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The level of acceptability of the use of timber as a sustainable material in the design and construction of buildings in Enugu State, Nigeria

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ABSTRACT

This study addresses the acceptance of timber in building design and construction within Enugu state. The research aims to evaluate the current level of acceptability and identify factors influencing perceptions towards timber usage. Objectives include assessing prevailing attitudes, examining structural considerations, and proposing strategies to enhance the integration of timber in construction, ensuring safety, sustainability, and regulatory compliance. To achieve the aim and objectives, the study adopted a descriptive survey where the opinions of 982 respondents comprising the clients, consultants and end users were sought. The study found that timber is not a well-accepted material in the design and construction of buildings in Enugu State. The reason for the non-acceptance of timber as a sustainable material in the building delivery process in Enugu State are due to the lack of government and non-governmental programmes promoting the use of wooden construction among others in Enugu. The study concludes by stating that timber as a building material possesses qualities and performs better when compared with most other common building materials. The study recommends that there should be proper government and non-governmental programmes promoting the use of timber construction in Enugu State. This will grow the confidence of people and encourage them to invest in its usage.

***Keywords*:** Timber, Acceptability of Timber, Sustainability of Timber, Building Material, Qualities of Timber, Enugu State

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1. INTRODUCTION

Timber is an organic material with a wide variety of physical and mechanical properties. It is an efficient building material, not only concerning its mechanical properties but also because it is a highly sustainable material considering all phases of the life cycle of timber structures; production, use and decommissioning. Timber is a widely available natural resource throughout Nigeria; with proper management, there is a potential for a continuous and sustainable supply of raw materials in the future.

Timber has excellent material properties. It is a light material and compared to its weight, its strength is high. Its high strength-to-weight ratio makes it an attractive framing material. Timber withstands humidity with less structural change than other building materials. It is very durable and there are numerous finishes available to protect and enhance the natural beauty of the material. These sealants and protective finishes promote its durability. If well protected and well installed, timber can last for centuries with minimum maintenance (Sturges, 1991). Timber is more fire resistant than bare steel, as charring forms an insulating layer that protects the inner core of the material. Heavy timber construction is less prone to damage by short-term high temperatures allowing for a longer period for evacuation in case of fire.

It has been established that a sustainable building material must be affordable, durable, environmental friendly and flexible in usage (Okereke, 2006; Chen, 2010; Schmidt & Griffin, 2012; Abimaje and Baba, 2014). Research activities are now being sponsored, supported and carried out by government, organizations and academia in an effort at analyzing, quantifying and comparing environmental impacts of building materials and design, with alternatives being sort in natural products.

However, little research effort has been directed towards quantitatively determining the level of awareness and perception of populace on the sustainability potentials of building materials especially in Nigeria. Although, building materials specifications ideally comes from the building consultants (especially architects), this cannot be without the input and in agreement with the client. Evidently, public perception of qualities of a building material could to a great extent influence their choices. According to Florez (2010) market demand is a critical factor to be considered in realizing sustainability goals since inappropriate materials choices may hinder the desired sustainability objectives

1. 1. Timber buildings and sustainability

The climate changes observed in recent decades, global warming, and the increasingly frequent natural catastrophes are under everyone's eyes. In this context, the concept of climate protection summarizes all the possibilities that allow combating global warming as well as all measures to mitigate its effects.

The carbon cycle is the biogeochemical cycle through which carbon is exchanged between the geosphere, the hydrosphere, the biosphere, and the Earth's atmosphere. The current balance of the carbon cycle shows that CO_2 that enters the atmosphere is higher than the one that comes out. Much of the emissions due to human activities cannot be balanced by the natural absorption of the oceans and terrestrial ecosystems such as forests and soils, and the increase in CO_2 and other greenhouse gases leads to consequences such as the increase in global average temperature.

In this contest, regarding climate protection there are basically two possible approaches: the reduction of climate-changing emissions (CO_2 and other greenhouse gases) and the expansion of carbon reservoirs, the term carbon reservoir meaning any stored form of CO_2.

Wood allows both roads to be traveled (Hildebrandt, Hageman, Thrän, 2017: Ramage, et al, 2017). Thanks to photosynthesis, a tree can store large quantities of CO_2 in the wood. It is estimated that 1 m^3 of wood stores approximately 1 ton of CO_2, which remains stored in the material throughout its life, even when the wood undergoes the transformations that make it a semi- finished product or a finished product, for example, for the building industry, starting from the raw material. Therefore, the use of wood in construction involves two fundamental advantages: on the one hand, the gradual replacement of the most energy-intensive and polluting building materials with timber reduces the climate-changing emissions associated with the production and management of these materials; on the other hand, the management of forests aimed at the use of wood in industrial sectors such as buildings involves the continuous renewal of the forest itself with an increase in the capacity to extract CO_2 from the environment (see Figure 1).

Fig. 1. A typical timber framed structure

1. 2. Perceptions of wood products

Previous studies on the perceptions of wood products have explored a variety of topics, including perceptions of wood product use in North America (Kozak and Cohen 1997; Kozak and Cohen 1999; O'Connor et. al. 2004; Robichaud et al., 2009); perceptions of wood product use in green building (Knowles et al. 2011); perceptions of wood use in tall buildings (Hammon, 2016; Hemström, 2010; Larasatie et al., 2018) and architect perceptions of CLT (Laguarda Mallo and Espinoza 2015). The studies most relevant to the current research (Kozak and Cohen 1999; O'Connor et. al. 2004; Robichaud et al., 2009) focused on opportunities and barriers of wood-use in non-residential construction and concluded that the wood products industry is not properly addressing specified perceptions, thus missing important growth opportunities in the construction sector. Kozak and Cohen (1999) found that there is room to improve the competitiveness of wood products in the North American construction sector, but that regional

differences must be taken into account. They suggested creating targeted campaigns that focus on regions of North America that are "wood friendly", such as western North America, to start.

Hammon (2016) and Laguarda Mallo and Espinoza (2015) highlighted that architects or end-users who were most familiar with wood (or specific wood products) were least concerned with potential obstacles or barriers to wood construction. Laguarda Mallo and Espinoza (2015) suggested that the success of CLT will greatly depend on the information about the material being disseminated to architects.

Another study identified drivers of material selection, and found that architects' knowledge of wood (e.g., physical, mechanical, and environmental properties), experience with the use of wood, perceived control of the use of wood, and attitudes toward wood used structurally in buildings three stories or higher, were all statistically significant influencers of architects' specification of wood products in urban construction (Bysheim and Nyrud 2009).

2. MATERIALS AND METHODS

This study employed a descriptive research design: The descriptive design collected information regarding timber and its acceptability in the study area through a questionnaire (field survey). The target population of the study comprised of clients (215', consultants (405) and end-users (400). A total of 982 respondents were sampled using simple random sampling and the results obtained were analyzed using SPPSS version 22 and presented in Tables.

2. 1. Area of the Study

The following study areas were carefully selected because they represent the three senatorial zones of Enugu state in Nigeria for a fair and unbiased research. The study will focus on Enugu-East, Udi and Nsukka which are subsets of the 3 zones as they are the fastest developing towns in the 3 zones and boast of tremendous construction works going on there. Hence, most participants of this survey have the latest opinion on building materials (Fig. 2).

2. 2. Population of the Study

A population can be defined as the complete set of subjects that can be studied: people, objects, animals, plants, organizations from which a sample may be obtained (Chen and Shao, 1999). It can also be referred to as all individuals that form part of the group that the researcher intends to study (Cooper and Schindler, 2013). Simply put, population is the entire group or set of cases that a researcher is interested in generalizing. Therefore, the target population of this study will constitute of building construction professionals, end users, and clients. The population of the study comprised of registered professionals particularly Architects, Builders, Structural Engineers and Quantity Surveyor residing and practicing in Enugu state.

The population of these professionals as obtained from the various secretariats in the state.The population of the end users is 722,664 as projected from the National Population Commission (NPC) data of Enugu metropolis population as at 9th May 2023. While that of clients is 169,422 gotten from the list of registered building in the metropolis for the last 10 years. The building owners (clients) of the residential neighbourhood. Building owners were selected as participant for this study since they have a predominant influence on building material choices especially for residential building projects in Nigeria.

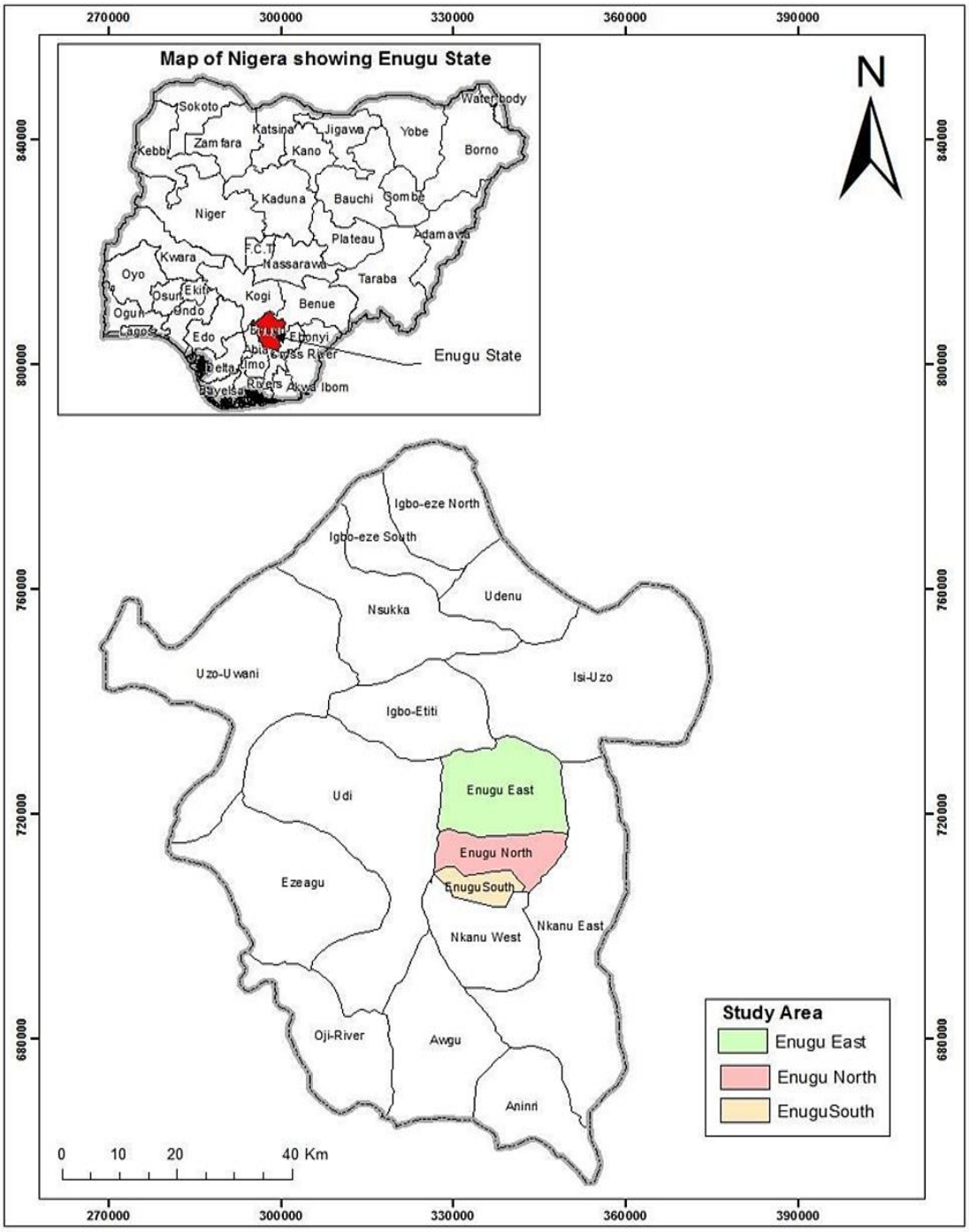

Fig. 2. Map of Nigeria, showing Enugu State (study area)

2. 3. Sample Size

According to Saunders, Lewis and Thornjill (2003), sampling provides a valid alternative to a census when:

a) It would be impracticable to survey the entire population, due to budget and time constrains
b) Reasonable data is collected but results may be required quickly.

The term 'sample' means a specimen or part of a whole (population) which is drawn to show what the rest is like (Nauom, 2007). The techniques/Strategies for determining sample size according to Glenn (2013) are

a) Using of census for a small population;
b) Using a sample size of a similar study;
c) Using published table; and
d) Using a formula to calculate the sample size (e.g. Taro Yamani Formula)

However, Cochran's sample size calculation procedure will be employed to determine the appropriate sample size for contractors and clients in this study. To do this, Cochran's return sample size formula is first determined using the formula presented in equation 1 (Cochran, 1977)

$$n_0 = \frac{(t^2)\times(p)(q)}{(d^2)} \quad \text{----------} \quad \text{Equation 1}$$

where:

t = value of selected alpha level usually 0.025 in each tail of a normal distribution obtained as 1.96 (the alpha level of 0.05 indicating that the risk the researcher is willing to take that the true margin of error exceed the acceptable margin of error is 5%).
(p)(q) = this is the estimate of variance given as (0.5) (0.5) = 0.25
d = acceptable margin of error for proportion being estimated given as 0.05 (this is the error level the researcher is willing to expect).

Thus, after calculating the Cochran's return sample size no (see Equation 1), we will employ the Cochran's correction formula to obtain the appropriate or final sample size and the formula is given in equation (2) as:

$$1 = \frac{n_0}{\left[1 + \left(\frac{n_0 - 1}{N}\right)\right]} \quad \text{----------} \quad \text{Equation 2}$$

However, to obtain the sample size for the professionals, clients and end users, equations 1 and 2 would be applied.

2. 4. Instrument for Data Collection

This study engaged the use of questionnaires and interview as the tools for its data collection. The questionnaire was divided into different sections namely: Professionals, end users Clients and general section. It was designed in a plain, unambiguous, clear and simple language for easy comprehension and selection. In this study, given the research methodology

structured questionnaires were administered on respondents and respondents' views which were codified recorded and translated.

Questionnaires that was administered in the field had both open-ended and closed-ended questions and the responses of participants was codified during data presentation and analysis. Interviews was conducted through the researcher's trained representatives and by the researchers himself in the study area amongst construction stakeholders, or their representatives/employees in a purposive and simple random sampling manner highlighted in earlier sections.

Since the research design is mixed in nature, both quantitative and qualitative data will be collected.

According to Sarantakos (2005) the strategy of data collection which is best preferred by quantitative researchers is questionnaires or survey.

2. 5. Reliability of the Instrument

Eze, Obiegbu, Jude-Eze (2005), Okolie (2011) defined reliability as the degree to which the measure of an instrument is consistent or dependable. That is, the degree to which the findings of a research are independent to accident circumstance. Simply, reliability measures consistency and not accuracy.

Some questions will be asked in different forms just to confirm a single point. The reliability of responses from the pilot study will be tested using Cronbach's alpha coefficient of reliability so as to determine the dependability of the instrument.

This technique (Cronbach's alpha) requires only a single test administration and determines the average correlation or internal consistency of items in the survey instrument and uses it to measure the degree of reliability (Santos, 1999; Gliem and Gliem, 2003). Cronbach's alpha coefficient ranges from 0 to 1 with alpha coefficients > 0.70 representing a satisfactory reliability.

Furthermore, to achieve reliability of data from questionnaire distribution, the researcher will endeavor to tackle the process with care and caution, to ensure that questionnaires will be administered to the right respondents, only necessary questions will be asked, which will be neither offensive nor misleading and options of answers will be provided to questions, except where opinion of respondents are needed to confirm the answers. Information contained in the questionnaire will be clear and unambiguous and the researcher should have a personal determination and commitment in order to follow up, collect, and present data in its real and undiluted form.

3. RESULTS

Table 1 shows the stakeholder's perception on the use of timber as a sustainable material in building's delivery process in their area. From the table, it could be seen that 10 perceptions were sampled and ranked accordingly. Majority of the stakeholders believed that a Timber house is flammable. This came first with a group mean of 0.8429. On the negative perception side again, the stakeholders perceived that there is a lack of professionals who can build a Timber house and also that A Timber house is exposed to pests.

This came 4th and 5th with a group mean of 0.7902 and 0.7815. Similarly, the stakeholders believed that the structure of a Timber house is impermanent and requires frequent

maintenance, a Timber house cools down quickly, but also heats up quickly and that a Timber house absorbs moisture easily. All these negative perceptions are what this study is set to identify and debunk.

Table 1. Distribution of stakeholder's perception on the use of timber as a sustainable material in building's delivery process in the study area.

S/N	Options	Stakeholders	RII	Group mean	Rank
1	A Timber house absorbs moisture	Consultants	0.6809	0.7320	9th
		Clients	0.7146		
		End users	0.8005		
2	Maintenance of a Timber house is cheaper than that of a traditional house	Consultants	0.5721	0.6292	10th
		Clients	0.6583		
		End users	0.6573		
3	The structure of a Timber house is impermanent and requires frequent maintenance	Consultants	0.8409	0.7478	7th
		Clients	0.6583		
		End users	0.7443		
4	A Timber house cools down quickly, but also heats up quickly	Consultants	0.7079	0.7412	8th
		Clients	0.7719		
		End users	0.7438		
5	Building a Timber house is cheaper than building a brick house	Consultants	0.8270	0.7991	3rd
		Clients	0.7422		
		End users	0.8281		
6	There is a lack of professionals who can build a Timber house	Consultants	0.8279	0.7902	4th
		Clients	0.7719		
		End users	0.7708		
7	A Timber house is exposed to pests	Consultants	0.7451	0.7815	5th
		Clients	0.7714		
		End users	0.8281		
8	A Timber house can be built in a short period of time	Consultants	0.9200	0.8021	2nd
		Clients	0.6859		
		End users	0.8005		

9	A Timber house is flammable	Consultants	0.8437	0.8429	1st
		Clients	0.7995		
		End users	0.8854		
10	A Timber house is healthy and friendly to residents	Consultants	0.8270	0.7616	6th
		Clients	0.7146		
		End users	0.7432		

Table 2. F Statistics output for the Hypothesis: Timber is not well-accepted material in the design and construction of buildings in the study area

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2144.300	1	2341.382	117.254	.152[b]
	Residual	319.150	214	1.234		
	Total	4131.030	214			

Table 2 tests if it is statistically significant or not, using 5% level of acceptance to measure. From the Table, the F-statistics is 117.254 and the probability value (p-value) which is represented by sig in the Table is .152. Judging with the level of significance of 0.05, it is seen that the p-value is greater (p-value > 0.05), hence, the null hypothesis is accepted. It is, therefore, stated that timber is not a well-accepted material in the design and construction of buildings in the study area.

4. CONCLUSIONS

The results of the study have highlighted the perception of timber as a construction material among building professionals, clients and the end users. The study therefore concludes that, the reason for the non-acceptance of timber as a sustainable material in building delivery process in the study area are due to lack of government and non-governmental programmes promoting the use of wooden construction, decay and susceptibility to attack by insects, fungi and vermin, low public awareness of the features, advantages and possibilities of timber construction including the methods and technologies used, the popular belief that timber construction means high fire risk and perception/demand by client.

The study recommends that there should be proper government and non-governmental programmes promoting the use of timber construction in the study area. This will grow the confidence of people and encourage them to invest in its usage.

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