INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 9, ISSUE 05, MAY 2020 ISSN 2277-8616

# Investigating Green Materials For Construction Of Affordable Building Using Structural Equation Model (SEM)

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**Abstract:** The problem of accommodations in the developing countries in the recent time cannot be exaggerated; it has become a major problem for the people with less income generation to build house at a reasonable cost due to high cost of materials which is a major resource in the construction of a building. Therefore solutions to housing problems must deal with the issue of building materials, based on the foregone this study was carried out to assess the viability of green materials as an alternative to the widely used conventional materials in the construction building at affordable rate for people of the low-income generation. Four hundred structured (400) questionnaires were prepared and distributed to the building professionals in north-central Nigeria to generate data for the study. 305 representing 76.2% of the responses were found usable after the screen of the returned questionnaires. The SPSS and AMOS/SEM was used to assess the data via confirmatory factor analysis of relevant green materials, factors hindering the suitability, selection factors, and benefits of green materials variables. Thus, at the end of the analysis green materials found to be economically viable and its adoption will produce building at an affordable cost for the lower middle and lower class in the society.

**Index Terms:** Accommodation, Affordable building, Green materials, Low-income group, structure equation model

## 1 INTRODUCTION

The cost building has gone beyond the reach of the low-income group in Nigeria, the problem linked with the provision of housing for the workers at middle and lower class in the society was as a results of high cost of construction materials and the technical knowhow[1],[2],[3],[4]. However, the re-introduction of Green materials will mitigate this problem to some extent; these materials are eco-friendly and readily available within the environment at a moderate cost when compared with the conventional materials. [5],[6],[7]confirms earth bricks, bamboo, improve concrete panel and timber as excellent and promising materials for low-cost building construction. Furthermore, integration of green materials into building construction projects will helps in decreasing the environmental effects associated to the cost of transportation, processing, manufacture, fabrication, installation, as well as promoting recycle, reuse for construction works [8]. Therefore, this study assesses the economic viability of green materials using the structural equation model (SEM) toward the provision of an affordable building to the lower class citizen in the developing countries.

## 2 GREEN MATERIALS

The green materials have been considering as natural earth materials, recycle and renewable materials from industrial waste that are suitable for building construction which is available within the society.


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Furthermore, a material is consider to be green when it has at least one positive environmental characteristic and it availability differ across the world which depend on the geographical location of each zone[9],[10],[11]. The green materials remain the major building resources in the Mideast where the vault and dome construction originated, and Africa the use of earth materials for building predominately found in the mind and Fayum site in the Nile delta of Egypt[12]. [13] Classified green materials into three categories namely: earth materials, Natural Materials and Industrial waste materials as illustrated in Figure 1

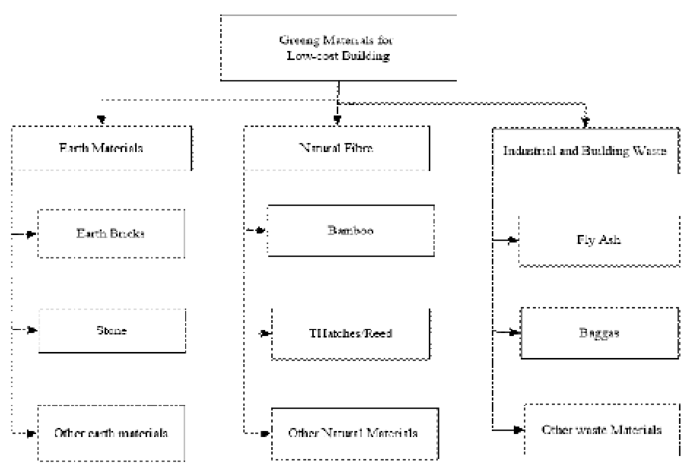


***Figure 1*** *Classification of green materials. Adapted from ManjeSrivastavash & Kumar, (2018)*

[5],[14] suggested some GMs which includes but not limited to the following: Earth Bricks, Bamboo, and Timber as excellent and promising materials for low-cost building construction. According to [15],[16] material such as bamboo, stone, earth bricks and the likes are used in their original form with a very little transformation devoid of fossil fuel for their extraction which make distinct from the conventional material where the various composite materials are made at much energy particularly using fossil fuel that produce carbon dioxide

emission to the atmosphere that is dangerous to the health of human being. The green materials have many benefits such as high durability, cost effectives, less energy consumption reduce waste, little maintenance functional adeptness with minimum defects[17].

### 2.1 Benefits of Green Materials

According to [6] stabilized earth bricks which one of the families of green materials has served as alternative building materials that are very important cheaper than using the conventional sandcrete bricks/block, environmentally sustainable and has been used as construction material in every age and every continent. The application of this materials for construction of building save energy, time and cost as well as reducing environmental pollution with the construction site[12]. [18]said that green building materials and mechanisms involve re-using or recycling because they are ecologically friendly materials and that the materials are environmentally recognized. Furthermore, the advantages of green materials over conventional building materials are enormous. In the study carried out by [19] it was point out that the green resources is of great benefits to the building owners in term of energy usage, maintenance cost, replacement cost, improve health of occupant and minimizing associated with changing space throughout the life of the building. The conclusion of the study explicitly stated that the green building materials minimized the energy consumption of the building as well as more efficient than the conventional materials. The building of houses with affordable resources expands the quantity of housing development for low-cost income group. According to [20] low-cost building could be attained by application of the good project management and planning, application of alternative construction techniques, and economical construction with low-cost materials. The green building materials and mechanisms involve re-using or recycling because they are ecologically friendly materials and that the materials are environmentally recognized[18],[8],[21].

## 3. THE STUDY TECHNIQUES

The study was carried out with the aids of quantitative research method. In this study, relevant materials were source from previous and similar work to area of this research. The secondary data through literature review helps in developing a framework and research instrument used for information collection from the prospective respondents. Proceeding to distributions of the questionnaires, a total number of 30 participants across the professional were contacted for the pilot study to solicit for their understanding of the study. The outcome of the pilot survey provides a whole adequate picture of the questionnaire items, measure and scale. The reliability test was conducted using alpha Cronbach's tool and the results indicates that the scales items for the three sections of the questionnaires have an average 0.761 which greater than the acceptance range of 0.70. Subsequently, a final questionnaire was developed after all the grey area has been addressed. The questionnaire was in four sections. The first section was on the demography information of the respondents, followed by establishing the relevant green materials, selection criteria's and the assessment of the economic benefits respectively. A total of 400 questionnaires were produced as a sample size to collect the primary data from the responded population of about 2411 professional from the built environment in the north-central area of Nigeria. The questionnaires were distributed across the professional in the study area on face to face bases and after rigorous follow-up, 385 questionnaires were retrieved. However, screening by removing invalid and incomplete responses brings down the number to 305 questionnaires that were found usable for the data analysis. This gives an overall response rate of 76.2%, which is very high and acceptable for the researchers (Table 1).

***Table 1*** *The response rate*

| Sample | No. of responses | Percentage % |
|---|---|---|
| Building Professionals | 400 | 100.0 |
| Unsuitable questionnaires | 95 | 23.8 |
| Suitable questionnaires | 305 | 76.2 |
| Overall response rate | | 76.20 |

Finally, the SPSS (version 23) was use to carried out an exploratory factor analysis which form the bases of the measurement model, the validity and the normality of the variables were also assessed with Kaiser-Meyer –Olkin (KMO) and Barlett's test. In addition Structural equation model (SEM), was used to determine the satisfactory fitness of the model.

## 4. ANALYSIS, FINDINGS AND DISCUSSION

### 4.1 SEM Model Developments

The model developed for the application of green materials commenced with the development of structural equation model by pooling together the entire measurement model earlier generated from the relevant green materials, factor hindering the suitability of the GMs, the selection factors, and the socio-economic benefits of GMs. The initial measurement model was established and confirmatory factor analysis (CFA) was used to validate the constructs. The four main constructs that are involved in this research are relevant GMs, factors that determine the green materials selection for construction of low-cost building and economic viability of GMs for construction of affordable building. The study theories framework formulated for this research (Table 2) were tested accordingly.

***Table 2*** *Research Hypotheses for Constructs*

| | |
|---|---|
| H1 | Relevant GMs has significant effect on the economic viability of GMs for low-cost building construction |
| H2 | RGMs has a positive and significant relationship on factor determines selection GMs |
| H3 | Hindering factors on the suitability of GMs has a significant relationship with the RGMs |
| H4 | Selection factors for GMs have a significant effect on the economic viability of GMs |
| H5 | Selection factors for GMs mediate the effect of relevant GMs on the economic viability of using GMs for low-cost building construction |

The formations of primary relationships between the constructs are illustrated in Figure 2.

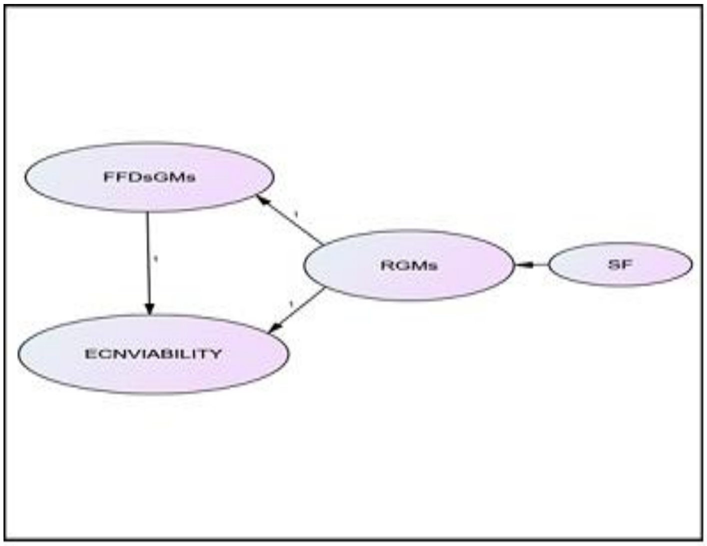


***Figure 2***.*Primary model showing the constructs relationship*

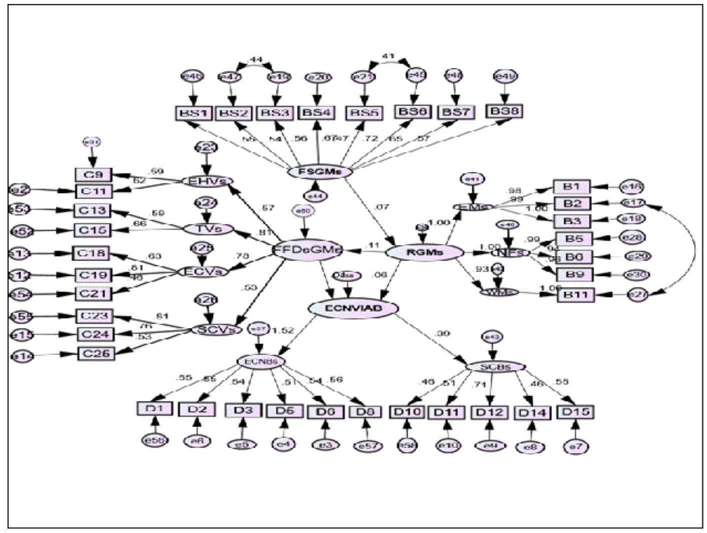


***Figure 3.*** *Structural equation model for the entire constructs*

For each of the construct (Figure 2) there are variables that need to be measured as indicated in the study instrument. The relevant green materials (RGMs) was assessed with three sub construct which are Earth Materials (4 variables), Natural Fibres (5 variables), and Industrial and Building Waste (4 items), making a total of 13 items measured for this construct. The factors hindering the suitability (SF) of green materials were assessed. The Factors for Determining Selections of GMs construct (FFDsGMs) is examined using Criteria for GMs selection with 8 items. The Economic Viability construct is also measured using Economic Benefits (ECNVIABILITY) of GMs (8 items) and Socio-cultural Benefits of GMs (7 variables). The measurement models was developed and pool together to develop the structural equation model after conducting the confirmatory factor analysis on each of the latent variables and follows by the assessments of the model fitness.

### 4.2 The Validation of Measurement Model

As previously stated the models must be validated through the CFA process to establish its fitness before transforming measurement model to structural model. The process of confirmation involves the checking the construct uni-dimentional, fitness of model, reliability and validity of the models. The AMOS statistic's shows the overall values of the model fitness index which serves as bases of including any of the measurement models in the structural model further analysis or otherwise. However, these procedures are carried out in an orderly manner to describe every measurement models fits of the availability of relevant green materials, factors hindering the suitability, factors for determining selections and economic viability of green materials.

Figure 3 presents the overall fitness measures for the structural model. It shows a good value of RMSEA of 0.055, Chisq./df of 1.91, P value of 0.000 and excellent fitness value for CFI of 0.930, TLI of 0.924, NFI of 0.868, GFI of 0.845, and AGFI of 0.882. Thus, the RMSEA, Chisq. And P values figures achieved the acceptable range of the fitness index. Similarly, the most of the value attained for the common index categories that are within the 0.90 values are acceptable due to the significant to the sample size (Hooper et al., 2008; Sharma et al., 2005). All the results are presented from the standardised estimates results of the analysis. Therefore, the revised structural model results are considered fit having meet up with all the finesses parameter. The variables measurement outcome in the structural model indicates that the loading factors are all within the acceptable loading factor parameter (≥0.50). The summary of the results is presented in Table 2 for the final structural model.

***Table 0*** *Summary of SEM results*

| Endogenous Variables of the constructs | | |
|---|---|---|
| Code | Relevant Green Materials | Factor loading |
| B1 | Earth bricks to replaced sandcrete block walls | .98 |
| B2 | Stone/Rock for foundation and walls | .99 |
| B3 | Timber for windows, doors and roof trusses | 1.00 |
| B5 | Bamboo to replaced steel reinforcement in short column, beam and lintel | .99 |
| B6 | Thatches can replace roofing sheets, especially for sit outbuilding | 94 |
| B9 | Straw fibre to be used as binders/reinforcement in making composite items such as bricks | .99 |
| B11 | Rice husk used in making composite item like particleboard | 1.00 |
| Code | Hindering factors of suitability | Factor loading |
| BS1 | Client preference | .55 |
| BS2 | Socio-economic influence | .54 |
| BS3 | Human neglect | .56 |
| BS4 | Discontinuity of local labour | .67 |
| BS5 | Climate and weather influence | .47 |
| BS6 | Aesthetic less pleasing | .72 |
| BS7 | Uncertainty in the project outcomes | .66 |
| BS8 | Limited accessibility to relevant information | .57 |

| Endogenous Variables of the constructs | | |
|---|---|---|
| Code | Selection Factors | Factor loading |
| C9 | The materials have to be Eco-friendly | .61 |
| C11 | Ozone friendly properties of the materials | .59 |
| C13 | Consideration must be given to the obtainability of technical knowhow | .58 |
| C15 | Recycle and reuse characteristic | .67 |
| C18 | The selected materials have to be energy efficiency | .64 |
| C19 | Materials cost at reduce price as an advantage over the conventional materials | .80 |
| C21 | Material embodied | .48 |
| C23 | Compactible with cultural tradition | .81 |
| C24 | The custom and lifestyle of the people | .75 |
| C25 | Consideration must be given to the types and size of the family | .53 |
| Code | Benefits of green materials | Factor loading |
| D1 | Cost-Effectiveness | .55 |
| D2 | Readily Available | .55 |
| D3 | It is energy efficiency | .54 |
| D5 | GMs reduces the cost of construction | .51 |
| D6 | It reduces waste on site | .54 |
| D8 | It improves the economy of the community | .56 |

| Endogenous Variables of the constructs | | |
|---|---|---|
| D10 | Improve occupant productivities | .46 |
| D11 | Adaptability to the environment | .51 |
| D12 | Eco-friendly | .71 |
| D14 | It enhance socio-wellbeing | .46 |
| D15 | Reduce the carbon dioxide emission | .55 |

### 4.3 Causal Effects Relationship

The hypotheses H1, H2, H3 and H4 reflected in table 3 were analysed to determine the relationship among the constructs. The results show by the structural equation model indicates that the P-value of 000 indicates that 0.03 of the $R^2$ was within accepted value. Furthermore the value denotes 3% of the relevant green materials concept implies that the three constructs could be estimated. Similarly, the 8% of the factors that determine the selection of GMs construct ($R^2$=0.08) could be measured through relevant green materials and economic viability constructs. The values of the regression analysis base on P-value less than 0.05 in Table 3 shows the details of the regression path coefficient among the hypotheses and its importance.

***Table 3*** *The Regression Path Coefficient between the constructs and its significance*

| Construct | Path | Construct | Estimate | S. E | C.R | p-value | Result |
|---|---|---|---|---|---|---|---|
| Relevant GMs | ----> | Economic Viability of GMs | 0.065 | 0.043 | 1.518 | 0.000 | Sig. |
| Factors Hindering Sustainability | ----> | Relevant Green Materials | 0.061 | 0.055 | 1.121 | 0.004 | Sig. |
| Factors that Determined GMs Selection | ----> | Economic Viability of GMs | 0.015 | 0.069 | 0.211 | 0.000 | Sig. |
| Relevant GMs | ----> | Factors that Determined GMs Selection | 0.064 | 0.041 | 1.564 | 0.014 | Sig. |

The path coefficient in Table 3 indicates the relationship and effect of each of the construct on the its evaluating constructs respectively, for instance the path coefficient of the relevant green materials reliability estimate is 0.065, this value indicate that in every one unit of relevant green material there will be an increase of 0.065 in economic viability of green materials. Therefore, the effects of relevant green materials on its economic viability are very significant with P-value less than 0.05. Thus, the entire hypothesis has significant effects on the variables as shown in the results in Table 4.

***Table 4*** *The result of hypothesis testing for constructs (H1 to H5)*

| | Hypotheses Statement | Estimate | p-value | Results |
|---|---|---|---|---|
| H1 | Relevant GMs has a positive and significant effect on the economic viability of GMs for affordable building construction | 0.065 | 0.000 | Supported |
| H2 | Factors hindering the sustainability of GM has a positive and significant effect on Relevant GMs | 0.061 | 0.004 | Supported |
| H3 | Selection criteria for GMs have a positive and significant effect on the economic viability of GMs | 0.015 | 0.000 | Supported |
| H4 | Relevant GMs has a positive and significant relationship on selection criteria for GMs | 0.064 | 0.014 | Supported |
| H5 | Selection criteria for GMs mediate the effect of Relevant GMs on the economic viability of GMs for low-cost building construction | 1.00 | 0.000 | Supported |

### 4.4 Mediating Effects of Relevant GMs towards Selection criteria for GMs on the economic viability of GMs for affordable building construction

The hypothesis 5 was used as mediating between the constructs in the model (Table4 refer). There are two effects incorporating in a relationship; the direct and indirect effect, this is considered in analysing the mediator among the construct involved in this study. The direct effect occur directly between the dependent and independent constructs, while the indirect effect exist from the independent and dependent constructs but goes indirectly into the mediating construct.

## 5 CONCLUSIONS AND RECOMMENDATIONS

The study focus on the green materials embracing for the construction of an affordable building construction for the low-income groups in Nigeria. The results of the analysis show that there are relevant green materials in the study area (North-central Nigeria), the hindering factors, selection factors as well as the economic viability factors were also established at the final structural equation model (SEM) that was developed at the final stage of the confirmatory factor analysis. Thus, the adoption of green materials for building construction will mitigate the high cost of a building project and promote the construction of more structure at an affordable cost for the benefits of the lower-income group in Nigeria.

## 6 ACKNOWLEDGEMENT

Appreciation goes to the Malaysia Ministry of Education (MOE) through the Research University Grant (RUG) funding number 1501 also the government of Nigeria that established Tertiary Education Trust Fund (TETFUND) for financial assistant while conducting this research project.

## REFERENCES

[1]. O. B. Adegun and Y. M. D. Adedeji, “Review of economic and environmental benefits of earthen materials for housing in Africa,” Front. Archit. Res., vol. 6, no. 4, pp. 519–528, 2017.
[2]. O. A. Nwoke and B. O. Ugwuishiwu, “Local Bamboo and Earth Construction Potentials for Provision of Affordable Structures in Nigeria,” Int. J. Sustain. Constr. Eng. Technol., vol. 2, no. 2, pp. 17–31, 2011.
[3]. I. Ben Ugochukwu and M. I. Ben Chioma, “Local Building Materials: Affordable Strategy for Housing the Urban Poor in Nigeria,” in Procedia Engineering, 2015, vol. 118, pp. 42–49.
[4]. W. Alaghbari, A. Salim, K. Dola, and A. Abdullah Abang Ali, “Developing affordable housing design for low income in Sana’a, Yemen,” Int. J. Hous. Mark. Anal., vol. 4, no. 1, pp. 84–98, 2011.
[5]. J. Bredenoord, “Sustainable Building Materials for Low-cost Housing and the Challenges Facing their Technological Developments: Examples and Lessons Regarding Bamboo, Earth-Block Technologies, Building Blocks of Recycled Materials, and Improved Concrete Panels,” J. Archit. Eng. Technol., vol. 06, no. 01, pp. 1–10, 2017.
[6]. M. S. Zami and A. Lee, “Economic benefits of contemporary earth construction in low-cost urban housing – State-of-the-art review,” J. Build. Apprais., vol. 5, no. 3, pp. 259–271, 2010.
[7]. K. T. Alade, A. N. Oyebade, and N. U. Nzewi, “Assessment of the Use of Locally Available Materials for Building Construction in,” vol. 2, pp. 36–41, 2018.
[8]. G. Mehta, A. Mehta, and B. Sharma, “Selection of Materials for Green Construction : A Review,” vol. 11, no. 6, pp. 80–83, 2014.
[9]. C. Fithian and A. Sheets, “Green Building Materials Determining the True Definition of Green Green Building Materials,” pp. 1–13, 2009.
[10]. U. J. Phatak, “Green Building Materials – A Way,” vol. 4, no. 4, pp. 244–249, 2015.
[11]. M. Mahmoud, “Green Building Material Requirements and Selection ( a Case Green Building Material Requirements and ( a Case Study on a Hbrc Building in Egypt ),” no. May, 2016.
[12]. M. Zami, “Using earth as a building material for sustainable low cost housing in Zimbabwe,” Built Hum. Environ. Rev., vol. 1, pp. 40–55, 2008.
[13]. ManjeSrivastavash and V. Kumar, “The methods of using low cost housing techniques in India,” J. Build. Eng., vol. 15, no. January 2017, pp. 102–108, 2018.
[14]. A. H. Jasvi and D. K. Bera, “Sustainable Use of Low Cost Building Materials in the Rural India,” pp. 534–547, 2015.
[15]. A. Basnet, “BREEAM & LEED: a study of materials and their life cycle impacts,” 2012.
[16]. D. Omoregie and E. Imuetinyan, “Assessment of the Use of Compressed Stabilized Interlocking Earth Block for Building Construction in Nigeria,” vol. 7, no. 12, pp. 1–7, 2015.
[17]. H. Danso, “Building Houses with Locally Available Materials in Ghana: Benefits and Problems,” Int. J. Sci. Technol., vol. 2, no. 2, pp. 225–231, 2013.
[18]. N. Shabrin, S. Bin, and A. Kashem, “A Comprehensive Cost Benefit Analysis of Green,” no. February, 2017.
[19]. S. Misra, G. R. K. D. Satya Prasad, N. Kumar, S. K. Sah, S. Kumar, and R. Maurya, “Comparison analysis of Green building materials and conventional materials in energy efficiency performance,” Int. Res. J. Eng. Technol., pp. 2395–56, 2016.
[20]. A. Vidya, “Alternative low cost building Materials,” 1980.
[21]. J. Park, J. Yoon, and K. H. Kim, “Critical review of the material criteria of building sustainability assessment tools,” Sustain., vol. 9, no. 2, 2017.