Benefits of Using Green Materials for the Construction of Low-Cost Building in Nigeria

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Abstract:
The earth and recycle materials have been in utilisation for the construction of building at a reasonable price by human being from time immemorial. Conversely, in the resent time the cost of building has increased to the extent that is now beyond the power of lower and middle class to construct or buy building of their own. Therefore, this paper assesses the benefits of using green materials for erection of structure at affordable prices. Four hundred structured survey instrument questionnaires were prepared and distributed through purposive sampling to construction professionals in the north-central part of Nigeria, seeking their views on the benefits of using green materials towards provision of building at reasonable price. The responses received were analysed using analysis of moments structure (AMOS) through structural equation model (SEM). The results show that green material is cost-effective, readily available, energy efficiency, reduced cost of construction, reduced waste, improved the economy of the community promotes cultural heritage, adaptable to the environment, eco-friendly, enhance social wellbeing, and reduced carbon dioxide emission. Consequently, a combination of green materials with conventional materials will promote delivery of more buildings to the citizenry at reasonable cost.

Keywords: *Green Materials, Affordable price, Building, Benefits, Structural equation model, Nigeria.*

INTRODUCTION

The ambition of people to construct the house of their own or ability to own residential property is very high, but this remains a mirage due to high cost of conventional materials. This problem forms the main reason of carried the research in other to proffer solution through the application of an alternative materials term green materials. There are different forms of the definition of green materials by various scholars, some defined it as sustainable materials that are environmentally friendly while others feel that they are materials that are natural and subjects to reuse and recycle in building construction. According to green building team (2011), green materials refer to sustainable material that gave high performance and save the precious environment.

Fithian and Sheets (2009) said as long as materials have an affirmative effect on the environment that materials could be described as green. Since building with conventional material at affordable rates becomes an issue in recent times, thus re-introducing green materials as alternative material will no doubt ease the flight of low-income earners in the country.

Therefore, green materials are natural and recycled materials such as earth bricks, bamboo, recycle materials and waste, etc. that are readily available within our environment. The socio-economic benefits of these materials were assessed in this paper, and the results of the Structural Equation Model (SEM) were subsequently discussed.

Affordable Building

Building construction cost in the 21st current century remained very high to the extent that it is now difficult for the low and middle-income earners to facilitate or construct building of their own at an affordable rate; as a result of this there is a lot of abundant or uncompleted buildings are within the community across the nation. The perception of building at a reasonable and economical cost is a challenging matter and remains a persistent and extensive difficult for

several nations (Mulliner & Maliene, 2012). Internationally, accommodation affordability is defined in many ways. The most common definition of affordable building is referred to the housing affordability is taken as a measure of spending on construction or buying housing to income of the household (Gopalan & Venkataraman, 2015a). Affordable building as an element that can be afforded by that segment of people whose income is lower than the middle household revenue and it was also defined by Karan and Manish (2016). the Us and Canada defined it as the ability of potential owner to have a building of his own at a cost not more than thirty percent of his income annually.

Esruq-Labin *et al*, (2014) described an inexpensive building as a notion that is used to describe socio-economic and growth environs, that purpose of certifying if building to be developed for people can be achieved at an affordable cost by the target group of people within the low and middle-income earners. According to UNIDO, (2018), there is major problem in the provision of adequate housing to the populace globally. It was revealed that many people across all types of urban centres could not afford to have a building of their own or even afford the cost of paying rent.

In the study carried out by Tajudeen & Basirat (2017), it was discovered that materials and construction methods adopted in accomplishing the building have a significant effect on the expensiveness and unaffordability of building to members of the society. In Malaysia, Osman *et al.*, (2017) established in a study that notwithstanding the existence of inexpensive housing strategy for the State of Johor, housing cost remains at higher cost which makes difficult for majority of the people to achieve the aim of having personal house, and this reflected in the fact that the housing index for some of the area was harshly excessive amounts and mainly tricky for the people of the state to accommodate.

Green Building Materials

The building materials are one of the significant components in the construction industry that determines the overall total cost of constructing building as it constitutes the most substantial single input in executing a project (Ben, & Chioma, 2015). As a result of the escalated price of the conventional materials, stakeholders in the building industry now suggest alternative materials known as green materials to reduce the overall cost of construction (ManjeSrivastavash & Kumar, 2018, Jasvi & Bera, 2015, Mukiibi, 2015, Jasvi & Bera, 2015). Accordingly, potential green materials are materials that are locally oriented and renewable that are environmentally friendly; they composed of renewable rather than non-renewable resources (Mahmoud, 2016). It was further revealed by Mahmoud (2016) that mixing of the natural materials into the construction of housing could mitigate the effect of the environment problem links with the production, conveyor, processing assembly, construction, recycle, reuse, and discarding of these materials.

In a study, Bredenoord (2017) suggested the following as promising building materials for the construction of affordable housing:

- Bamboo/Timber
- Compressed earth bricks
- Adobe blocks
- Recycle materials
- Improved concrete panel

Figures 1, 2, and 3 show some of the available green materials in Nigeria. Bamboo are materials that are generally available in Nigeria, they are multi purposely use in construction of building at various stage of the building projects, in addition is it tension strength that has been established by materials expert to be more than that of mild steel (Kayode & Olusegun, 2013,

Alade *et al*., 2018). According to Atanda (2015) bamboo is known to be one of the most fasted growth plants in the world and now been considered as a replacement of steel and wood in construction activities.

Timber is also a common material that is used for formwork, support, roof trusses, and scaffolding in building construction process, it is available in various sizes and types (see Figure1) at a reasonable price depending on the specification required (Magutu 2015, Tam, 2011, Odeyale & Adekunle, 2008).

Fig 1: Various sizes of planks

Compressed earth brick is made from selected soil and has been the first building materials since the existence of humans. The technology of compressed earth bricks has, in recent times increased and may be used to produce housing at affordable, durable and robust (Gohnert, Bulovic, & Bradley, 2018). According to Jackson & Dhir (2016), the materials for bricks are readily available, produced in mass and required little or no maintenance with high durability and load-bearing capability.

Figure 2: Earth brick column and walls

Benefits of Green Materials

The benefits of green materials are numerous and readily available in most of the countries across the globe. The introduction of green materials brings the cost of constructing a structure to the barest minimum and more cost-effectiveness as well makes accommodation affordable for more people in society (Ugochukwu & Chioma, 2015). According to Zami, (2008) rammed earth wall is 40% lower than the cost of standard stud wall including labour cost. Zami stressed further that there are other benefits such pleasant comforts and energy efficiency and

unseen ecological benefit like enhance more oxygen to the environment. Oshike, (2015) postulated that green materials such as earth has a comparative environmental advantage over the building constructed of conventional material

Figure 3: Thatches in stock with roof in place

In the study carried out by Danso (2013), obtainability and affordability, among other advantages are some of the significant benefits of using green material in building construction in Ghana. Zami (2008) concludes that the flexibility and simplicity in technology of the usage of green materials promote the transfers of knowledge between the stakeholders in the building industry, individuals and communities at large can easily participate in the activities of constructing their building at an affordable cost.

The summary of the previous study on the benefits of green materials was presented in Table 1.

Table 1: Previous study on the benefit of green materials

No	Author(s)	Objectives of the study	Outcomes of the study
1	Gohnert, Bulovic, & Bradley (2018) South Africa	The need to develop low-cost housing alternatives to make housing more affordable to people	Green materials as an economical solution to the provision of building at affordable cost
2	Danso H. (2013) Ghana	To examine and analyse the benefit and problem of houses constructed with local materials in developing country	Promotion of cultural heritage, readily available, temperature regulation, affordable and cheap
3	Kumar, Gupta, Sagar, Singh, & Haroon, (2017) India	To review the alternative construction materials and techniques for building design	It was established that fly ash brick, one of the green materials is comparatively low cost than the conventional bricks
4	Adegun & Adedeji, (2017) Nigeria	To review the economic and environmental advantages and disadvantages of earthen materials for housing in Nigeria	The earthen construction material discovered to have benefit of cost and cost to the environment.
5	Shen, Yang, Zhang, Shao, & Song, (2019) China	Assessment of bamboo benefit and barrier for promoting bamboo as a green material in china	The benefits of using bamboo are summarised as; low cost, large scale and fast growth, lightweight and high strength, environmentally friendly, and socio benefit.

METHODOLOGY

Survey questionnaire was prepared and distributed to Nigerian Building Construction practitioners. During the conduct of this research, questionnaires were distributed to Nigerian Building Construction professionals; comprising of the Architects, Quantity Surveyors,

Builders and Civil Engineers who were duly registered members of different organizations and practicing in the building construction industry. The questionnaires were distributed to the targeted respondents on purposive bases without been bias. The main merit of the purposive approach is the broad range sampling methods that could be used in all the research design. Therefore, in the six-state two towns were selected as study area per state. The capital of the state and next city to the state capital as specified in Table 2

Table 2: State with towns for data collections

State	**Town A**	**Town B**
Benue	Makurdi	Gboko
Nasarawa	Lafia	Nasarawa
Niger	Minna	Bida
Kogi	Lokoja	Okeene
Kwara	Ilorin	Offa
Plateau	Jos	Bassas

The method adopted in the administration of the questionnaire was to group all the professionals by states, to determine the exact number for each state. Thereafter the number of an expert in each state was calculated as a proportion of total members in the entire north-central geopolitical zone and multiplied by the total number of questionnaires to obtained sample proportion. The questionnaires were then distributed proportionally among the state in accordance to the population of the professionals; Benue 60, Nasarawa 45, Niger 120, Kogi 59, Kwara 65, and Plateau State 51 samples respectively see table 3 for the entire population.

Table 0: Population of the registered professionals in north-central Nigeria

S/N	State	Architecture	Building Engineer	Civil Engineer	Quantity Surveying	Total	No. Per State
1	Benue	55	44	200	64	363	60
2	Nasarawa	45	80	123	20	268	45
3	Niger	80	215	312	120	727	120
4	Kogi	68	65	202	19	354	59
5	Kwara	69	82	180	59	390	65
6	Plateau	42	64	155	48	309	51
	Total	359	550	1172	330	2411	(400)

Source: *NIQS head Office and State chapters of NIA, NIOB, and Civil Engr. respectively (2018).*

Hence, out of the 400-questionnaire distributed in the six different states of the north-central zone of Nigeria (Plateau, Niger, Benue, Nasarawa, Kogi, and Kwara States); after retrievals of the questionnaires, 305 were valid and suitable for the analysis, 40 copies were not properly filled, while 55 copies were not returned as presented in Table 4

Hence, Valid response rate = 305/400*100 = **76.2%**

Table 4: Analysis of respondents

Sample	Number of responses	Percentage %
Non retrieved response	55	13.75%
Unsuitable response	40	10%
Valid and suitable response	305	76.2%

This valid response is considered as the suitable response rate; therefore, the numbers of 305 questionnaires representing 76.2% are considered and adequately suitable for this study. There is no agreed standard of agreement on the level of response rate on a survey questionnaire. The results are accepted as good considering Fowler (2002) study, which indicates that 75% response rate are demanded by some federal funding agencies on the survey instruments as standard. However, Visser, et al., (1996), suggested that the survey with lower rates like 20%

have more accurate measurements than the ones with higher response rate such as 60% and above.

ANALYSIS AND RESULT DISCUSSION

The structural equation model (SEM) used in carrying a confirmatory factor analysis (CFA) of the constructs. The construct which was on benefit (economic viability) of green materials contains 15 indicators that were evaluated in confirmatory factor analysis. The 15 observed variables were derived from two sub-scales in part D of the survey. Figure 4 shows the first measurement model for the benefits of GMs. Table 3 shows the displays for the first measurement model for the benefits of GMs construct.

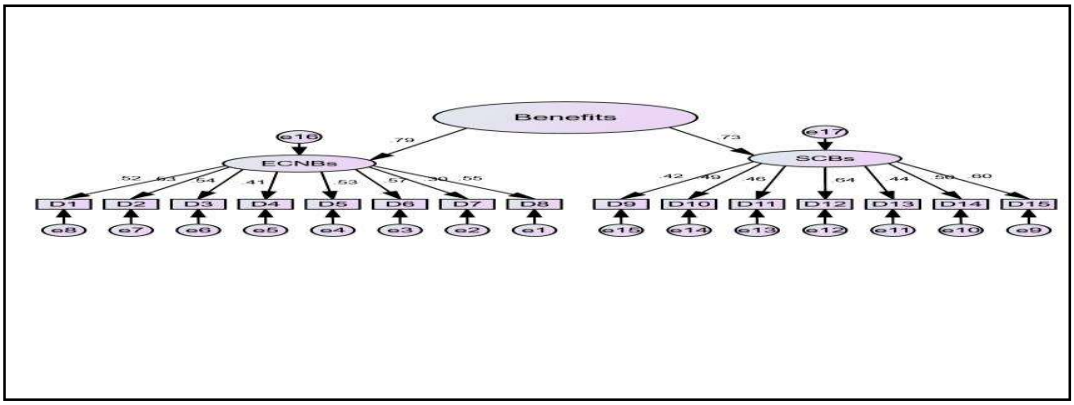

Figure 4: First measurement model for construct on the benefit of GMs

Table 5: Details for the first measurement model for concept on benefit of GMs

Construct	Code	Indicators
Economic Viability of GMs	D1	Cost-effectiveness
	D2	Readily available
	D3	Energy efficiency
	D4	Create jobs for people
	D5	Reduced cost of construction
	D6	Reduced waste
	D7	Aesthetics /beautification
	D8	Improved the economy of the community
	D9	Promote cultural heritage
	D10	Improved occupant productivities
	D11	Adaptability to the environment
	D12	Eco-friendly
	D13	Improved social capital
	D14	Enhance social well being
	D15	Reduced CO2 emission

The parameter of the fitness index, as shown in Figure 4, specifies the poor fit of the measurement model, with values of detailed indices of (ChiSq/df= 2.331 <3.00) and (GFI = 0.916); while AGFI, CFI, TLI and NFI < 0.90), and (RMSEA=0.066 < 0.08). Therefore, the model required modification to accomplish a suitable index. To reach uni-dimensionality for the model, variables that have weak loading factors below 0.5 were deleted. The final measurement model for the construct on the socio-economic benefit of GMs, once low load items exclusion, is shown in Figure 5. The model attains the construct validity with the acceptable Fitness Index of: P-value=0.041, RMSEA=0.046, GFI=0.977, AGFI=0.957, CFI=0.954, TLI=0.93, NFI=0.900 and ChiSq/df= 1.63. Table 4 shows the indicators for the modified measurement model for concept on socio-economic benefit of green materials for affordable housing in Nigeria.

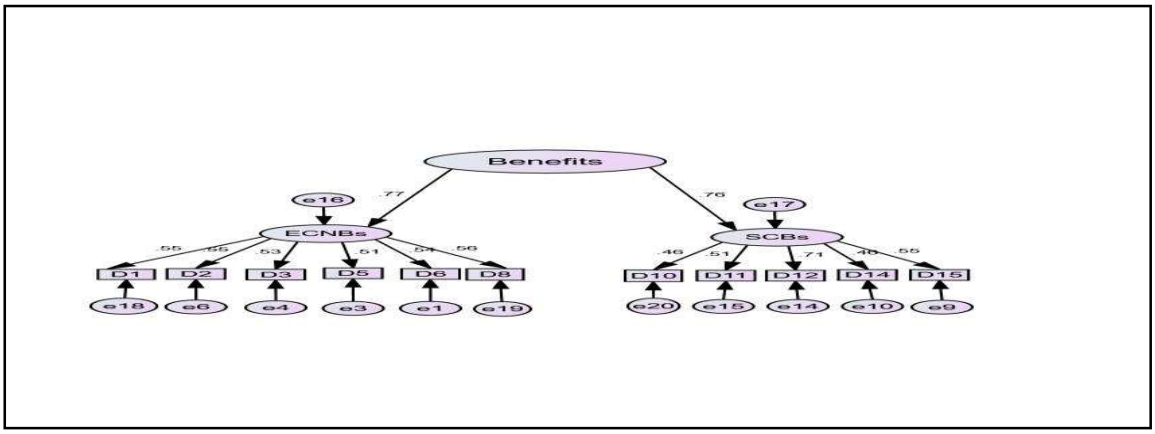

Figure 5: Modified measurement model for construct on Benefits of GMs

Table 6: Details for the Modified measurement model for construct on Socio-Economic benefits of GMs

Construct	Code	Indicators
Economic Viability of GMs	D1	Cost-Effective
	D2	Readily available
	D3	Energy efficiency
	D5	Reduced cost of construction
	D6	Reduced waste
	D8	Improved the economy of the community
	D10	Improved occupant productivities
	D11	Adaptability to the environment
	D12	Eco-friendly
	D14	Enhance social well being
	D15	Reduced CO2 emission

The composite reliability and convergent validity for the model were also realized with a CR value of 1.49, and 0.98 (≥0.6) and an AVE value of 1.80, and 1.44 (≥0.5). Table 5 displays information on the validity and reliability evaluation for the model. From the overall fulfilled values of Fitness Index, uni-dimensionality, validity, and reliability for the measurement model, the model was then recognized to put forward to be part of the final evaluation in the structural equation model.

Table 7: Validity and reliability assessment for benefits of GMs measurement model

Constructs	Items	Factor Loading (≥ 0.5)	AVE (≥ 0.5)	CR (≥ 0.6)
Socio-Economic benefit of GMs	D1	0.55	1.80	1.49
	D2	0.55		
	D3	0.58		
	D4	Deleted		
	D6	0.54		
	D7	Deleted		
	D8	0.56		
	D9	Deleted	1.44	0.98
	D10	0.46		
	D11	0.51		
	D12	0.71		
	D13	Deleted		
	D14	0.46		
	D15	0.55		

Therefore, the analysis reveals the followings; the cost-effectiveness, readily available, energy efficiency, reduce waste, improve the economy of the community, improve occupants' productivity, adaptability to the environment, eco-friendly, enhance social wellbeing and reduce the emission of carbon dioxide as the benefits of using green materials for the construction of affordable building. This is comparable to the findings of Umar and Khamidi (2012), which discovered that green building practice makes efficient use of natural resources, safeguard occupant health and enhance employee productivity, and reduce waste materials, pollution, and environmental degradation. Social-culturally, this study showed that GMs help promotes cultural heritage, improved occupant productivities, enhance social well-being and reduced CO_2 emission. Evidence by Jaiganesh *et al*., (2016) has established that the use of GMs for the low-cost building has socio-cultural advantages.These outcomes was also comparable to the results obtained by Gohnert, Bulovic, & Bradley (2018), Ugochukwu & Chioma, (2015), Oshike, (2015) and Adegun & Adedeji, (2017) on the advantages of using green materials.

CONCLUSIONS AND RECOMMENDATIONS

This study assessed the benefits of using green materials for the realization of affordable buildings for the average citizen in society. Four hundred questionnaires was prepared and distributed through purposive sampling to the registered building professionals in the north central zone of Nigeria. Analysis of moment structure (AMOS) a statistical analysis was carried out through the structural equation modeling (SEM) on the useable and valid data collected, the finding revealed that there are potential benefits of green materials for the construction of low-cost building. Thus, this study is recommending the re-introduction and use of relevant green materials as construction resources to mitigate the problem of high cost of conventional building materials and subsequently provision of affordable building to the lower income groups in Nigeria.

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