greenhouse gas emission from activities in the built environment is increasing exponentially due to increase in building operations. This study aims at determining factors that affect adoption of Green Building Technologies that normally reduce greenhouse gas emissions. To elicit relevant information, online structured questionnaire forms were administered on practitioners who have been involved in green building development in Nigeria. Mean score ranking was adopted in ranking the barriers to green building technologies, while discriminant analysis was performed to examine how organizations groups (client, consulting, contracting, academia) were distinguished on the barrier factors identified. Findings revealed that, out of the 23 barrier factors considered in this research, lack of institutions to formulate policies and set guidelines (mean score - 4.5) ranked 1st as barrier to adoption of green building technologies in Nigeria. This is closely followed by lack of information about green products (4.0), low level of awareness about sustainability issues (4.0), human resource and client knowledge, lack of knowledge about green building technologies, high cost of green products, while unavailability of sustainable materials and products ranked the lowest (2.7). Only nine factors at 0.05 level of significance entered the discriminant analysis model and emerged as variables with the most significant power in differentiating the organization groupings on the basis of perceived barriers to adoption of green building technologies. The study recommends that there should be strong political will from government, to establish institutions that formulate policies on green building technologies.

Keywords: *Barriers, Green Building, Green Building Technologies.*

INTRODUCTION

Buildings are considered to be the largest driver for both energy use and carbon dioxide (CO_2) emissions and studies have shown that buildings and construction industry products accounts for about 40% of greenhouse gas emission (Geng, et al., 2017). According to Global Status Report, buildings and construction jointly account for 36% of global final energy use and 39% of energy-related carbon dioxide (CO_2) emissions (Global Status Report, 2019). The report suggested that the intensity per square meter (m^2) of the global buildings sector needs to improve on average by 30% by 2030 in order to be in line with global climate ambitions set out in the Paris Agreement. Therefore, buildings and construction sector should be a primary target for Green House Gas (GHG) emissions mitigation efforts. This trend is said to be lower in the underdeveloped and developing countries because of lower industrial activities compared to the developed economies. However, rapid economic growth and industrialization in these countries is pushing the GHG emissions to higher levels in developing economies (Ahmad, et al., 2016; Darko, et al., 2017). Consequently, the challenge to reduce the energy and GHG footprints of new and existing buildings is a very serious one. Additionally, Information and Communication Technology (ICT) adoption is spreading rapidly in developing countries and the buildings built and operated by ICT firms requires substantial quantity of energy and materials throughout their lifecycle (Nguyen, et al., 2017). Additionally, all completed building projects are expected to be energy efficient through the use of components that have limited negative impact on the environment (Arora, et al., 2014). However, the level of awareness and knowledge of Green Building Technologies adoption as a requirement for sustainable building development is low in the developing countries (Zainul-Abidin, 2010).

This article examines the adoption of Green Building Technologies (GBT) by the practitioners in construction industry. With the objectives of investigating the level of agreement among the industry practitioners on the barriers factors affecting the adoption of GBT. This study is important because knowledge of barriers to the adoption of GBT influences individuals and organizations ability and desires to incorporate GBT in their building projects. (Arora, et al., 2014) (author). In addition, adopting green innovations in construction activities will result in high performance and minimize their environmental impacts (Wang, et al., 2018). This will assist industry stakeholders in developing strategies to overcome the barriers in order to adopt the technological requirements for green buildings. on the other hand, demand plays an important role in the shaping and selection of new technologies (10). Sectors change over time in response to technological innovations. The specific focus of this study is to determine the barriers factors influencing the adoption of technologies that could enhance the performance of building buildings. This was achieved through the following questions:

1) What are the factors that can influence potentially beneficial technologies in green building development?
2) Is there agreement in the perspectives of industry practitioners about the barriers factors influencing the adoption of the identified technologies?
3) How does clients demand and government policies influence the adoption of green building technologies?

The research questions were addressed with quantitative approach, through questionnaire survey to organizations in the construction industry. The paper is organized as follows. Review of previous studies on Green Building Technologies adoption in the industry and how it affects the use of green building components and technology. followed by research method, data analysis, discussion of results and conclusions.

LITERATURE REVIEW

Green Building (GB) is referred to as a structure which is designed, built, renovated, operated, or reused in an environmentally friendly and resource-efficient manner. This concept is evolving rapidly and attracting the attentions of stakeholders globally. The need to promote sustainable development has made green building concepts to take front foot in the construction industry. Industry stakeholders are developing strategies to become more involved GB concepts. According to USEPA, 2016, Green building is defined as “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s lifecycle”. Working with this definition therefore, the development of green buildings would among other things result in substantial reduction of negative environmental effects and efficient utilization of resources in the overall interest of sustainable development. This realization has spurred the development of Green Building Technologies (GTBs) for enhancing sustainability during the entire life of building. Towards this end, several green building technologies have been developed to pave the way and ease the process for long-term practices in green and sustainable construction.

Features of Green Building Technologies

Ahmad *et al.* (2016) defined, GBT as technologies that are incorporated into building design and construction to make the end product sustainable, Zhang *et al.* (2011) identified some of the technologies as including solar system technology, green roof and wall technologies, and heat pump technology among others. According to Wang, et al., (2018) GBT is the general term of the products, measures, processes and technical means to be employed to accomplish the aim of "energy saving, water saving, land saving, material saving and one environmental protection" during the design process. Green building technologies should constantly be introduced into buildings to reduce the potentials for consuming electricity and harmful impact of the building on the surrounding environment. According to Chan, et al., (2017), the main specifications of the green building technologies are: efficient utilization of resources (energy, and water); enhancing and protecting the health and well-being of the occupants of buildings, and; reducing negative impacts on environment (waste, sewage, and pollution). For implementation of sustainable development objectives, new building are required to make use of green technologies such as equipment and systems that conserve the natural environment and resources (Chan, et al., 2017). These technologies can improve the performance of the buildings on environment, people, and economy (Bond, 2011). Ahmad et al. (2016) divided GBT into seven categories: indoor lighting technology, control technology, energy-saving and water-saving technology, renewable energy technology, energy and water recovery technology, air quality assurance technology and comfort zone temperature related technology.

Further, when GBT are incorporated into buildings, they have a lower carbon footprint and a reduced impact on the environment (Bond, 2011; Akadiri, 2015). Example of such technologies include Solar power, Biodegradable materials, Green insulation, the use of smart appliances, Cool roofs, Sustainable resource sourcing, Low-energy house and Zero-energy building design, Electrochromic Smart Glass, Water efficiency technologies, Sustainable indoor environment technologies, Self-powered buildings, Rammed Earth Brick (Akadiri, 2015; Wang, et al., 2018)

For a building to qualify as green building, it therefore requires the possession of some features, some of these as documented by Das, *et al.*, (2016) include the following:

Energy efficient equipment for air conditioning lighting system and use of onsite renewable energy

i. Reduction of building footprint to minimize the impact on environment
ii. Use of recycled and environmental-friendly building material
iii. Efficient use of water recycling
iv. Indoor air quality improvement for the safety and comfort of human
v. Installation of high efficiency irrigation methods and selection of vegetation which have low water consumption
vi. Recycling of construction debris to other sites
vii. Use of rapidly renewable materials
viii. Providing daylight and views for the occupied areas

All these constitute the qualities of a green building, achieving them requires a greater extent, the use of green building technologies and materials which in the construction industry are classified into four categories as shown in Table 1: Energy- comprising passive solar, heat pumps and solar energy. Water technology, their practice and adoption by all stakeholders in the construction industries is very important to achieve the overall goal of energy sufficiency, optimum resources utilization and sustainable development.

Table 1. Green Building Technologies

S/N	Types	Green building technologies
1.	Energy	Passive solar, heat pumps and solar energy (Ahn, et al., 2013; Ahmad, et al., 2016)
2.	Water technology	Grey and rain water and harvesting, aqueduct system (Akadiri, 2015; Geng, et al., 2017)
3.	Natural lighting	Design with retractable awnings and day lighting design (sunlight transportation systems, energy efficient light bulbs, compact fluorescent lights(CFL), light emitting diodes (LED), and sustainable lighting (Chan, et al., 2016; Chan, et al., 2017)
4.	Natural ventilation	Integrating natural ventilation system into building design (Mosly, 2015; Chan, et al., 2018)

Benefits of Green Building Technologies

Literature is replete with the various advantages of green building and its technologies. Geng, *et al.*, (2017) observed that conventional buildings are the largest drivers for energy use and Carbondioxide (CO_2) emissions while products in construction industry account for about 40% of greenhouse gas emission. Green building, is capable of averting these environmental impacts. According to Rumaithi and Beheiry (2016), green buildings permit other benefits such as lowering ecological effect and carbon footprint on the environment, healthier life style for residents and end users, higher service life, less water and energy consumption and less maintenance. These are however not possible except with the use of appropriate green building technologies. Das, et al., assert that among other benefits, green building reduces consumption of energy by 26%, and consumption of water by 54% (US General Services Administration Output). There was further agreement that it has capacity to reduce wastage of solids by 70% and provides health and safety to building occupants.

Barrier factors affecting adoption of Green Building Technologies

In spite of the numerous benefits associated with Green Building Technologies, studies have identified several factors that seriously threaten its adoption particularly in the developing countries. The main barriers for extensive adoption of green buildings technology in the construction industries includes higher initial costs of GBT, limited knowledge and skills on the part of subcontractors, interest and market demand, (Darko, et al., 2017; Hwang, *et al.*, 2017; Qian, *et al.*, 2015; Zhang, *et al.*, 2011), lack of knowledge and awareness of GBT and their benefits as well as resistance to change (Chan, *et al.*, 2016), lack of government incentives, and resistance to change. Qian, *et al.*, (2015); Ahmad, et al., (2016) revealed that barriers to adoption of GTBs also include limited availability of reliable green suppliers and lack of building codes and regulations, while Chan, *et al.*, (2017) identified lack of incentives, awareness and knowledge and experience. In order to appropriately address these barriers and efficiently promote the adoption of GBT, Das, *et al*., (2016) posits that proper strategies and policies must be devised for overcoming the barriers.

Chan, et al. (2018) conducted a study of the critical barriers to the adoption of GBT in developing countries. The authors identified 20 critical barriers, with the top three barriers as higher cost of Green Building Technologies; lack of government incentives, and lack of financing schemes. Using factor analysis, the barriers were further classified into five namely government-related, human-related, knowledge and information-related, market-related, and cost and risk-related barriers. The authors identified government related barriers as the most dominant among the underlying groups. Wang et al., (2018) adopted structural equation modeling to analyze key factors to Green Building Technologies adoption in developing countries, they found that adoption motivation, capability of GBT, knowledge structure and the defects of GBT are the important factors affecting design.

Darko, et al. (2017) identified resistance to change, lack of knowledge and awareness, and higher cost as the most critical barriers to the adoption of GBT. They considered the drivers for GBT adoption to be greater energy- and water-efficiency, and company image and reputation. Furthermore, they, pointed out that the most important strategies to promote the adoption of GBTs are finance, market-based incentives, availability of better information on cost and benefits of GBTs, green labeling and information dissemination

Mosly, (2015) studied the barriers to the diffusion and adoption of GBT in Saudi Arabia and classified the barriers into four groups namely: cultural and market, governmental, financial, and technical. The study found that lack of skill personnel and lack of government support and regulations were the most dominant factors inhibiting the diffusion and adoption of GBT in Saudi Arabia.

Research Method

In order to validate the survey instrument, the key barriers to green building technologies adoption identified from previous studies were summarized under twenty-three headings. These factors were further verified by three industry practitioners and a scholar who has been involved in sustainable/green building development research. The refined questionnaire was therefore used as survey instrument. Respondents were requested to rate their opinion on the 23 items used in measuring barriers to green building technologies adoption on a 5-point Likert Scale ranging from 1 – not at all a barrier to 5 - extreme barrier. The twenty-three items measuring barriers to green building technologies adoption were subjected to reliability test using SPSS version 20. A Cronbach Alpha value of 0.78 was obtained which shows that there is internal consistency among the twenty-three items. A purposive sampling approach was adopted on experienced professional in the North Central Nigeria. The email ID of the respondents were obtained through collaboration with various professional bodies such as Nigerian Institute of Architects (NIA), The Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Society of Engineers (NSE): Nigerian Institute of Builders (NIOB). A total of 373 professionals were contacted through e-mail to seek their participation in the online survey. Only 193 responded to the email, with 120 indicating previous involvement on sustainable construction project. Therefore, 120 copies of questionnaires were sent out to the respondents through online survey out of which 92 responded after repeated phone calls. This gives a response rate of 77%. This was considered adequate for this study. According to Archer (2008) the expected response rate from a web-based survey is dependent on the type of survey. The author pointed out that 48.3 percent is adequate based on the calculated response rate of 84 web-based survey deployed in the US over 33 months. For the data analysis, discriminant analysis was performed to examine how respondents were distinguished based on the items used in measuring barriers to Green Building Technologies adoption. The rationale for using discriminant analysis is based on the fact that group mean differences among organization groupings (client, consulting, contractor, academia) on perceived barriers to green building technology adoption was tested. Discriminant analysis is an appropriate statistical technique for testing for equality of group means and building a predictive model of group membership based on a set of observed discriminating variable (Hair et al., 1998). It is useful in determining whether a set of variables are effective in predicting group membership (Green et al., 2008).

RESULTS AND DISCUSSION

Respondents Demographic Information

About 38% of respondents are Builders, 30.4% (Quantity Surveyor), 16.3% (Engineer), and 7.6% Project Manager and Architects. In terms of educational qualification, 35.9% of respondents possess Masters' degree (MSc), 29.3% (Bachelor Degree), 20.7% (PhD) and 14.1 (Higher National Diploma). Out of this number, 39.1% are from consulting firms, while 30.4% are from academia, 22.8% (client) while 7.6% are contracting organizations. In terms of working experience, 38% have worked between 16-20 years, 30.4% between 6-10 years, 16.3% between 11-15 years and 7.6% more than 20 years.

Barriers to Green Building Technologies Adoption

The 23 items (barrier factors to green building technology adoption) were ranked through their mean scores (Table 2). The results, shows the highest mean obtained was 4.5 and the least 2 .7. The barrier factor that ranked 1st is 'lack of institutions to formulate policies and set guidelines' followed by 'lack of information about green products and high-performance building systems' (2nd), 'low level of awareness with regard to sustainability issues' (3rd), 'human resource and client knowledge' (4th) and the last 'unavailability of sustainable materials and products' (23rd).

Table 2. Mean Rank of Barrier Factors to Green Building Technologies Adoption

Code	Description of Item	Mean	Std. Dev.	Rank
BA_1	Lack of institutions to formulate policies and set guidelines.	4.4674	.63680	1st
BA_2	Lack of information about green products and high-performance building systems	4.0109	1.11429	2nd
BA_3	Low level of awareness with regard to sustainability issues	4.0000	.96077	3rd
BA_4	Human resource and client knowledge	3.9022	1.15844	4th
BA_5	Lack of knowledge about Green Building Technologies	3.8587	.77858	5th
BA_6	Industry Practitioners' awareness is low	3.8478	.661912	6th
BA_7	Higher costs of green products and materials	3.6957	.82194	7th
BA_8	Long payback periods,	3.6957	.82194	8th
BA_9	Tendency to maintain current practices,	3.6196	.73891	9th
BA_10	Limited subcontractors' knowledge and skills	3.6196	1.21205	10th
BA_11	Resistance to change,	3.6087	.49072	11th
BA_12	Lack of government incentives	3.4565	.84402	12th
BA_13	lack of research,	3.2174	.80964	13th
BA_14	lack of interest and communication amongst project team members	3.2174	1.12734	14th
BA_15	Lack of interest from clients and market demand	3.2174	.58977	15th
BA_16	Lengthy preconstruction	3.0761	1.14098	16th
BA_17	Uncertainty with green equipment and materials.	2.9239	.72980	17th
BA_18	Lengthy planning and approval process for new technology	2.9239	.82853	18th
BA_19	Lack of information and awareness	2.9130	.73607	19th
BA_20	Risks and uncertainties involved, unfamiliarity	2.9130	1.07573	20th
BA_21	Poor relationship between stakeholders	2.8370	.95247	21th
BA_22	Lack of building codes and regulations	2.8370	1.03007	22nd
BA_23	Unavailability of sustainable materials and products,	2.6848	1.06832	23rd

In the previous section, the barrier factors to green building technology adoption was ranked based on their mean scores. The first 12 barrier factors in order of their mean score starting from the highest B_1 (4.5) to B_12 (3.5) were subjected to further test via discriminant analysis. Thus, four group discriminant analysis was adopted to explore and test for possible differences in perception of respondents on barriers to adoption of Green Building Technologies in Nigeria. Specifically, the objective is to determine if there are significant mean differences in perception of respondents on barrier factors highlighted. A description of the 12 items is presented in Table 3.

Table 3. Barrier Factors to Green Building Technologies Adoption

Code	Barrier factors
B_1	Lack of institutions to formulate policies and set guidelines.
B_2	Lack of information about green products and high-performance building systems
B_3	Low level of awareness with regard to sustainability issues
B_4	Human resource and client knowledge
B_5	Lack of knowledge about Green Building Technologies
B_6	Industry Practitioners' awareness is low
B_7	Higher costs of green products and materials
B_8	Long payback periods,
B_9	Tendency to maintain current practices,
B_10	Limited subcontractors' knowledge and skills
B_11	Resistance to change,
B_12	Lack of government incentives

The results in Table 4 show the class means score differences among the four organization groupings (client, consulting, contracting, and academia). The class mean score is based on 12 variables used in assessing barrier factors to green building technology adoption. The result shows that the variables recorded Total Means (TM) range from 4.4 to 2.9 and total Standard Deviation (STD) ranging from 1.2 to 0.6. A closer look at the distribution of class means reveal that respondents from contracting organizations recorded highest mean score in most of the variables followed by those from client and consulting firms. Out of the 12 variables, those from contracting organizations, recorded highest mean score in 9 variables: B_1, B_3, B_6, B_7, B_8, B_9, B_10, B_11, B_12. The mean score of these variables is 5, which is an indication that respondents from contracting organizations perceived them to be extreme barriers to adoption of green building technology in Nigeria. On the contrary, respondents from the academia recorded lowest mean score in B_1, B_6, B_9 and B_11. They perceived B_1 (Lack of institutions to formulate policies and set guidelines), B_6 (Industry Practitioners' awareness is low), B_9 (Tendency to maintain current practices) and B_11 (Resistance to change) as not being major barriers to adoption of green building technology in Nigeria. Based on the test of equality of group mean (Table 4) 11 variables (B_1, B_2, B_3, B_4, B_5, B_6, B_7, B_8, B_10, B_11 and B_12) registered strong discriminatory power and therefore contributed significantly in differentiating the four organization groups on the basis of perceived barriers to green building technology adoption in Nigeria. The variables F values range from 86.5 (highest) to 4.0 (lowest) $p<0.05$. One variable B_9 ($F= 2.1$, $p>0.05$) (Table 3) revealed poor discriminatory power, thus no significant differences were recorded among the groups.

Table 4. Group Mean Scores

		Client	Consulting	Contractor	Academia	Tests of Equality of Class Means		
Items	TM (TD)	CM (CD)	CM (CD)	CM (CD)	CM (CD)	Wilks' Lambda (Λ)	F	Sig.
B_1	4.00000 (.9607)	4.66667 (.4830)	4.00000 (1.0954)	5.00000 (.0000)	3.25000 (.4409)	.618	18.127	.000
B_2	3.84783 (.661912)	3.00000 (000000)	4.19444 (.401386)	4.00000 (.0000)	4.00000 (.720082)	.493	30.217	.000
B_3	4.01087 (1.1142)	4.66667 (.483046)	4.02778 (.6540)	5.00000 (.0000)	3.25000 (1.5061)	.716	11.641	.000
B_4	3.85870 (.7785)	4.66667 (483046)	4.02778 (.654047)	3.00000 (.0000)	3.25000 (.4409)	.451	35.680	.000
B_5	3.69565 (.8219)	4.33333 (483046)	3.61111 (.8027)	4.00000 (.0000)	3.25000 (.8443)	.756	9.472	.000
B_6	3.69565 (1.1409)	4.33333 (483046)	3.80556 (.401386)	5.00000 (.0000)	2.75000 (.4409)	.253	86.597	.000
B_7	3.07609 (.8285)	2.66667 (4830)	2.80556 (.7490)	5.00000 (.0000)	3.25000 (1.5061)	.722	11.284	.000
B_8	2.92391 (.4907)	2.33333 (4830)	3.00000 (.6324)	5.00000 (.0000)	2.75000 (.4409)	.383	47.282	.000
B_9	3.60870 (.8440)	3.66667 (4830)	3.58333 (.5000)	4.00000 (.0000)	3.50000 (5091)	.932	2.150	.100
B_10	3.45652 (1.2120)	2.33333 (4830)	3.77778 (.4216)	5.00000 (.0000)	3.50000 (5091)	.276	76.965	.000
B_11	3.61957 (.6368)	4.00000 (0000)	4.00000 (6324)	5.00000 (.0000)	2.50000 (1.5275)	.576	21.594	.000
B_12	4.46739 (.8219)	4.33333 (4830)	4.61111 (4944)	5.00000 (.0000)	4.25000 (.8443)	.880	4.002	.010

TM = Total Mean; **TD** = Total Standard Deviation;
CM = Class Mean and **CD** = Class Standard Deviation

Predicting Discriminant Function for Class Perceived Barriers to GBT Adoption

The aim in this section is to identify significant predictive variables that best differentiate the perceived barriers to green technology adoption based on four organization groupings. Thus, a model that best predicts where the organization groupings belong was developed. In achieving this, all the 12 variables measuring barriers to green building technologies adoption were subjected to stepwise method in order to select the variable that maximizes the overall Wilks'Lambda at each step. The results in Table 4 show at 0.05 level of significance only 9 out of the 12 variables entered the model and emerged as the variables with the most significant power in differentiating the organization groupings on the basis of perceived barriers to green building technology adoption. The variables in order of their magnitude are: B_6, B_10, B_12, B_7, B_9, B_11, B_4, B_5 and B_3. What could be inferred from this result, is that B_6 (Low awareness among industry practitioners), B_10 (Limited subcontractors' knowledge and skills), B_12 (Lack of government incentives) are some of the major variables that distinguish the organization groupings on the account of perceived barrier to green technology adoption. Looking at the function of group centroid (Table 4) the first discriminatory function (DF1) which accounts for 91.3% variance in the model separates the organization groups (client -26.478, consulting 1.180, contractor 58.671 and academia 3.673) on barriers towards green building technology adoption. Adopting a zero cut-off (mid-point) whereby a movement above zero signifies (+) and below (-), results (Table4) show that respondents from contracting organization, academia and consulting (DF1 =58.671, 3.673 and 1.180) perceived these 9 barriers as being extreme. In other words, these are major barriers impeding the adoption of Green Building Technologies. On the contrary, respondents from client organization with negative value (DF1 client -26.478) perceived these factors highlighted as not being barriers to green building technology adoption.

Table 5. Variables entered through stepwise

Step	Entered	Statistic (Approximate F)	Sig.
1	B_6	86.597	.000*
2	B_10	80.758	.000*
3	B_12	64.435	.000*
4	B_7	93.792	.000*
5	B_9	86.620	.000*
6	B_11	92.949	.000*
7	B_4	101.284	.000*
8	B_5	165.403	.000*
9	B_3	349.439	.000*

Functions at Group Centroids (B_6, B_10, B_12, B_7, B_9, B_11, B_4, B_5, B_3)

Organization Group	**D F1**	**DF2**	**DF3**
Client	-26.478	3.388	-1.583
Consulting	1.180	4.026	1.404
Contractor	58.671	6.511	-2.276
Academia	3.673	-9.345	-.049
Eigenvalue	445.981[a]	40.526[a]	1.818[a]
Chi Square (X^2)	918.075	402.412	87.538
% of Variance	91.3%	8.3%	0.4%

Classification Accuracy (hit ratio) = 100%

DF1 = First discriminant function,
DF2 = Second discriminant function,
DF3 = Third discriminant function

CONCLUSION

In climate change debate, energy use during construction of private and public buildings and the attendant carbon dioxide emissions have dominated policy dialogue among stakeholders. In order to address the problem associated with energy use in buildings, the concept of green building (GB) which incorporates designing, building, operating or reusing a building in an environmentally friendly and energy efficient manner was developed in late 20th century. The premise behind this concept is that, the design and type of materials used will significantly affect energy use during construction and on the other hand, determine energy consumption of the building throughout its life cycle. Thus, this study examined the factors professionals in building and construction industry in Nigeria perceived as major barriers to green building technologies adoption. Findings from the study revealed that lack of institutions to formulate policies and set guidelines ranked 1st among the barriers to green technologies adoption followed by lack of information about green products, low level of awareness with regard to sustainability issues and human resource. In most developing countries, Nigeria inclusive, there is absence of green building regulatory body (Green building index) to formulate policies on how green building technologies could be applied in construction industry to enhance efficient energy use and sustainable environment. This is one major challenge hindering green technologies adoption in Nigeria. As revealed from the findings of the study, information about green products is lacking and this could be linked to the first factor highlighted. Also findings from the study through discriminant analysis revealed that organization groupings (client, consulting, contracting, and academia) varied in their perception of barriers to green building technologies adoption. Respondents from contracting, academia and consulting organizations perceived 9 barriers (lack of institutions to formulate policies, low awareness among industry practitioners, limited knowledge and skills, lack of government incentives, resistance to change, human resource and client knowledge, lack of knowledge about green building technologies and low level of awareness about sustainability issues) as strong barriers mitigating against green building technologies adoption in Nigeria. On the contrary, respondents from client organization perceived the effect of these factors as being moderate to adoption of green building technologies. The findings from this study on identification of barrier factors affecting the adoption of green building technologies by practitioners in the construction industry will assist industry stakeholders in establishing approaches to overcome the barrier factors so as to enable built environment professionals to adopt green building technologies in building project implementation. Future research work is required to investigate the capacity of the various organizations to adopt green building technologies in order to reduce the greenhouse gas emission in the built environment. Similarly, it is important to investigate leadership roles in ensuring that industry stakeholders are provided with the enabling environment to ensure seamless transition from the use of conventional building components to the adoption of green building technologies.

REFERENCES

Ahmad, T., Thaheem, M. & Anwar, A., 2016. Developing a green building design approach by selective use of systems and techniques. Architectural Engineering and Design Management, 12(1), pp. 29-50.

Ahn, Y., Pearce, A., Wang, Y. & Wang, G., 2013. Drivers and barriers of sustainable design and construction: the perception of green building experience. International Journal of Sustainable Building Technology and Urban Devevelopment , 4(1), pp. 35-45.

Akadiri, P. 2., 2015. Understanding barriers affecting the selection of sustainable materials in building projects. Journal of Building Engineering, Volume 4, pp. 86-93.

Arora, S. et al., 2014. Drivers of technology adoption — the case of nanomaterials in building construction. Technol. Forecast. Soc. Change, Volume 87, pp. 232-244.

Bond, S., 2011. Barriers and drivers to green buildings in Australia and New Zealand. Journal of Property Investestment and Finance, 29(4/5), pp. 494-509.

Chan, A. C., Darko, A., Olanipekun, A. & Ameyaw, E., 2018. Critical barriers to green building technologies adoption in developing countries: The case of Ghana. Journal of Cleaner Production, Volume 172, pp. 1067-1079.

Chan, A., Darko, A., Ameyaw, E. &., 2017. Strategies for promoting green building technologies adoption in the construction industrydan international study. Sustainability, 9 (6), p. 969.

Chan, A., Darko, A. & Ameyaw, E., 2017. Strategies for promoting green building technologies adoption in the construction industrydan international study. Sustainability, 9(6), p. 969.

Chan, A., Darko, A., Ameyaw, E. & Owusu-Manu, D., 2016. Barriers affecting the adoption of green building technologies. Journal of Management Engineering. 33 (3) 10.1061/(ASCE)ME.1943-5479.0000507., 33(3), pp. 1943-5479.

Darko, A. Chan, A.P.C, Ameyaw, E.E. Hec, B. & Olanipekun, A.O. (2017). Examining issues influencing green building technologies adoption: The United States green building experts' perspectives. Energy and Buildings, Volume 144, pp. 320-332.

Darko, A. Chan, A.P.C., Gyamfi, S. Olanipekun, A.O., He, B.J., & Yu, Y (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. Building and Environment, Volume 125, pp. 206-215.

Geng, X., Wen, Y., Zhou, C. & Xiao, C., 2017. Establishment of the sustainable ecosystem for the regional shipping industry based on system dynamics sustainability. Sustainability, Volume 9, p. 742.

Global Status Report, 2019. 2019 Global Status Report for Buildings and Construction Towards a zero-emissions, efficient and resilient buildings and construction sector, s.l.: Global Aliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme.

Gou, Z., Lau, S. & Prasad, D., 2013. Market readiness and policy implications for green buildings: case study from Hong Kong. Journal of green Building, 8(2), pp. 162-173.

https://www.worldgbc.org/news-media/global-status-report-2017, , 2017. World Green Building Council. [Online]

Available at: Global Status Report 2017

[Accessed 23 December 2019].

Green, S.B., Salkind, N. J. & Akey, T. M. (2008). Using SPSS for windows and macintosh: Analyzing and understanding data. New Jersey: Prentice Hall.

Hair, J. F. Jr., Anderson, R. E., Tatham, R. L. & Black W. C. (1998). Multivariate data analysis. 5th Ed. New Jersey: Prentice Hall.

Hwang, B. & Ng, W., 2013. Project management knowledge and skills for green construction: overcoming challenges. International Journal of Project Management, 31(2), pp. 272-284.

Hwang, B. & Tan, J., 2012. Green building project management: obstacles and solutions for sustainable development. Sustainable Development, 20(5), pp. 335-349.

Hwang, B., Zhu, L. & Tan, J., 2017. Green business park project management: barriers and solutions for sustainable development. Journal of lean Production, Volume 153, pp. 209-219.

Mosly, I., 2015. Barriers to the Diffusion and Adoption of Green Buildings in Saudi Arabia, Journal of Management and Sustainability; Vol. 5, No. 4, 5(4), pp. 104-114.

Mulligan, T., Mollaoglu-Korkmaz, S., Cotner, R. & oldsberry, A., 2014. Public policy and impacts on adoption of sustainable built environments: learning from the construction industry playmakers. Journal of Green Building, 9(2), pp. 180-202.

Nguyen, H. Skitmore, M., Gray, M., Zhang, X, Olanipekun, A.O. (2017). Will green building development take off? An exploratory study of barriers to green building in Vietnam. Resource Conservation Recycle, Volume 127, pp. 8-20.

Ofori, G. & Kien, H., 2004. Translating Singapore architects' environmental awareness into decision making. Building Resource Information, 32(1), pp. 27-37.

Qian, Q., Chan, E. & Khalid, A., 2015. Challenges in delivering green building projects: unearthing the transaction costs (TCs). Sustainability, 7(4), pp. 3615-3636.

Shen, L., Zhang, Z. & Long, Z., 2017. Significant barriers to green procurement in real estate development. Resource Conservation Recycl, Volume 116, pp. 160-168.

United States Environmental Protection Agency, 2017. Definition of Green Building. [Online]

Available at: https://archive.epa.gov/greenbuilding/web/html/about.htlm

[Accessed December 2019].

Wang, W., Zhang, S., Su, Y. & Deng, X., 2018. Key Factors to Green Building Technologies Adoption in Developing Countries: The Perspective of Chinese Designers, Sustainability, Volume 10, p. 4135.

Zainul-Abidin, N., 2010. Investigating the awareness and application of sustainable construction concept by Malaysian developers. Habitat International, Volume 34, pp. 421-426.