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Assessment of Influence of Environmental Factors on Large Construction Firms in Nigeria.

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Abstract

This research assessed the influence of the environment on large construction firms registered with the Federation of Construction Industry (FOCI) in Nigeria and to determine the importance they attach to environmental factors. This research was conducted on construction firm's personnel responsible for marketing the services of their firms in Abuja and other ten states in Nigeria Simple random sampling technique was used to select the sample for the field study resulting in a sample size of 42 firms, which were all contacted but 35 firms responded. The data obtained from the study were subjected to inferential statistical analysis, the hypothesis was tested and validity established by employing inferential statistical techniques, using computer-based statistical package for the Social Sciences (SPSS). Findings of the study showed that all the environmental factors have significant levels of importance placed on them, which inferred that large construction firms attach significant importance to environmental factors. It was recommended that all employees of construction firms should focus on issues of environmental factors, since it enhanced the future survival, performance and growth of construction firms.

Keywords: Assessment, Environmental factors, significant influence, and large construction firms

1.0 Introduction

The future, survival, performance and growth of construction firms are linked to the country's economy, environmental factors, strategic factors, organizational factor efficiency and effectiveness of their marketing practices. According to Dibb, Simkin, Pride and Ferrell (1991), the environment has been seen as a key variable for explaining performance. The environment is the totality of the external forces directly or indirectly influence an organizations' acquisition of inputs (men, money, machines, materials, management and information) and generation of outputs (services, products, ideas and information).

Environmental factors consist of demographic, economic, physical, technological, political and cultural factors as well as market, public, facilitators' and marketing firms, client, competitor, distribution and supplier factors.

The concept of the marketing environment of construction firms consists of both the macro environment surrounding the industry and the task environment in which the firm intimately operates. The environment includes both general economic factors and additional factors, specific to the construction sector.

Furthermore, the macro-environment of construction firms consists of large-scale forces and factors influencing the company's future over which the company has little control. Also, marketing practices include the marketing strategy, marketing organization, marketing system, marketing productivity and marketing function.

Some researchers argue that the actual product in construction is the service which the contractor provides by selling expertise Mochtar (2004). Chen and Messner, (2009), while others believe that it is neither pure goods, nor a pure service; rather, it is a hybrid process consisting of both goods and service components. None of these suggestions, however, take into account the specifications and definition of these terms from the marketing viewpoint. Maloney. (2002). Smyth and Lecoeuvre (2015) Mokhtariani. Sebt and Davoudpour (2017).

The problem toward which the current study is directed is the task of getting jobs and creating jobs with particular focus on the environment of construction firms. It is therefore desirable to seek empirical explanation and understanding of the environmental factors (political, economic, technological, physical, demographic and cultural/social as well as public, facilitators and marketing firms, supplier, distribution, competitor, client and market), which exert significant impact on organizational performance in the construction industry.

This result would be useful to construction firms who need to make sound decisions and apply environmental approaches to achieve organizational goals with an attendant stimulant to the nation's overall economic growth and development. Also government, educational institutions, professional bodies and individuals concerned with formulating curriculum, construction policies and strategies can benefit from this research.

The aim of the study is to assess the influence of the environment on large construction firms in Nigeria. The objective of this study derived from the research problems is to determine the importance attached to environmental factors by large construction firms in Nigeria.

The hypothesis postulated to guide the study is that large construction firms in Nigeria do not attach significant importance to environmental factors (political, economic, technological, physical, demographic and cultural/social as well as public, facilitators and marketing firms, supplier, distribution, competitor, client and market).

The focus of this research is on the marketing environment of large construction firms in Nigeria. This study is limited to large construction firms in some selected states in Nigeria (Abuja, Abia, Bayelsa, Delta, Edo, Enugu, Imo, Jos, Kano, Lagos, Kaduna, Oyo, Rivers and Sokoto) because of limitations of time and funds.

Large construction firms in Nigeria have the following characteristics among others: employ at least 600 workers permanently, have a high capital base, are capable of executing large and complex projects successfully and earn high revenue.

The study focused on personnel responsible for marketing in a simple random selection of large building construction firms in Nigeria registered with the Federation of Construction Industry (FOCI), a trade / employers association which was incorporated in Nigeria on 3rd November 1954.

2.0 Literature review

According to Fahey and Narayanan, (1996); Jaunch, et al, (1980) Kotler and Armstrong (2014) business environment is made up of several segments such as clients, competitors, economic and regulatory segments. Also, Dess and Beard (1984); opined that uncertainty characterizes the business environment and relates to the degree of dynamism (rate of change), hostility (threat to the firm posed by competitors) and complexity (variations among the firm's market. They concluded that the changing business environment is a critical impetus for firms to make organizational adjustments in order to improve business performance.

The marketing environment produces both threats and opportunities, which must be analyzed by the organization so that it can avoid the threats and take advantage of the opportunities. There is a wide perception that the nature of the construction industry is such that it is not capable of being planned, i.e., its dynamic environment prevents any long – and medium-term planning. This argument is invalid because changing environmental factors affect all industries, which make planning all the more important so that organizations can anticipate and cope, which changes that, may affect business Yisa, et al. (1995).

According to Teo (2003) environments exert major influences over the organization's structure and its operations. Thus the environments are of primary significance to the organization's success. Organizations draw on their environment for markets and resources (including people and technology) that provide opportunities, but are subjected to environmental constraints and threats.

The environment within which most organizations operate is changing rapidly. Organizations failing to adopt and respond to the complexity of the new environment tend to experience survival problems sooner or later. In this climate of change, the development, implementation and use of adequate performance measurement is one of the major challenges confronting organizations and can play an important role in their success Samson and Lema, (2003). Wilson (1982) opines that four major forces of change are at work. These are government activities, technological change, sociological change and economic change – all irresistible forces in their own right and all intertwined with each other. The impact of these forces on the outer environment must cause shock waves to the industrial environment and in turn within the firm itself. No organization is or can be insulated.

As the pace of change (in technology, type of work, project procurement systems, etc.) increases, it becomes even more necessary to be flexible in order to accommodate change rapidly. As a result, the construction organizations need to have flexible diversification strategies to cope with the fluctuating demand (Walker, 1996)

SWOT analysis is a valuable tool that has been used in marketing-related decisions in the construction industry such as International market entry, market selection, and entry mode selection Utama, et.al, (2017) Mokhtariani, et, al. (2017). Lee, et. al, (2011) Tang et.al, (2012) Chen, (2008).

The following authors Ghalayini and Noble (1997); Landrum, et al. (2000); Santos, et al. (2000) postulated that the construction business environment has been in constant change which have resulted into higher user requirements, customer requirements, environment, safety and quality assurance on one hand, and increased competition among organizations, dwindling resources, the increased risk in construction contracting and accelerated emergency of new technology on the other hand. Such changes have initiated a crisis in construction and as a result organizations have aggressively searched for better management solutions to improve their performance and sustain a competitive advantage. Organizations, which do not address these changes in their strategies, processes and in daily activities, have begun to lose their market shares.

3.0 Research Methodology

In order to capture the practices that prevail, attitudes that are held and report on the main subject of this study a survey research design was adopted, a questionnaire was designed and validated to observe the variables of the research study. In order to test the hypotheses, the data collected were subjected to inferential statistics using SPSS Windows 12 of Statistical Package of Social Sciences.

The population for the study was taken from construction firms located in Abuja, Bayelsa, Delta, Edo, Enugu, Imo, Kano, Kaduna, Lagos, Oyo, River States and the sampling frame comprises the contractors listed in the Federation of Construction Industry (FOCI) 2001 directory with an overall population of 108 members. The respondents for this study were those personnel responsible for marketing the services of the firms. The sample for this study was selected through random sampling technique. The 83 firms fully registered with FOCI as at 2001 were compiled, from which a simple random sampling selection of half the population was done. This resulted in a sample size of 42 firms. The questionnaire was completed with the interviewer available so that respondents could, if necessary, fully probe the meaning of questions and reflect upon the nature of answers given. To achieve a higher response rate, a follow up mail was undertaken after contacting the firms personally. This was found to be an excellent method to encourage participation, with 35 firms agreeing to take part. The 35 useable questionnaires that were returned yielded a response rate of 83 percent.

A survey packet including a personalized cover letter requested participation in the study. Confidentiality was assured. The letter also mentioned an incentive to participate, which is making the findings of the research available to the respondents' organization. The self-administered questionnaire was taken personally to the chief executive officer and the personnel in charge of marketing each eligible company.

A set of questionnaire was used for the study. This questionnaire contains 40 items and was divided into two sections.

Section one contains company and personnel details such as name of respondent, organization's name and address, title / position as well as department in organization, age bracket and highest academic qualification.

Section two contains items relating to the marketing environment, which consists of both the macro environment surrounding the industry and the task environment in which the organization intimately operates.

The detailed items of the macro environmental factors in the questionnaire used for the study are as follows:

Demographic factors: Population size, average annual population growth, number of working adults, population density, age structure of population, number of young adults, life expectancy, urbanization.

Economic factors: GNP per capital, income distribution, annual growth rate of GNP, inflation, foreign exchange rate, prices, savings, growth rate of economic sectors restrictions on capital flows, external debt, interest rate.

Physical / environmental factors: Cost and availability of natural resources & energy, pollution & conservation.

Technological factors: Scientific/technological skills, existing production technology, existing consumption technology.

Political / Legal factors: Laws & regulations, safety, advertising, government system, frequency of government changes, frequency of riots, insurrections, strikes, military coups, & influence, political stability, environmental standards, regulation of competition, monopolies.

Cultural / social factors: Public attitude client lifestyles & values, number of ethnic groups, number of languages, dominant religion.

The detailed items of the task environmental factors used in the questionnaire are as follows:

Market factors: Market size, structure, growth, segments, geographical distribution and profits.

Client factors: Client behavior & Philosophy, client profile, attributes, needs, procurement processes & decisions. Clients rating of firms on the basis of reputation, product quality, service & price.

Competitor factors: Major competitors and their objectives, strategies, strengths weaknesses, sizes and market shares. Trends that will affect future competition & substitutes for the company's products & services.

Distribution factors: Main trade channels for bringing products & services to clients, Efficiency levels & growth potentials of the different trade channels.

Supplier factors: Availability of key resources used in production. Trends occurring among suppliers.

Facilitators and marketing firms: Cost & availability outlook for financial, machine, material & labour resources. Effectiveness of company's advertising agencies and marketing research firms.

Public: Public representing particular opportunities or problems for the company and firm's response to each public.

A total of 42 questionnaires were administered in Abuja and thirteen states of the federation of Nigeria to personnel involved in marketing each firm that was registered with the Federation of Construction Industry. 35 were returned and used for the study. Lagos was chosen being the commercial nerve-centre of Nigeria where majority of the firms have their headquarters. Abuja was also chosen because it is the political seat of government and being at a developing stage, where many development projects were still going on to date. Other States considered for this study are Abia, Bayelsa, Delta, Edo, Enugu, Imo, Kaduna, Kano, Oyo, Plateau, Rivers and Sokoto because the registered members of FOCI are located in these states.

Questionnaire was delivered by hand to those involved in marketing the products and services of the selected organizations registered with the Federation of Construction Industry. The register of members of the Federation of Construction Industry served as an accurate sampling frame used in the study.

Respondents were asked to complete the questionnaires. A follow-up was embarked upon later to collect the questionnaires from respondents who completed the questionnaires.

Data analysis sheets were prepared and used in collating data extracted from completed questionnaires. These data were further processed for analysis using computer SPSS Windows Release 10 software program.

4.0 Findings

Hypothesis

Objective: To determine the importance attached to environmental factors by large construction firms in Nigeria.

Null Hypothesis - H_0: Large construction firms' in Nigeria do not attach significant importance to environmental factors.

Alternate Hypothesis - H_1: Large construction firms' in Nigeria attach significant importance to environmental factors.

Table 1: One-sample t-test results of the importance of environmental factors to large construction firms' (n = 35).

Environmental Factors	T cal	D.F.	T tab	Significance
A Macro environmental factors				
V18 A1 Demographic factors	12.969	21	2.08	S*
V18 A2 Economic factors	19.654	30	2.04	S*
V18 A3 Physical/environmental factors	17.026	29	2.045	S*
V18 A4 Technological factors	21.746	28	2.048	S*
V18 A5 Political/legal factors	20.254	26	2.056	S*
V18 A6 Cultural/social factors	14.23	25	2.06	S*

B. Task environmental factors				
V18 B1 Market factors	18.025	23	2.069	S*
V18 B2 Client factors	27.382	30	2.04	S*
V18 B3 Competitor factors	18.767	24	2.064	S*
V18 B4 Distribution factors	15.402	23	2.0969	S*
V18 B5 Supplier factors	18.427	28	2.048	S*
V18 B6 Facilitators and marketing firms	18.767	24	2.064	S*
V18 B7 Public	14.905	24	2.064	S*

S * = Significant at $p < 0.05$

It was hypothesized that large construction firms in Nigeria do not attach importance to environmental factors in their marketing efforts. Table 1 indicates the one-sample t-test of the importance of environmental factors.

Where t calculated at the degree of freedom is more than the tabulated value of t at the same degree of freedom, the decision is to reject the null hypothesis that large construction firms' in Nigeria does not attach significant importance to environmental factors. It is obvious that all the macro and task environmental factors are statistically significant. This implies that the alternative hypothesis is accepted that large construction firms' in Nigeria attach significant importance to environmental factors.

The inference here is that large construction firms in Nigeria place adequate

Importance on political, economic, technological, physical, demographic and

Cultural/social as well as public, facilitators and marketing firms, supplier,

Distribution, competitor, client and market factors.

Discussion of Findings

The results of the data presented and analyzed, revealed that all the macro environmental factors (demographic factors, economic factors, physical factors, technological factors political factors and cultural factors) and task environmental factors (market factors, client factors, competitor factors, distribution factors, supplier factors, facilitators and marketing firms and public) are statistically significant. This implies that large construction firms' in Nigeria attach significant importance to environmental factors.

Findings of Dikmen, Birgonul and Ozcenk (2005) and Samson and Lema (2003) both agree that the environment within which most organizations operate is changing rapidly and organizations failing to adapt and respond to the complexity of the new environment tend to experience survival problems, sooner or later.

The present research findings also show that all the macro environmental factors (demographic factors,

knowledge is that large construction firms' in Nigeria attach significant importance to macro environmental factors (demography, economy, physical, technology, politics and culture) and task environmental factors (market, client, competitor, distribution, supplier, public, facilitators and marketing) within their marketing practices/operations.

The summary of the result obtained is that environmental factors and the marketing operations variables have significant levels of importance and

economic factors, physical factors, technological factors political factors and cultural factors) and task environmental factors (market factors, client factors, competitor factors, distribution factors, supplier factors, facilitators and marketing firms and public) are statistically significant.

The findings of the statistical significance of the macro environmental factors and the task environmental factors in this research are in agreement with the findings of Dikmen, Birgonul and Ozcenk (2005). The main contribution of the study to

emphasis placed on them by large-scale contractors in the Nigerian construction industry.

Recommendations and Conclusion

The study recommended that all employees of construction firms in Nigeria should focus on issues of environmental factors, since it enhances the future survival, performance and growth of construction firms. The study thus concluded that large scale construction firms in Nigeria succeed in business due to effective consideration of environmental factors.

The results obtained so far suggest the following conclusion large scale Nigerian contractors are successful in their business for effective Consideration of environmental factors in their business enterprise.

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Examination of the Microbial Quality of Epie-Creek, Yenagoa, Bayelsa State, Nigeria.

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Abstract

This study examined the microbial quality of Epie Creek, Yenagoa, Bayelsa State, Nigeria. The study adopted the survey research design. The purposive sampling technique was employed in the selection of sampling locations. Data were collected from Primary and secondary sources. The purpose of the microbial examination is to indicate the degree of sewage pollution of the water at the time of sampling and thus the possibility that diseases may be transmitted by water so polluted. Standard test for the coliform group technique was carried out. The aim is to estimate the number of bacteria of the coliform organisms present in a given volume of water as an index of the degree of pollution. Coliform Organisms with special attention to are Escherichia coli (E.Coli), and Salmonella typhi. Laboratory results were analysed using simple descriptive statistics and T-test, using SPSS, version 20. It was observed that Epie creek surface water is polluted in terms of the quality of the surface water judging from the water quality assessment that was carried out. The findings of this study are in tandem with literatures earlier reviewed. Akpofure (2013) reported similar result from the investigation on Biological Characteristics of Stagnant Surface Water Bodies used for drinking and domestic purposes in the Niger Delta. Amongst others, the study recommends that the inhabitants should be prevented from channelling their sewage directly into the Epie creek.

Keywords: Epie-Creek, Examination, Microbial Quality, Surface Water.

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1. Problem Identification

In recent time, the volume of untreated wastewater discharged into Epie-creek has increased. This is as a result of influx of people in Yenagoa city coupled with increased urbanization. Most houses built on both sides of Epie-creek lack properly constructed septic tank system for sewage disposal, and as such, sewers from individual homes along the creek at both sides are channelled into the creek. The wastewater contains a wide spectrum of biological agents including viruses, bacteria, parasite, helminthics and fungi, as well as chemical constituents that have the potential to cause disease conditions when it comes in contact with human being. This is in addition to the devastating environmental effects.

Epie-creek, located at the heart of Yenagoa city is subjected to all sorts of environmental abuses, and this is a growing concern. Among these are the unregulated and indiscriminate discharge of wastewater and dumping of refuse into the creek. These activities are perpetrated by households, hotels, bakeries and other commercial centres located along the Epie-creek at the both sides of the creek.

The Epie-creek provides services such as fishing, cultural activities, and the water is equally used for bathing and other domestic purposes including washing and cassava processing, mainly by the natives. The various waste discharged into the creek destroys its ecological integrity, water quality and aesthetic potentials, with attendant environmental and health effects.

This study focuses on the microbial quality of Epie-creek, as there is little or no published data on water quality status of the creek. It is obvious that whatever affects the Epie-creek water invariably affects the inhabitants/communities that make use of the Yenagoa River for drinking and other domestic uses, as the Epie-creek empties into it. This therefore calls for this study.

2. The Study Area

Yenagoa city is the capital of Bayelsa State in the Niger Delta region of

Nigeria. It is geographically located between Latitudes 4^{0}51' and 5^{0}01' North, and between Longitudes 6^{0}12' and 6^{0}27' East, in the southern part of the Nigeria. Bayelsa state, and in particular Yenagoa metropolis, is a low-lying environment, which slopes toward North-South direction to the sea.

The vegetation of the study area falls within the fresh water swamp forest, comprised of evergreen trees, small climbers, epiphytes, shrubs, and grasses, as well as other economic trees like *Elaeis guineense* (oil palm trees), *Raphia hooker* (Raffia palm), *Irvingia gaboneense,* etc. In addition, the area is rich with streams and ponds which are hosts to fishes, reptiles and hydrophytes such as water Hyacinth (*Eichhornia crasspes),* water lettuce (*pistiastraliotes)* among others.

The area has a tropical climate with alternating wet and dry seasons. The mean monthly temperature ranges from 25^{0}C to 27^{0}C with a range of 2^{0}C between wet and dry seasons (Obafemi & Omiunu, 2014). The temperature is equable for the entire Bayelsa State. The hottest months are December to April, and the relative humidity is high throughout the year decreasing slightly in the dry season. The rainfall varies in amount from one area to another. The soil is mainly deltaic in nature composing mainly of loamy and alluvial soils close to the River Bank (Obafemi & Omiunu, 2014). The soils of the coastal plain are rich in topsoil nutrients and best for planting crops such as cassava etc.

The natural drainage system of Yenagoa metropolis is characterized by creeks and swamps, crisscrossing each other as they flow through the Epie Creek and finally empties to the Atlantic Ocean through River Nun. Epie creek runs from Orashi River up North to Yenagoa River down South. The Yenagoa local government has an area of 706 km^2 with a population of 353,344 consisting of 187,791 males and 165,553 females with yearly growth rate of 2.9 as at the 2006 national census (Federal Republic of Nigeria official Gazzete, 2007). But at present, the population of Yenagoa metropolis stood at

24,335 at estimated growth rate of 2.9. , as released by the National Population Commission, across major cities.

Epie Creek is used for various socio-economic and cultural activities, ranging from fishing, and agricultural activities at the bank of the creek, canoe racing, and recreational activities like bathing and in rare occasions, it is used in processing food items by the natives. Therefore, discharging of untreated wastewater into the creek is a direct abuse and negation of the proper use of this environmental resource, for the development and betterment of society as it concerns Yenagoa city.

The creek was used as route for travelling to other villages by the Epie people. According to Barugu (2014), Epie creek links the area with the Enginni and Kalabari land through the Orashi River. This is true, the creek takes off from the River Nun and flows south-ward into the Brass estuaries.

Fishing activities are conducted in the Epie creek, streams, swamps and lakes using various methods and instruments.

In addition, agricultural activities are conducted at the bank of the Epie creek, as the people are known for farming activities. Cassava chips locally called (Tapioca) are usually soaked in the river (i.e. creek) as part of the preparation before consumption, though this practice has been reduced to the barest minimum, other uses like bathing in the river is still rife, more especially among children. According to Obafemi and Omiunu (2014), almost half of the population engages in agricultural activities. As a result of its well-endowed natural oil and gas resource deposits, the area plays host to multi-national companies such as Shell Multi-National Petroleum Company at Gbarin oil and gas flow Station. With these naturally abundance resourc

it equally serves as a hub of other ancillary economic activities as artisanship which service the oil companies. Fig. 1 shows the map of the study area.

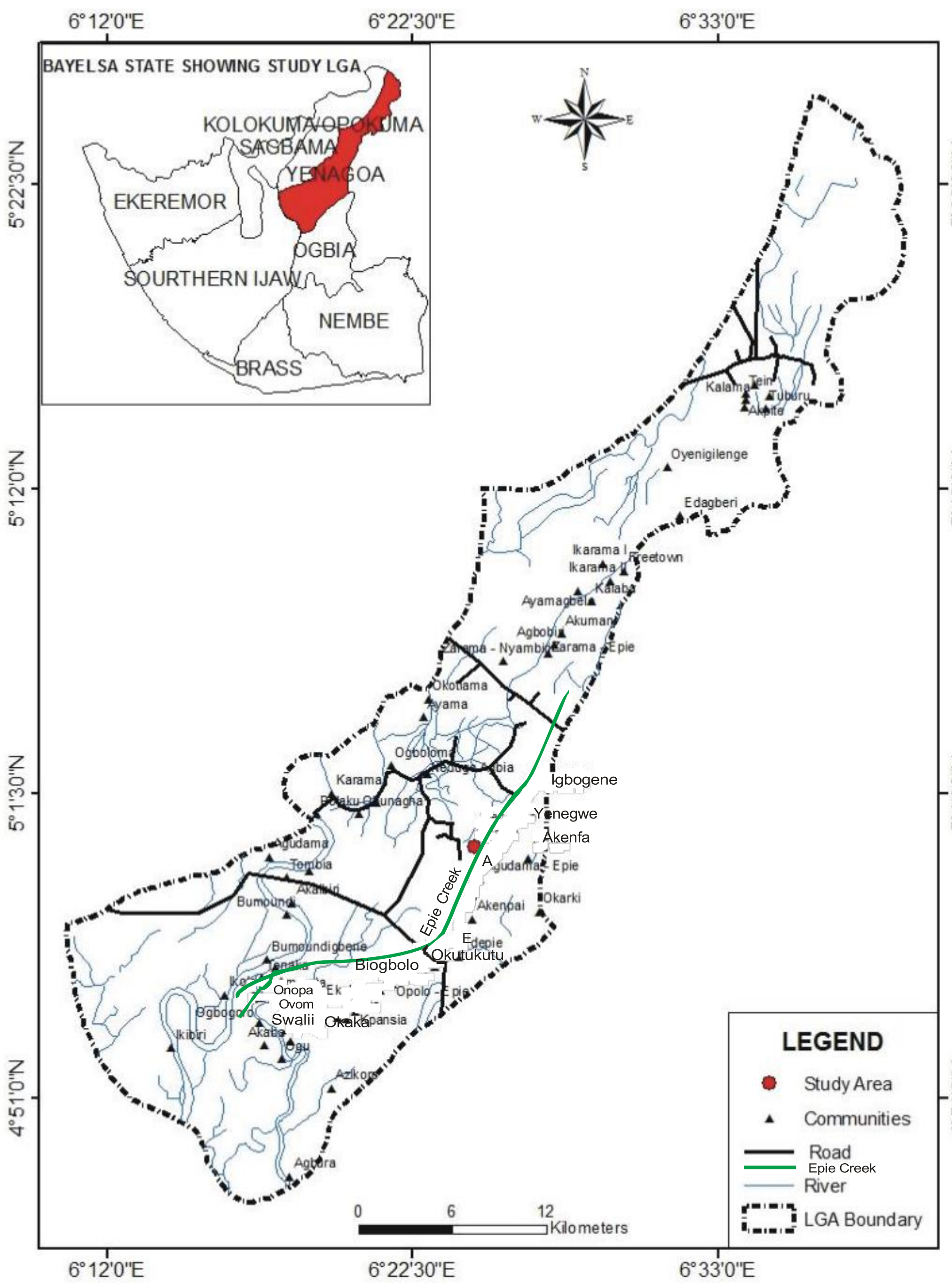

Fig. 1: The study area.

3. Microbial contaminants of surface water

The importance of water resources is not tied only to its quantity and availability, but also to its quality (Depline; Ali; & Jasini, 2013), hence,

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the monitoring of biological composition and physicochemical parameters. Giving a clear picture of the key sources of pollution in the developed world, human waste takes centre stage in many developing countries, where 90 – 95% of sewage is dumped untreated into water systems (Depline, *et al*., 2013).

Again intestinal organisms known as coliform group, if present in water indicates pollution by sewage (Rajni & Keshav, 2010). Pollution of water by sewage municipal wastewater is very common particularly in the third world countries including Nigeria. Sewage normally contains various food-borne bacteria (*Salmonella, Staphylococcus*) and other pathogenic organisms responsible for the various types of diarrhea, fever, and other infectious diseases (Naraganan, 2009). The presence of *E-coli* indicates that various pathogenic bacteria and other organisms are also present (Ranu *et al.*, 2010)

Furthermore, the presence of total coliforms, *faecal coliforms, faecal streptococci*, and *clostridium perfringens* are regarded as evidence of faecal contamination and have been used for assessing water quality for many years (Glynn& Hainke, 2005). Pathogens are disease causing organisms that grow and multiply within the host. Water is a potential carrier of pathogenic micro-organisms. These pathogens are carried into the water bodies by sewage and wastes from various industries, especially tanning and wheat packaging industries (Ranu *et al,* 2014).

The detection and identification of the different types of microbial pathogens in wastewater are always difficult, expensive, and time consuming. To overcome these problems, indicator organisms are commonly used to determine the risk of the possible presence of a particular pathogen in wastewater (Paillard, Dubois, Thiebaut, Nathier, Hogland, Caumette, & Quentine, 2005). The indicator organisms include coliforms, *feacal coliforms*, and *fecal streptococci, clostridium perfringers* and other pathogenic organisms.

Wastewater (especially domestic wastewater) can contain high concentrations of excreted pathogens, especially in countries where diarrhoeal diseases and intestinal parasites are particularly prevalent (UN-Water, 2015). Water is tested for indicator organisms that are present when fecal contamination occurs. It is virtually impossible to test for each specific pathogen that might be present in a body of water. Therefore, an indirect method called the fecal coliform test has been developed. This test is based on the fact that huge population of bacterium called *E. coli (Escherichia coli)* normally inhabit the lower intestinal tract of humans and other animals, and large numbers of the bacteria are excreted with fecal material (Richard & Dorothy, 2012).

The presumption is that when *E-coli* are found in natural waters, it is an indication of recent and probably persisting contamination with sewage. Additionally, in some instances, *E-coli* is not a pathogen itself, but is referred to as indicator organism. Its presence indicates that water is contaminated with fecal wastes and that sewage borne pathogens may be present (Richard & Dorothy, 2012).

Sewage normally contains various “food borne” bacteria (*salmonella, staphylococcus*) and other pathogenic organisms responsible for various types of diarrhea, fever and other infectious diseases (Narayanan, 2009). New, strains of *Escherichia coli* are part of a coliform group of bacteria found in sewage. Contact with some harmful strains of *Escherichia coli* such as serotype 0157:H7 can result in food poising and diarrhea and other diseases like gastroenteritis. On the other hand, several species of Salmonella may be present in raw sewage from an urban community in a typical developing country, including Nigeria, where *S. typhi* and many other pathogenic organisms are found culpable. These organisms are responsible for diseases like gastroenteritis, diarrhea and typhoid fever (Idris-Nda, *et al*., 2013).

4. Laboratory Procedure for Microbial Analysis:

The purpose of the microbial examination is to indicate the degree of sewage pollution of the water at the time of sampling and thus the possibility that diseases may be transmitted by water so polluted. Standard test for the coliform group technique was carried out. The aim is to estimate the number of bacteria of the coliform organisms present in a given volume of water as an index of the degree of pollution. Coliform Organisms with special attention to are *Escherichia coli (E.Coli*), and Salmonella typhi.

Media Preparation: Four nutrient agar were weighed and dissolved in one (1) litre of distilled water and autoclave for 15 minutes at 121^{o}C, then lactose broth was poured into the already prepared media at the same 121^{o}C to produce chocolate media. At low temperature, the broth was poured into some part of the nutrient agar to produce blood media. They were poured aseptically into the Petri dish and allowed to cool.

Inoculation: After the solidification of the media, samples were inoculated into the media using an eptical method. After inoculation, it was incubated at 37^{o}C for 24 hours in an incubator.

Reading of Plate count: After 24 hours of inoculation, the cultured samples were read for further identification. Gram staining was carried out for proper identification of the organisms. Gram positive organisms take up the primary stain while the negative organisms take up the counter stain or secondary stain.

5. Results and Discussions

The results of microbial laboratory analysis of water samples collected from Epie creek are presented and analysed in Tables 1 and 2.

Table 1: Microbial Properties of Epie Creek (Dry Season)

Parameters	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	MV	SD	WHO STD.
E.coli count/100ml	46	58	85	95	20	60.8	30.2	<10
Salmonella count/100ml	25	50	58	86	25	48.8	25.5	<10

Note: The following applies to both Tables 1 and 2.

SPL = Sample; Std. Dev. = Standard Deviation; SPL 5 = Upstream
SPL 1 = Ovom Community
SPL 2 = Amarata Community
SPL 3 = Okutukutu Community
SPL 4 = Akenfa 1 Community
SPL 5 = Akenfa 111 Community

MV = Mean Value
SD = Standard Deviation

Table 2: Microbial Properties of Epie Creek (Rainy Season)

Parameters	SPL 1	SPL 2	SPL 3	SPL 4	SPL 5	MV	SD	WS	DM
E.coli count/100ml	35	55	70	86	25	54.2	24.9	<10	0.13
Salmonella count/100ml	30	46	50	75	18	43.8	21.6	<10	0.14

MV = Mean Values

SD = Standard Deviation

WS = WHO Std. for domestic use

DM = Difference in Mean values of both seasons (p-values)

5.1 Discussion of Tables 1 & 2:

***Escherichia coli*:** The presence of *E. coli* and total coliform organism is an indication of feacal contamination in any water body. The presence of *E. coli* has a number of negative implications on human. The presence of *E. coli* coliform organism affect human more than aquatic organisms. It is an acceptable fact that the presence of coliform organisms is an indication of pathogenic organism in the water body.

In this study, *E. coli* concentration ranges from 20/ml to 95/ml during the dry season while that of the rainy season recorded 25mg/l to 86/ml. The result in both dry and rainy seasons respectively shows that both seasons exceeded the WHO recommended threshold, with sample station 4 (Akenfa 1 community) having the highest point of *E. coli* concentration in the dry season (Table 1).

***Salmonella*:** salmonella concentration in the result shows between 25/ml to 86/ml during the dry season. The rainy season result shows between 18/ml to 75/ml. This shows a high level of concentration at both seasons when compared with the WHO standard recommendation of <10/ml.

The findings of this study are in tandem with literatures earlier reviewed. Akpofure (2013), reported similar result from the investigation on Physico-chemical and Biological Characteristics of stagnant surface water bodies used for drinking and domestic purposes in the Niger Delta region, Nigeria.

6. Conclusion

It has been observed that Epie creek surface water is polluted in terms of the quality of the surface water, judging from the water quality assessment that was carried out in this study (see Tables 1 & 2, laboratory results from sampled locations). If sewage related pollutants are not treated before discharged into any natural water bodies as in the case of Epie creek, severe environmental health problems are expected to arise. Apart from that, the effect on the aquatic life, such as fishes and other smaller micro and macro-organisms which provide support to the food chain that maintains functional eco-stability may be hampered.

7. Recommendation:

Government should ensure that houses built on the bank of the Epie creek, have septic tanks for onsite treatment of sewage generated at homes. The inhabitants should be prevented from channeling their sewage directly into the Epie creek. The inhabitants should be enlightened on the dangers of dumping waste along the river bank. Sound environmental bye-laws should be enacted at both the local government and community levels. Potable water supply to be provided by the government.

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An Evaluation of Influence of Environmental Factors and Marketing Practices on Optimal Utilization of Resources of Large Construction Enterprises in Nigeria.

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Abstract

This research evaluates the influence of environmental factors and marketing practices on the optimal utilization of resources of large construction enterprises registered with the Federation of construction industry (FOCI) in Nigeria. This research was conducted in Abuja and ten states of Nigeria on construction firm's personnel responsible for marketing the services of their firms. Simple random sampling technique was used to select the sample for the field study resulting in a sample size of 42 firms, which were all contacted but 35 firms responded. The research was conducted on construction firms' personnel responsible for marketing the services of the firm. The findings revealed that there exists a relationship between the variables of the environment, marketing practices and optimal utilization of resources of large construction firms. The paper also developed a model for the optimal utilization of resources in the context of the Nigerian construction industry.

Keywords: Environmental factors, Marketing, Optimal utilization of resources, Large enterprises.

1.0 INTRODUCTION

Globalisation has great effect on all industries including construction.The construction industry has complexity in its nature because it contains a large number of parties as clients, contractors, consultants, stakeholders, shareholders, regulators and others Bekr (2017). The survival of a construction firm is determined by its ability to create and sustain a strategic market position (Ngowi, Iwisi,& Rwelamila 2000) Marketing is becoming a much more serious activity in construction borne out of necessity (Ganah, Pye and Walker, 2008). The challenge for the Nigerian construction contractor today could to a large extent be effective and efficient marketing, which is the focus of this study. This is so because marketing – orientation concept in construction firms is slow and is the least developed of the management activities according to Yisa, Ndekugri and Ambrose (1995)

Many construction firms in Nigeria do not have the skills and experience to market their services and products, they rely on invitation only. They also lack the ability to do market research and find out what opportunities exist and where. Other characteristics of construction firms include substandard marketing practices and inadequate attention to marketing which manifested in the paucity of research materials on marketing (Arditi and Davis, 1988, Yisa, Ndekugri and Ambrose, 1995, Harris, 2000) Nigeria's economy and politics since independence have witnessed changes and have suffered severe recession since the second half of 1982 which have impacted on the performance and survival of the construction industry.

Demand in the private sector decreased also because of high interest rates. There was a drop too in demand for construction services and products because of rising inflation and unemployment. The net effect of these two was reductions in demand. These led to fluctuating demand, the inability of construction firms in Nigeria to secure profitable work, meet their liquidity needs, disruptive project execution and diverse problems to the construction industry (Adegbile, Dada, Nubi and Iyagba 2001)

Some researchers argue that the actual product in construction is the service which the Contractor provides by selling expertise Mochtar (2004), Chen and Messner, (2009), while others believe that it is neither pure goods, nor a pure service; rather, it is a hybrid process consisting of both goods and service components. None of these suggestions, however, take into account the specifications and definition of these terms from the marketing view point Maloney (2002), Smyth and Lecoeuvre (2015), Mokhtariani, Sebt and Davoudpour (2017).

The significance of the study is in the following areas; it will fill the gap created as a result of the level of priority and slow orientation to marketing in Nigerian construction industry by investigating empirically the relevance of environmental factors and optimal utilization of resources and **developing a model** that will enable contractors and developers predict the chances of achieving firms' goals and objectives. It will also assist in making improvements in areas of deficiencies that will enhance marketing, and consequently optimal utilisation of resources of construction firms.

The aim of the study is to assess the influence of the environment and marketing on the optimal utilization of resources of large construction firms in Nigeria. The objective of this study derived from the research problems is to: develop a predictive model for optimal utilization of resources of large construction firms in Nigeria.

The hypothesis postulated to guide the study is as follows:

There is no significant predictability between environmental factors, marketing and optimal utilization of resources of large Nigerian Construction firms.

The study is premised on optimal utilization of resources of construction firms in Nigeria as being partly a function of environmental factors and strategic marketing practices. The focus of this research is on the marketing environment, organizational marketing practices, average growth rate and performance of large construction firms in Nigeria.

2.0 LITERATURE REVIEW

Kotler and Armstrong (2014) define marketing as "a social and managerial process by which individuals and groups obtain what they need and want through creating and exchanging value with others". A relationship approach to construction project management and also marketing has been crucial as a means to provide the construction customers with better value for money. Returns have been higher and projected relationship value considerable (Smyth and Fitch, 2009) **.**

Empirical studies have provided a steady stream of evidence that supports the existence of relationship between marketing orientation and business performance (Jaworski & Kohli, 1993, Kohli & Jaworski 1990, Narve & Slater 1990, Slate & Narver 1994) The argument is that organizations that are market oriented can better satisfy customers by creating superior value through the coordinated application of resources (Day 1994, Narver & Slater 1990, Warszawski, 1996). Also, several authors include performance variables such as short – term; lack of strategic focus and failure to provide data on quality, responsiveness and flexibility; lack of encouragement of local optimization; and do not encourage continuous improvement (Neely, 1999).

Confronted with the need to achieve their goals and strategies in a developed, developing and / or extreme economy, construction firms can improve their performance and grow during different extremes in the business cycle and economic downturn by adopting strategic management, restructuring, shrinking selectively, long-term strategies, efforts in planning and control at both project and firm levels, efforts in efficient and effective marketing, cost cutting, sub-contracting, improved safety, geographical diversification, technological competence and imaginative labour relations, personnel management and other actions

(King,1997, Low,1992, Nueno,1993, Palmer,1991,Tingle,199, Whittington, 1989)

Recession provides both a major challenge and an opportunity. History shows in terms of economic difficulty and uncertainty it is the 'smart' organisation that emerges as winners by building market share (Chambers, Fitch, Keki and Smith 2009). The environment within which most organizations operate is changing rapidly.

As the construction industry shifts towards partnering and creating long lasting relationships with clients, contractors become more able to add a significant value to their organisation by adopting in-house marketing skills (Walker, Ellis, and Mulcrone 2007). According to Baker and Hart (1989), consideration of marketing factors is central to organizational success. Also, Shaw (2000) concluded that once corporate goals and strategies are designed and implemented, the role of marketing is to contribute to their achievement. Nevertheless, the lack of marketing management skills as taught in business schools for the construction industry professionals, appear to have resulted in the ignorance of the true nature of marketing and has led individuals in construction companies to view marketing as a discipline limited to sales and promotion (Walker et; al 2007).

Hamm (2006) concluded that optimal utilization of resources gives firms an advantage over its competitors, leads to a more effective execution of jobs and increase in market share as well as free up resources other resources to focus on organizational goals and that client satisfaction gives firms a long term health, leads to more jobs and revenue, achievement of business goals as well as increase in market share.

In general, the future, survival and growth of any organization in an economy can be said to be a function of the efficiency and effectiveness of its marketing practices (Dawes, 2000, Lafferty, Thomas & Holt 2001, Udell, 1992). Moreover, Matsuno, Mentzer and Ozsomer (2002), Osuagwu (1997) found out that the survival, performance and growth of the construction industry is linked to a country's economy and such environmental factors as politics, culture, competition, government policies and regulations, technology, legislation and organizational management.

3.0 METHODOLOGY

This study is a questionnaire survey limited to large construction firms in some selected states in Nigeria (Abuja, Abia, Bayelsa, Delta, Edo, Enugu, Imo, Jos, Kano, Lagos, Kaduna, Oyo, Rivers and Sokoto), personnel responsible for marketing of large building construction firms in Nigeria registered with the Federation of Construction Industry (FOCI), (a trade / employers association which was incorporated in Nigeria on 3rd November 1954) were targeted for the study. The sample for this study was simple random sampling technique. The sampling frame was based on the 83. Firms fully registered with FOCI as at 2006 were compiled, from which a simple random sampling selection of half the population was done. This

resulted in a sample size of 42 firms; however, only 35 firms took part. Useable

Independent Variable	Coefficient B	Standard error	T-value	Significant T	Remark
Constant	-7.502	1.247	-6.017	0	Significant
V18 B4 Distribution Factors	1.859	0.21	8.844	0	Significant
V406 Plant and Equipment Leasing	1.699	0.222	7.667	0	Significant
V20 D4 New service and product dev.	1.828	0.2	9.16	0	Significant
V18 A3 Physical Environmental Factors	-1.528	0.196	-7.783	0	Significant
V20 B4 Organizational Factors	0.71	0.14	5.077	0	Significant
V20 B2 Functional Efficiency	-0.719	0.13	-5.523	0	Significant
V20 C3 Volume of work	0.605	0.161	3.76	0.001	Significant
V20 D5 Managerial style	-0.432	0.165	-2.614	0.016	Significant
V407 Sale and supply of bldg. Materials	0.663	0.263	2.517	0.019	Significant
V403 Repair and Maintenance	0.565	0.255	2.211	0.037	Significant

Questionnaire from 35 construction firms that were returned yielded a response rate of 83 percent, were collated from the survey and analysed.

4.0 FINDINGS

Using the overall performance as dependent variable, a ten-step regression analysis was completed for large construction firms and its independent variables. The results of the multiple regression analysis are presented in tables 1 and 2 and discussed below.

Table 1 shows that only ten independent variables are significantly contributing to overall performance (optimal utilization of resources). The multiple correlation coefficient between the ten predictors and optimal utilization of resources of large construction firms is 0.947 (R = 0.947). This indicates high positive correlation. Together these ten predictors explained 89.7 % (i.e. R squared = 0.897) of the variation in optimal utilization of resources.

Significant at $p < 0.05$

Table 1: Model fitting results and stepwise selection for optimal utilization of resources of large-scale construction firms.

Source of Variation	D.F.	Sum of Squares	Mean Square	F Ratio	P Value
Regression	10	174.489	17.499	19.938	0
Residual	23	20.129	0.875		
Multiple R= 0.947					
R squared = 0.897					
Adjusted R square =	0.852				

Table 2: Analysis of variance of optimal utilization of resources of large scale construction firms.

R Squared is the coefficient of multiple determinations, which is the square of the correlation coefficient, R. From Table 1 ten variables explained 89.7

per cent of the variance of the optimal utilization of resources. The correlation between them and the dependent variables is 0.947, which is highly significant at 0.005 level. This resulted in the formulation of an equation for optimal utilization of resources model thus:

P (p $_1$) = 7.502 + 1.895 (V18 B4) + 1.699 (V406) + 1.828 (V20 D4) – 1.528 (V18 A3) + 0.71 (V20 D5) – 0.719 (V20 B2) + 0.605 (V20 C3) – 0.432 (V20 D5) + 0.663 (V407) + 0.565 (V403) (1)

Optimal utilization of resources = 7.502 + 1.895 (distribution factors) + 1.699 (plant and equipment leasing) + 1.828 (new service and product development) – 1.528 (physical/environmental factors) + 0.71 (organizational culture) – 0.719

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(functional efficiency) + 0.605 (volume of work) – 0.432 (managerial style) + 0.663 (sale and supply of building materials) + 0.565 (repair and maintenance)

From equation 1, 1.859 V18 B4 suggests that on the average an increase of 1.859 of the optimal utilization of resources of the organization can be expected for each unit increase in distribution factors when all other variables and the slope intercept are kept constant.

In the same way 1.699 V406 suggests that on the average an increase of 1.699 of the optimal utilization of resources of the organization can be expected for each unit increase in plant and equipment leasing when all other variables and the slope intercept are kept constant

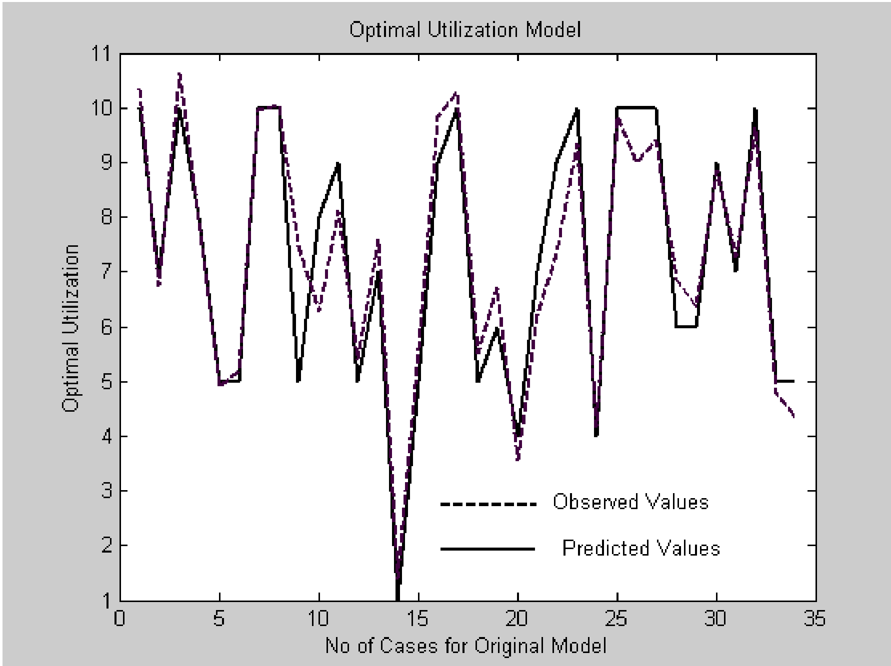

FIGURE 1: Predicted values against observed values for validation of optimal utilization of resources model.

Figure 1 is a graphical representation of equation 1 with a range of 1 to 10 and the closeness of the predicted and observed values indicates that the model has a high degree of accuracy. F-test results also show that the model is statistically significant (P Value = 0).

From the above analysis and from the other predictor variables, there is a clear indication that for every additional time, resources and expense on distribution factors, plant and equipment leasing, new service/product development, physical/environmental factors, organizational culture, functional efficiency, volume of work, managerial style, sale and supply of building materials and repair and maintenance the higher the optimal utilization of resources of large construction firms in Nigeria.

The equation shows that all the variables are significant as the T-statistics of the constants are significantly different from zero. The goodness of fit as indicated by the F-statistics is also reliable since F-calculated is greater than F-tabulated. Therefore the model can be said to a good predictor of the performance of the construction firms.

From the analyzed variables above and from other predictor variables there is a clear indication that the optimal utilization of resources model can be used by construction firms to predict their performance based on the time and expense incurred on distribution factors, plant and equipment leasing, new service/product development, physical/environmental factors, organizational culture, functional efficiency, volume of work, managerial style, sale and supply of building materials as well as repair and maintenance in order to optimally utilize their resources.

Optimal utilization model would lead to an increase in overall performance of construction firms as adequate time and expense are placed on the appropriate variables

Validation of optimal utilization of resources model.

The validation results comparing the actual with the predicted scores/values using the resulting model of optimal utilization of resources have the following data points as reflected in Table 3 while figure 2 shows the plot of predicted values against observed values for optimal utilization of resources model.

Figure 2 shows that the plot of predicted values did not deviate significantly from the observed values, hence it shows some measure of accuracy of the originally built model.

Further analysis using the same steps on the data points described earlier was used to construct another model for optimal utilization of resources for predicting future levels of optimal utilization of resources. The characteristics of this newly constructed model specifically, multiple R, R^2, Adjusted R^2, standard error and Analysis of Variance were compared with the characteristics of the original model and shown in Table 3.

Model validation for optimal utilization of resources		
Cases	Predicted values	Observed values
Case 1	8.43	8
Case 2	3.99	4
Case 3	5.91	4
Case 4	3.31	2
Case 5	2.25	2
Case 6	4.2	5
Case 7	4.37	5
Case 8	8.84	9
Case 9	5.87	4
Case 10	9.49	9
Case 11	4.64	5
Case 12	8.02	9
Case 13	7.54	9
Case 14	3.51	4
Case 15	3.55	3
Case 16	5.5	8
Case 17	7.54	7
Case 18	7.61	7
Case 19	6.28	8
Case 20	7.17	6

Table 3: Subset data points used for validation of optimal utilization of resources model.

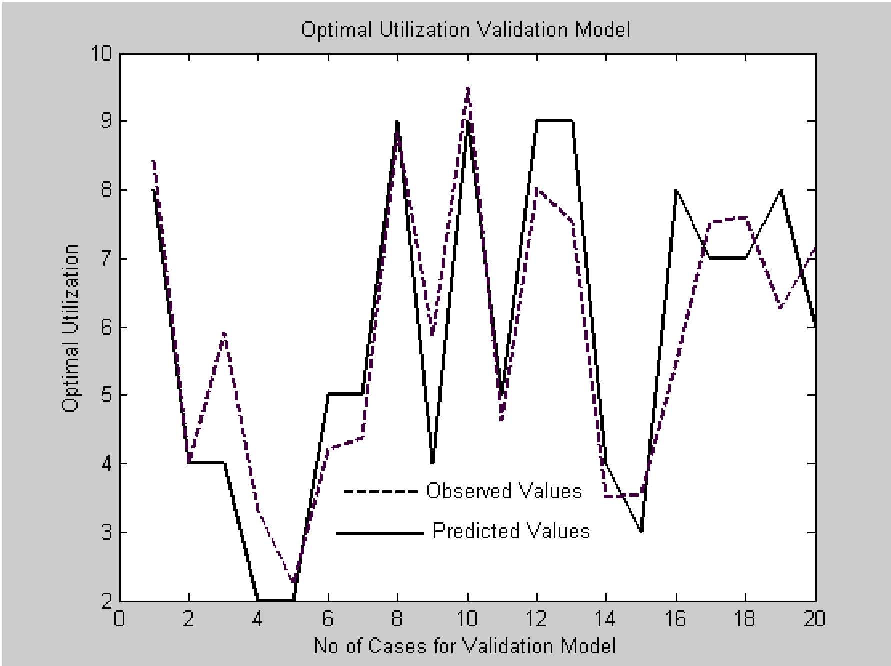

FIGURE 2: Plot of predicted values against observed values for validation of optimal utilization of resources model.

Figure 2 is a graphical representation of equation 1 with a range of 2 to 9 and the closeness of the predicted and observed values indicates that the model has a high degree of accuracy. F-test results also show that the model is statistically significant (P Value = 0).

Discussion of Findings

The results of the data presented and analyzed, reveal the findings summarized below: there is a clear indication that distribution factors, plant and equipment leasing, new service / product development, physical / environmental factors, organizational culture, functional efficiency, volume of work, managerial style, sale and supply of building materials and repair and maintenance are positively and significantly related to optimal

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utilization of resources of large construction firms in Nigeria.

This is in agreement with the findings of Hamm (2006) that optimal utilization of resources gives firms an advantage over its competitors, leads to a more effective execution of jobs and increase in market share as well as free up resources other resources to focus on organizational goals.

Validation of these models indicates accuracy to pass the reliability test and strongly support the assumption that there is a relationship between marketing, environmental factors and performance of large construction firms in Nigeria.

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Sustainable Environment: an examination of thermal comfort of residential buildings in warm humid climate of Abia State

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Abstract

Residential buildings are where people live permanently or for very long time. A place where dawn to dusk activities like reading, resting, sleeping and answering nature's call take place. It should therefore provide comfortable microclimate conditions for homemakers. This definition is at variance with the conditions of most residences in Abia state because many are cells of unhappiness due to thermal discomfort. This discomfort increases each time there is no electricity which is often. This paper relied on experimental studies by Alozie (2014) which examined thermal comfort in residential buildings in urban areas in Abia State to provide answers on how to remove the problem of thermal discomfort in residential buildings. In Alozie (2014) out of 81 residences tested for thermal comfort, 57 or 70.3% failed due to faulty architectural designs which allowed for improper building orientations that is responsible for heat gain in buildings. Radiation increases indoor temperature in buildings, causing thermal discomfort. Another outstanding reason for failure is specifications of non-climate responsive building materials. Other reasons include landscaping, and failure to observe building regulations. The buildings that failed thermal comfort test did not originate from architects and lacked expertise knowledge necessary to remove thermal discomfort in residential buildings. The study developed a template for designing and developing climate responsive buildings in warm humid environments such as the study area. It validated the template successfully and thus recommended that residences in warm humid climates be conceived using the template as guideline.

Keywords: Architecture, Residential Building, Indoor thermal comfort & Template

Introduction

Alozie (2014), in a thermal comfort study of residential buildings in Abia State urban environments concluded that most residential buildings in the State are cells of unhappiness because of their failure to naturally provide the inmates with acceptable thermal environment. This state of discomfort Alozie (2014) uncovered resulted from architectural designs and construction. A condition which is at variance with definition of residential buildings.

Residential buildings are buildings where people live for a long time or permanently, and where people carry out dawn to dusk activates like rest, read, sleep, cook, eat, and answer nature's call (Alozie, 2014, & Adebamowo, 2007). It is therefore a place that should provide comfort, among which are warmth and cooling, "thermal comfort".

Recent observations in Abia State, and Umuahia in particular revealed large number of homemakers staying in verandahs in the noon and night times, topless or wearing light cloths and fanning themselves with hand fans. This unsightly incident is more frequent in the evening and night time when groups of residents are seen outside the comfort their homes till about 10 pm to 11 pm waiting for the indoor temperature in their residences to drop to an acceptable degree. This ugly and unhappy experience happens whenever there is no electricity which is very often, as the average daily supply of electricity in Umuahia is about 4 hours (Alozie, 2014). The number of hours electricity is available in some parts in the state is even less, while some other areas don't have electricity in months. This is not peculiar to Umuahia, but almost a national issue (Alozie, 2014). Energy provided by electricity generating machines are expensive, noisy and causes pollution. Noise and gaseous pollutions are hazardous to health and does not allow homemakers the required peace especially when there are many and are operated simultaneously.

It became necessary therefore to examine thermal responses of homemakers in a warm humid climate using urban environments in Abia State. This quest to examine thermal condition in homes was further made obvious by references made to results by Alozie (2014, Alozie, Odim & Ehibudu 2016), Akande and Adebamowo (2010), Rao (2007) and others who concluded that residential buildings should provide indoor micro climate required for all human activities.

Le – Corbusier (1977), remarked that the architect is an authority with the mandate of bringing man in harmony with his environment and that includes the unwholesome indoor thermal discomfort felt in residential buildings. The principal tools in the hands of the architect in achieving this, remains design, therefore the need for contemporary architects to study pre electricity architectural era must then be underscored.

A study of architecture and indoor thermal comfort before the discovery of electricity in 16th century by Benjamin Franklin and the introduction of mechanical or artificial means of improving ventilation and lighting in buildings revealed that man was able to achieve indoor thermal comfort in his buildings through a mastery of his climate. Man used available building materials in his locality and applied knowledge acquired from mastery of the climate prevailing in his domain to achieve desired comfort (Morgan, 2017). In like manner, early Greek, Roman and American Arizona civilizations when hit by energy crisis in over 2500 years ago , developed ideas that enabled them overcome the situation (Botkin and Keller 1998).In Africa, Nigeria and specifically in Igbo region traditional builders were able to develop high degrees of indoor thermal comfort in their buildings (Domochowoski, 1990) and this is a pointer that contemporary architects with the advantage of technology , could supersede the achievements of these predecessors by naturally achieving thermal comfort in the new buildings they design and the old ones they renovate.

Presently, air conditioning and other thermal comfort gadgets used in providing cooling, heating and lighting in buildings have become too demanding because of high consumption of electricity, arising from an explosion in urban population and increasing number of buildings being constructed to accommodate the explosion. Electricity which is the main source of energy in developing nations have become scarce and expensive (Alozie 2014, Zain, 2004).

1.1.2 ARCHITECTURE

Architecture has been defined in many ways. Architecture is concerned with the creation of order out of chaos, a respect for organization, the manipulation of geometry, and creation of a work in which aesthetics plays far greater role than anything likely to be found in a humdrum building. Architecture has three conditions: Commodity, Firmness, and Delight (harmony of proportion, symmetry propriety and economy), this is also seen as beauty, firmness and convenience (Curl, 1999).

In simpler words, Curl (1999) defined architecture as the art and science of designing a building, having qualities of beauty, geometry, emotional and spiritual power, intellectual content and complexity, soundness of construction, convenient planning, many virtues of different kinds, durable and pleasing materials, agreeable coloring and decorations. Serenity and dynamism, good proportions' and acceptable scale, and many mnemonic association drawings on a great range of precedents. Little wonder therefore the claim by Frank Lloyd Wright, that an architect cannot bury his mistake, unlike the physician (Curl, 1999).

1.1.3 ARCHITECT: the architect is a person having the prerequisite education that enables him to prepare complicated plans, elevations, sections, site plans, and other preliminary and detailed drawings of simple and sophisticated buildings and having aesthetic content. The architect has knowledge and ability to supervise its construction in accordance with the drawings and specifications (Curl, 1999).The architect conceives his projects before designing just like our earliest ancestors built their huts only when they had pictures of them in their minds. It is this product of the mind and the process of creation that constitutes architecture.

1.2 Aim of the Study.

The aim of the study was to examine thermal comfort of residential buildings in warm humid climate of Abia State. The examination leaned extensively on the results of series of studies by Alozie (2014) to provide a template for designing, constructing and renovating residential buildings, that will natural provide indoor thermal comfort in warm humid climates environment of Abia State.

2.0 LITERATURE REVIEW

The study unveiled potentials in literature that will lead to achieving the study aim. Such potentials as listed below include:

2.1 Thermal Comfort

Indoor thermal comfort is achieved when occupants pursue without hindrance activities which the building is intended to (Akande & Adebamowo, 2010). Akande and Adebamowo align well with Dagostino (1978) who defined thermal comfort as a state of being able to carry on any activities without being either chilly or too hot. Both definitions are rightly acceptable to this study, however the study adopted American Society of Heating, Refrigerating and Air Conditioning Engineers ASHRAE's definition because it quantified thermal comfort. ASHRAE (2004) defined thermal comfort as that express satisfaction within the thermal environment, in which at least 80% of the sedentary or slightly active persons find their environment thermally acceptable.

2.2 Climate Responsive Buildings

Climate responsive buildings are buildings whose architectural designs, construction and operational strategies, have enabled to take advantage of potentials that will unconditionally create indoor thermal comfort and effective lighting conditions with little or no energy expenditure. (Vaughn Bradshaw 2006). According to ASHRAE (2004), this refers to buildings which take advantage of prevailing climatic potentials to create acceptable indoor thermal comfort and lighting conditions

2.3 Orientation and Spatial Organization

Orientation and spatial organization affects the ability of a building to ventilate and receive solar radiation. To minimize solar gain and maximize ventilation, traditional buildings in warm humid climates usually employ spread-out plans and permeable internal organization. According to Leaurungneong (2006) by orientating the longer sides of the buildings to intercept prevailing winds and the shorter sides to face the direction of the strongest solar radiation, effective ventilation can be achieved, while thermal impact from solar radiation is minimized, Leaurungneong (2006) implied that such strategy can also be applied effectively in modern buildings.

2.4 Shading

Solar gain through windows is often component of the heat gains of a building. Also solar radiation on the opaque part of the building envelope raises the surface temperature of the envelope and contribute to the heating of the interior environment. Investigations highlight the importance of providing effective shading as part of overall strategy for preventing overheating in warm humid climates

2.5 Material, Color and Texture

In warm climates, materials for building envelopes and the surrounding surfaces, such as walkways and terraces, should help minimize heat gains into the buildings. Leaurungneong (2006) revealed that many traditional buildings in warm humid climates use light-weight materials along with relatively permeable constructions, such as wooden walls with ventilation gaps and wooden bamboo strip flooring, to allow the interiors to cool rapidly in the evening following the outside air temperature, and achieve a relatively comfortable environment during sleep hours.

2.6 Vegetation

Vegetation can be an effective means of moderating the temperature around a building and reducing the building's cooling requirement. Vegetation in the form of trees, climbers, high shrubs, and pergolas for example, can provide effective shading for the building's walls and windows. Ground cover by plants also reduces the reflected solar radiation and long-wave radiation emitted towards the building, thus reducing solar and long-wave heat gains. The evapotranspiration process also cools the ambient air and nearby surfaces.

Furthermore, climbers over the walls can reduce the wind speed next to the wall surfaces and provide thermal insulation when the exterior air temperature is greater than that of the walls. Field work in warm humid climates revealed the ability of plants to lower the ambient temperature appreciably, with areas such as urban parks often found to be a few degrees Celsius cooler than the surrounding built-up areas;

Also the average temperature of the building's walls which are shaded by plants can be 5-15ºC less than that of unshaded ones, depending on the local climates and planting details (Parker, 1981). Likewise, a roof garden can attain temperature 10-30ºC below that of an exposed roof surface depending on the roof construction, planting details and surrounding conditions.

To compliment indoor thermal comfort in residential buildings, quantitative planting principles should be developed which will help optimize the cooling effect of vegetation especially when it is used in conjunction with and in place of conventional shading devices and insulation. Attention should be given to balancing the benefits from temperature reduction with the adverse effects from increased humidity due to the evapotranspiration process, especially when plants are grown near ventilation inlets. Optimization of the use of local plants should also be explored.

2.7 Cooling Techniques

Even with the best effort to reduce heat gains, cooling requirement may not be eliminated. In such cases, a range of passive cooling techniques may be employed to help achieve thermal comfort. Key coiling techniques for warm humid climate involve appropriate utilization of natural ventilation, thermal mass and heat dissipation by radiation and evaporation.

2.8 Thermal Mass

Thermal mass can be defined as a material that absorbs or releases heat from or to an interior space and can delay heat transfer through the envelope of a building and help keep the interior cool during the day when the outside temperature is high. Moreover, when thermal mass is exposed to the interior, it absorbs heat from internal sources and dampens the amplitude of the interior temperature swing.

3.0 Methodology

This paper was developed using the methodology, literature and results from experimental studies on indoor thermal comfort by Alozie (2014) in urban environments of Aba, Umuahia and Ohafia in Abia State, which examined indoor thermal performances of residential buildings in these three urban environments.

The survey was conducted on 81 residential buildings which was spread out to capture the three geopolitical zones of the state. Each of the urban areas: Umuahia, Aba and Ohafia was divided into three cells and 9 buildings were randomly selected from each cell. Each cell comprised of three High, three Middle and three Low income residences making the sample population from each urban area 27 buildings. The study lasted for three years, 2011 to 2013, 1st January to 1st December. Instruments such as data loggers (a digital instrument that measured temperatures and relative humidity) was used to determine indoor and outdoor temperatures and relative humidity in sample buildings. Infra-red thermometer was used to determine surface temperature of building materials. Indoor airflow was measured with an anemometer.

The data loggers were calibrated to read off and store by 7.30 am, when humidity is at its peak, 3.30 at the peak of sunshine and 9.30 pm when cooling have taken place. The Effective Temperature Index was used to determine comfort. The index approved a comfort range of 20 – 26 degrees Celsius for buildings in tropical warm humid environments. This index was preferred to others because of its convince in determining thermal comfort values, that provided numerical value for judgment was applied on American Society for Heating, Refrigeration and Air-conditioning Engineers ASHRAE (2004)'s definition which quantified thermal comfort as a condition in which 80% of the sedentary or partly active persons are comfortable. ASHRAE's judgment is based on a 7 point scale of -3 (very cold) to +3 (very hot).

This paper applied reviews in literatures on climate responsive architecture ,thermal comfort studies and in-depth reviews on ventilation, temperature, humidity, building orientation, building materials, thermal mass, vegetation, wind and shading. Measured drawings of case study buildings in Alozie (2014), questionnaires and interviews were also considered. Secondary information on climate came from Agricultural Meteorological Station Umudike, (AGROMET) a subsidiary of Nigerian Institute of Metrology (NIMET), as applied in Alozie (2014)

4.0 Findings and Discussion

In the study of thermal performance of residential buildings in urban areas of Umuahia, Aba, and Ohafia. Fifty seven residences out of eighty one, representing 70.3% failed, while twenty four buildings or 29.7% passed. The buildings that failed were discovered to have done so because their design and development did not adhere to professional regulations and did not follow findings as unveiled in literature. According to Alozie (2014) thermal comfort in buildings depends not only on air movement inside and outside buildings, but also on their architecture. This is true because architecture of buildings determines its ventilation. Ventilation plays significant role in indoor temperature and relative humidity especially in warm humid climates.

Alozie, (2014) underscored therefore the need for passive design which supports application of natural ventilation as effective means of removing unwanted or stale indoor air. Ajibola (2001) in his submission attached the amount of radiation into the building's interior as a major factor in determining its indoor thermal performance. Ajibola (2001), further listed passive design as a most appropriate natural tool to removing thermal discomfort in buildings. He called on environmental designers especially the architect to go back to master and apply the following in design; orientation of buildings on site, windows; (types, opening and location in buildings), landscaping; (use of trees , grasses, shrubs) which aids cooling by blocking radiation , and recommended the use of climate responsive building materials, and shading devices; (fixed and movable types).

The research discovered that the 70.3% or 57 of the test buildings which failed thermal comfort test had the following defects which resulted from design. It should be noted that the fifty seven buildings were not traceable to any architect.

4.1 Over Development of the Building Plots

Over development of the building plots and wrong zoning of spaces contributed to the failure of the buildings. Building regulation in the state allows only 33.3% or 1/3 of the available plot area to be built up in residential buildings. It was discovered that most buildings took up 65%, to 70% of the plot area. High fencing walls also contributed to poor air flow, which in some buildings, windows open very close to the fence due to inadequate setbacks.

4.2 Orientation

According to Ogunsote (1990), building orientation is a significant design consideration when designing to achieve thermal comfort in buildings. Buildings should be oriented to benefit from the prevailing climatic conditions like the sun and the wind. It is necessary that areas like the bedrooms and the living rooms be zoned away from being heated by sunlight. Windows should be aligned to take advantage of air flow around the site. The fifty seven buildings that failed comfort test were not properly oriented on site.

4.3 Inadequate Building Set Backs

Building regulation in the state requires that all buildings start from or must not exceed the building line. A set back of not less than 3 meters from the beginning of the road and all adjoining structures, including fences. This rules were faulted in the buildings that failed thermal comfort test.

4.4 Poor Ventilation

Of all elements in the building envelope, windows and other glazed areas are most vulnerable to heat gain or losses (Ogunsote, 1990). Proper location, sizing and type of windows and shading form an important part of bioclimatic design, as they help keep the sun and wind out of the building and allow them in when needed. The buildings that failed thermal comfort test had defects in their windows; (types and their locations)

4.5 Landscaping

Mazrina (1979), identified landscaping as important element in altering the microclimate of any building. Proper landscaping reduces direct sunshine from striking and heating up the building from the ground surfaces. In an experiment by Mazrina (1979), it was discovered that the indoor temperature of buildings shaded by trees were 2 to 2.5 degrees Celsius lower than those unshaded. Therefore trees, grasses and shrubs are landscape elements valuable in reducing radiation in buildings. According to Parker (1981), the average temperature of building walls shaded by plants can be lower by 5-15^{o}C while roof gardens can retain a reduction of 10-30 degree Celsius.

4.6 Thermal Mass

Thermal mass increases the indoor temperature during the night, as conventional hot air blowing through the mass empties into the building interior

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and heats it up. This may be good for arid climates where the night is cold and needs warming, but definitely not for warm humid climates. Concrete stores heat in the day and transmits same into buildings at night. Concrete mass is not recommended as a dominant landscape element for warm humid climates.

However due to limited plot sizes available for development in urban areas in Abia State, the available plots over built and this makes mass concrete preferred landscape element. Buildings with poor thermal performances were mostly landscaped in mass concrete.

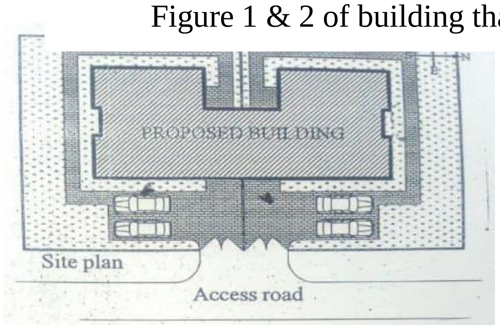
4.7 Specifications

This is a specialized professional input whose failure done results in many structural and environmental failures. Mazrina (1979) is of the opinion that the choice of building materials helps in promoting indoor thermal comfort as building materials reduces embodied energy required to attain the desired comfort conditions. The roof receives significant solar radiation and plays an important role in heat gain and losses. Choice of material for finishing outside and roofing materials may affect ventilation, day lighting and radiation. Buildings that failed thermal comfort test had inadequate specifications resulting from absence of professional input as none of the building plans was traceable to an architect.

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
TEMP(^{O}C)	22.2	21.0	21.9	22.1	21.3	22.3	23.8	22.0	21.4	21.0	22.1	24	22
HUMD(%)	83	78.6	78	76	77	80.3	77.3	80.1	77.6	72.6	74.3	76.3	78.2

Temperature/humidity values of case study building that passed thermal comfort test

Figure 1 & 2 of building that passed thermal comfort test



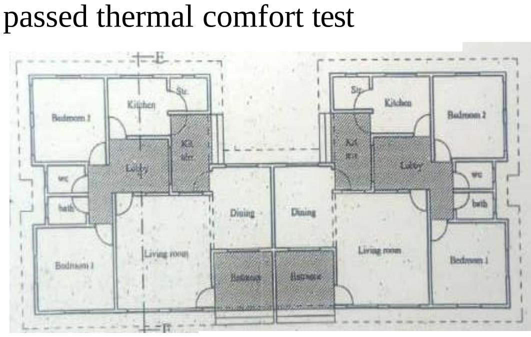


Figure 1 **Site Plan** **Figure 2** **Ground Floor Plan**

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
TEMP(°C)	29.3	30.7	30.7	31.0	31.1	30.6	30.7	30.3	30.5	30.3	31.2	26.0	30.5
HUMD(%)	51.4	50.6	80	59.9	54.9	58.8	61.3	56.4	56.0	57	54.9	51.5	56.1

Temperature/humidity values of case study building that failed thermal comfort tests

Figure 3 **Site Plan**

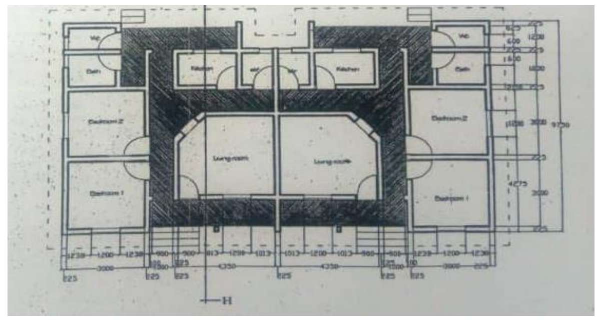


Figure 4 **Ground Floor**

5.0 Template for Achieving Indoor Thermal Comfort in Residential Buildings in Warm Humid Environment

The study took into considerations details of both buildings that passed thermal comfort test and those that did not. It considered factors that enabled both results. Reasons for both were analyzed and the results compared to literature. It was discovered that all the buildings that failed did not incorporate passive architecture principles because there were not professional products. The study hence listed the following measures as template or guide towards designing and development of thermally responsive residential buildings in warm humid climate of Abia State and areas in same climatic zone: Engagement of building professionals, Architects and Engineers at the inception of every building project as basic condition that will guarantee, proper building orientation on site, good ventilation, right choice of window types, sides and location on building envelope, good landscaping (planting of trees, grasses and shrub), applying shading devices in right locations, adherence to building codes and town planning regulations, and specification of thermal friendly building materials among other measures which the architect may consider necessary and as detailed under.

5.2 Radiation

Radiation is a major cause of heat gain in buildings' interior and major source of heat gain. Radiation into buildings are through openings such as windows and doors. Radiation could be controlled into buildings by avoiding windows on the western façade or reducing their numbers and their sizes.

By closing windows that face west in the morning hours and pulling down their blinds and opening them in the evening time when the sun sets reduces heat gain into the building. The use of lightweight materials reduces thermal mass. Example of lightweight material is timber. Concrete and Sand Crete blocks have high thermal storage. Both store heat in the day and transmit same at night into buildings. This could be removed by using timber.

5.3 Trees as Shading Devices

It is an ideal practice to have the longer sides of a building face south, as this enables more airflow through the building and less heat gain.

Use of trees, especially deciduous trees planted close to each other in the west, provides shading from the sun. Buildings shaded by trees can lower indoor temperature by 2 to 5 degree Celsius (Mazrina, 2007).

5.4 Thermal Mass

It is good practice avoiding concrete in landscaping and concrete in fascia roofs as both store and transfer heat into the building's interior at night. However the opposite is good for hot and dry climates where the day temperature is very high and night very cold. The concrete serves as a heat sink (reservoir) in the day and at night when it is very cold air blowing through the concrete mass (sink, reservoir) warms up the interior.

5.5 Orientation

The way buildings align on site in relationship to true geographical North is referred to its orientation. Building's orientation on site determines much of its thermal performance, as it affects airflow and heat gain into the building

Most buildings in residential estates however have fixed orientation because of the roads which determines the buildings frontal façade. It becomes impossible influencing the location of the longer side. In such situations, zoning of spaces becomes a key tool at the architect's disposal.

5.6 Zoning / Windows; types, sizes

Zoning in architectural design refers to scheduling of spaces according to the frequency of usage and desired comfort. It is good practice to have all bedrooms and living areas away from the west to prevent heating. Garages, dens, laundries, games and gym spaces are best zoned to the west

Airflow into building's interior should be enhanced by specifying appropriate window types and sizes. Knowing the wind direction is important in locating windows as increasing the window openings in the leeward direction enables more air flow while reducing the sizes or numbers in the outlet direction increases cooling. Window choice also affect air inlet into the interior. Casement, Louvered and Sliding windows are ideal types. Both Casement and Louvered admit 100% ventilation and 100% lighting. Sliding windows admit 50% to 63.33% ventilation and 100% lighting.

5.7 Vents

Much heat accumulates in roof structure of buildings and this increases the indoor temperature of buildings. This unwanted heat must be prevented from gaining admittance into the building's interior. A major means for checking this heat roof is by venting. Venting is a medium by which unwanted roof heat is prevented from flowing into the building's interior.

Climate responsive architecture also allows for the heat that generates in the roof structure to exit through ceiling vents. This practice was a very effective practice during colonial and post-colonial architecture in Nigeria but has been abandoned due for preference to concrete fascia roofs and aluminum ceiling for the eaves

Another kind of vent is the one that comes after lintel and on top of windows and door. This has been modernized to compliment the beauty of building while evicting heated indoor air especially at night when all windows may be shut.

5.8 Vegetation/Shading

The ideal home should have a landscape of green. In rural environments natural and planted trees enrich compounds. Trees, Shrubs and land covers such as grasses should be part of the landscape. Besides pleasant appearances, trees and land covers slow down the heating of earth. Trees also provide shading to buildings. Further shading in residential buildings could be provided with roof eaves, awnings, sun breakers such as window hoods.

5.9 Building Regulations

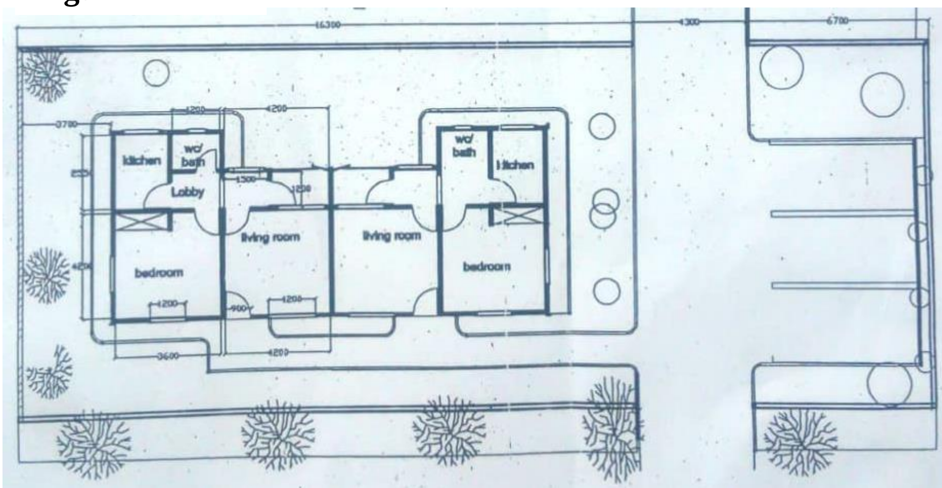
Every State in Nigeria has an urban development authority, whose task is to ensure that buildings and all physical development observe regulations. Some of these regulations are listed below,

- Residential buildings should develop 1/3 or 66.66% of the total plot area.
- There should be a 3 meters minimum set back from the fence and all adjoining structures.
- Standard bedroom size should be 3.6m by 3.6 m or 12.96m square.
- The floor to ceiling height should be minimum of 3 meters.
- All bedrooms and living rooms must be properly ventilated; cross ventilation that is when windows face opposite directions and natural, when Windows occurs at least on two sides of the room.
- Other rules though always not considered by homemakers but enhances thermal quality of indoors of residences are the choice of finishing.
- Sand Crete floors, terrazzo floors, ceramic and P V C floor tiles are ideal.
- Light emulsion colours such as white and blue which have cooling effects should be preferred.
- Electricity lights contribute to indoor heating. Low energy lamps are ideal

MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
TEMP(^{O}C)	20.7	20.5	20.3	20.5	20.5	21.0	21.0	22.4	21.4	22.5	21.4	20	21
HUMD (%)	77	79	80	76	75	78	80	78	81	80	78	60	76.8

Temperature/humidity values of model building

Figure 5



Ground Floor Plan of model building

Plate 1

Plate 2

3-dimensional views of model building

6.0 Recommendations

The study, successfully developed a template, applied same in design, construction and operation of a model building with success recommend that the task of creating buildings, beginning at the design inception and lasting through its construction be the exclusive task of the architect or his intern. (2) That the template be enshrined in building code as guide to development of climate responsive buildings.

Conclusion

When residential buildings which account for more than 40% of the total world energy consumption (Alozie, 2019, Botkin & Keller 1998) are designed, constructed and operated to achieve energy efficiency, the operational energy of buildings will be reduced significantly. When this happens a clean and less polluted environment will emerge. The study concluded that architects, engineers and estate developers apply the template in order to realize climate responsive residences.

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An Examination of the Effects of Gully Erosion on Urban Planning: A study of Nanka, Anambra State, Nigeria.

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Abstract

Erosion usually start off with the relatively uniform removal of the soil surface by excess runoff aided by steep sloping topography, soil/rock types, removal of vegetative cover and poorly designed construction works. The study aimed at highlighting the effects of soil erosion on planning: study of Nanka site. Data for the study was collected by various methods which included field survey; direct observations from fieldwork, interviews and literature review. To reduce the negative effects of gully erosion in planning, adequate knowledge of the environment is paramount as the need for an integrated environmental planning and studies is urgent. The effects of this menace have led to total disruption of planning activities especially in Nanka area and the entire Anambra State. The researcher therefore makes reliable proposing on the way forward through workable plans presented in this paper.

Keywords: Examination, Effects, Gully Erosion and Urban Planning.

1.0 Background of Study

Gully erosion is one of the most conspicuous forms of accelerated erosion which occurs in widely different climate, geologic and land use conditions (Egboka, Orji and Nwankwoala, 2019). Gully erosion accelerates the loss of soil and decreases the productivity of agricultural land. Eroded sediments are often transported into the receiving streams causing water quality problems and negatively impacting on geological process. They constitute threat to lives and property.

The government of Anambra State in 1994, estimated that over 70% of the land of the state were being ravaged or threatened by erosion at various levels of development and stages of maturity. And over the years, several efforts have been made towards solving or containing soil erosion menace in Anambra State (Okengwo, Okeke, Okerekere & Paschal 2015). Despite these efforts, the menace has continued to increase in spatial distribution and severity. The Nanka gully erosion was selected for this study due to its devastating nature which has attracted great attention over the years especially as it is a major challenge to planning in the area.

The erosion in Nanka has a large concentration of gully systems within the same drainage basin and geologic formation, accounting for large loss of agricultural land in South Eastern Nigeria with the catchment area covering an area of 35.75 kilometer square (Egboka & Orajaka 1988).

Empirical equations have been used to predict gully growth by the Soil Conservation Services (Egboka & Orajaka 1988). These equations consisted of linear measurement of gully-head retreat, by means of sequential aerial photographs at 1:20,000 scales.

Soil erosion is the detachment and transportation of soil by natural agents such as gravity, ice mass, running water and wind. It generally manifests itself in three forms: Sheet, Rill and Gully erosion (Okeke and Enwelu 2010). Geological field study of the area revealed that gully erosion hazard has remained active over the years, devastating the physical ecology of large part of Southeastern Nigeria. These gullies significantly have led to loss and degradation of agricultural lands, biodiversity loss, pollution of water, threat to lives and properties, according to Nwajide and Hogue(1979). Soil and gully erosion have been studied extensively by many researchers in Nigeria. Also as inferred by Okagbue and Ezechi (1988), once gullies are initiated, the soil properties become responsible for their rapid propagation (Okagbue and Ezechi 1988). Both natural attributes (rainfall, topography, engineering-geological properties of soils, slope of the land surface) and associated human activities contribute to initiation and propagation of gullies. Teme (2001) concluded that impermeable nature of the cohesive top soil assist in initiating the gully process by encouraging overland flows that lead to the formation of rills and eventual gullies. In addition, the soil erodibility index is influenced by both physical and chemical properties of soil (Osadebe and Akpokodje 2007). Soil erosion which is simply a systematic removal of soil, including plant nutrients, from the land surface by the various agents of denudation occurs in several parts of Nigeria under different geological, climatic and soil conditions. But the degree of occurrence varies considerably from one part of the country to the other. Thus, while it is true to observe that soil erosion is one of the most striking features on the land surface of South Eastern Nigeria, especially in Omambala (Anambra) and Imo States, only rare occurrences of the phenomenon are recorded in some other States of the Federation. Equally varied are the factors responsible for the inception and development of erosion, as well as the types that exist in several parts of the country. Soil erosion is a major environmental problem in Nigeria especially to planning and to be able to appreciate the full implications of the phenomenon, one should understand the factors responsible for its inception and development. One should also know the types of erosion that exist and the spatial distribution of those types.

Briefly, soil erosion can be regarded as merely a geomorphological process, whereby the surface layer of weathering rock is loosened and carried away by wind or running water and a lower horizon in the soil is exposed. Under natural conditions, transport of material down slope or in the direction of the wind usually goes on intermittently, and each movement is so slight that erosive processes are very slow and appear to be continuous. Under such circumstances, soil formation is able to keep pace with the slow attrition.

1.1 Types of Erosion

The major types of erosion, as noted by Brady & Weil (2010) are briefly highlighted below;

1. **Wind erosion:** This traditionally occurs during the dry season, when the North East Trade Wind (NETW) blows dry wind across the region, thereby drying the soil. The dried soil is easily carried by wind and deposited somewhere else, hence gradually causing a depression on the ground surface. The continual act of this process causes sheet erosion, rill and finally gully erosion. The wind erosion is also characterized by the occurrence of dust haze which can lead to partial blindness. The wind erosion also is associated with the presence of sand drifting. Wind erosion frequently takes place where there is little or no vegetal cover over the soil surface.
2. **Soil erosion:** Is the gradual removal of the top layer of the soil through the action of wind and water.
3. **Sea or coastal erosion:** occurs on both exposed and sheltered coasts; primarily caused by sea current and waves. Sea level (tidal) change sometimes can also contribute.
4. **Water erosion:** This form of erosion takes place during the rainy season when there is greater amount of rainfall in the area. This normally occurs between the month of July and October. Water erosion is the removal of the top soil by water run-off.

a. **Splash erosion:** Splash erosion is the first stage of the erosion process. It occurs when rain drops hit bare soil. The explosive impact breaks up soil aggregates so that individual soil particles are “splash”.

b. **Rill erosion:** Rill erosion is common in bare agricultural land, particularly over grazed land, and in freshly cultivated soil where the soil structure has been loosened. Rill erosion is often described as the intermediate stage between sheet erosion and gully erosion.

c. **Sheet erosion:** Sheet erosion is the gradual removal of the thin layer of the top soil by surface run-offs down a given slope. It affects majorly the finer aggregate of the soil particle. Sheet erosion involves the detachment of soil members by rain splash impacts and transports the same by over-land water flow.

d. **Gully erosion.** Gully erosion is the type of erosion that occur through over land flow or surface run-offs, taking advantage of minor irregularities on the surface to collect in shallow hills, increasing as it moves down slope both in length and breadth, depth and speed. Gully erosion could also be initiated by surface run-offs taking advantage of man-made features like cattle tracks, foot paths, cultivation of ridges etc.

1.3 Causes of Erosion

Brady & Weil (2010) further discussed factors that contribute to soil erosion in the area which he categorized into two: natural factors and anthropogenic (human) factors.

(a) Natural factors

Nature of soil: The degree of erosion in any area is influenced by the attributes of the soil. Soil of low resistance are easily broken down and washed away hence they are described as structurally unstable.

Nature of slope: Steep slope increases the propensity of soil erosion. Soil loss also increases surface drainage.

Climate: The intensity of rainfall is a major factor of soil erosion. Rain falling in sudden torrential storms tends to cause serious erosion to the soil. Associated with this is the splash erosion, which occurs when soil particles are dislodged by raindrops.

Vegetation: The amount and type of vegetation cover protects the soil from being eroded. It also helps to protect the surface of soil from direct rainfall that reaches the soil surface.

Humidity and Radiation: The average relative humidity corresponds fairly to the distribution of rain throughout the year. The area receives abundant and constant isolation. The average radiation is received at sunrise and sunset. The humidity and radiation together increases soil cracks and capillarity through thermal expansion.

(b) Anthropogenic (human) factors

Human activities that contribute immensely to soil erosion include:

Wrong farming practices, ranging from improper tillage and ridge making across the contour or monoculture.

Quarrying and some other mining operations including the removal of building materials such as laterites, sand and stones.

Road construction providing adequate side drainage and faulty channeling of storm runoff, especially in built-up areas.

Indiscriminate destruction of vegetation cover or reckless selective removal of plant species, through bush burning, lumbering, fire wood collection and establishment of construction sites.

It covers the western flank of the Anambra Basin (Fig.2).The dominant geological formation is the Nanka sands, which lies conformably on the Imo Shale of Paleocene age and overlaid by the Ogwashi- Asaba formation. The Basin delineates the southern border (or section) of the Benue Trough which was formed (along with the Afikpo syncline and Abakaliki Ridge) during the santoniantectonism (Offodile, 1975; Ofoegbu, 1985).

Overgrazing, path creation and trampling by livestock, Vibration on land caused by the passage of poorly made road surface by vehicles.

2.0 Area of Study

The study area lies between latitudes $6^{o}01^{I}$N - $6^{o}05^{I}$N and longitudes $7^{o}01^{I}$E - $7^{o}08^{I}$E

Creating, footpaths to streams, markets, farms, schools and other routes without regards to its negative effect to ecology.

The study area lies within the humid tropical rainforest belt of Nigeria with an average annual rainfall of 1800mm Nigerian Meteorological Agency (NIMET 2018).

Anambra State is a State in South Eastern Nigeria. The capital and the seat of government is Awka. Onitsha and Nnewi are the biggest commercial and industrial cities, respectively. The State theme is “Light of the Nation”.

Boundaries are formed by Delta state to the West, Imo state and Rivers state to the south, Enugu State to the East and Kogi to the North. Anambra State has a population of 4, 055, 48 people, National Population Commission NPC (2006). The name of the state is derived from Anambra River (Omambala) which is a tributary of the famous river Niger.

Nanka being the area of study is located in Amako Village in Orumba North Local Government Area of Anambra State. It lies between latitude $6^{o}3^{1}$N and longitude $7^{o}5^{1}$E. A major tarred road runs from Amawbia-Awka to Ekwulobiaa with othe minor roads and footpaths, helping to connect the gully site.

2.1 Climatic Condition of the Study Area

Nanka is located in the tropical zone of Nigeria and experiences two distinct seasons brought about by the two predominant winds that rule the area. The Southwestern Monsoon winds from the Atlantic Ocean and the Northeastern Dry wind from across the Sahara desert. The Monsoon winds from the Atlantic create seven months of heavy tropical rains which occur between March and October and followed by five months of dryness (November and March). The Harmattan is a particular dry and dusty wind which enters Nigeria in late December or in the early part of January and is characterized by a grey haze limiting visibility and blocking the sun rays.

Rainfall: The study area has a mean annual rainfall of 2000mm-2500mm. The rainy season usually starts from March and end in October in the area. The dry season starts from early November and ends in February.

Temperature: The temperature in Nanka is generally 27-30 degree Celsius between June and December but rises to 30-32 degree Celsius between January and April with the last few months of the dry season which are marked by intense heat.

Soil: The soil is unstable, porous and unconsolidated in nature, it is very prone to erosion. The soil is within the false bedded sand stone. The area consists of alluvial soil. The area is generally characterized by sandy soil mixed with silt and loamy soil.

Vegetation: The study area falls within the rain forest belt and characterized by growth of tall trees amidst thick undergrowth. Climbers and epiphyte forming complex tangles are common and trees have luxuriant foliage. Oil palm trees are common while swampy areas have thick cover of raffia palm. Lowlands are thickly vegetated with forest trees, while the highlands consist mainly of grasses with trees and shrubs sparsely distributed-typical of derived Guinea-Savannah. In some areas, only isolated stands of a few forest emergent trees remain as evidence of the original forest. This is due to high rate of human activities in form of deforestation as lands are cleared for purposes of farming and construction.

2.2 Geology of the Study Area

The geology of the area exposes two main lithological formations. They are Imo Shale (Paleocene-Eocene) and Nanka Sandstone (Eocene) a lateral equivalent of Ameki Formation. Imo Shale the older of the two geological formations cover about twenty five (25) percent of the study area. Light grey coloured Imo Shale is characteristically fissile and fine grained. Three sandstone units of about 25-40 meters thick separated by 2-3 meters thick Clay/Shale beds were observed in Nanka erosion site. The Sandstone Units consists of poorly sorted unconsolidated sand of variegated colour; yellow to brown to iron stained on weathered surface and white to milky white on fresh surface. The Clay/Shale beds are dark grey to grey with specks of mica and pyrite. Sandstone consists of quartz arenites with predominantly mono crystalline quartz. This is evidence of long transportation and mineralogical and textural maturity

2.3 Topography

The dominant topographic feature in the study area is the North-South Awka-Orlu escarpment, which runs from Awka in Anambra State through Ekwulobia to Orlu in Imo State. Agulu-Nanka lies in the Minor escarpment of the uplands, revealing steep slopes through these places. Sandstone and laterite form the highlands while shale/clay form lowlands. Figure 5, shows the position of Nanka with respect to Awka-Orlu uplands. Terrain Observation reveals a ravine complex with hanging hills, slopes and valleys as plains of weakness that

2.4 How Gully Erosion Operates

There are two fundamentally different kinds of gullies: those developing mainly by scour, and those developing mainly by head ward erosion.

i. Scour Gullies: These occur where runoff is concentrated onto loose, unprotected soil or alluvium. The concentration may be caused by either the coalescence of a series of rills, or by

The development of scour gullies will therefore be favoured by:

a) Runoff of high intensity and duration
b) Concentration of runoff
c) Steep slopes
d) Loose soil

For example, some of the most spectacular scour gullies developed on the flanks of the Colbinabbin Range, where the long, steep slopes, and the clay soil forms loose aggregates. Intense storms breaking when the ground was bare-fallowed caused gullies more than 200 yards long to develop in a few hours.

trigger off gully erosion in the area. These hills show gentle slope on the western part and slopes in the east

collection of runoffs in depressions such as a roadside drain. The soil particles are removed by sluicing - the washing effect of running water on loose grains - and the material that is most easily moved is that of the size fine to medium sand. Material of this size may be in the form of loose sand, or in the case of heavier soils, it could be derived by slaking - the disintegration of large aggregates during wetting

One of the characteristics of a scour gully is that it develops considerable length quickly, and later cuts downwards and sideways. A scour gully may lengthen both up-slope and downslope by further scouring. In many instances, the fan of debris at the lower end of a scour gully has a higher gradient than the general slope and is a favourable location for new scour gullies. Some scour gullies later develop into head ward eroding types.

3.0 Literature Review

Erosion is the process whereby, the surface layer of weathered rock is detached and carried away by wind or running water and a lower horizon in the soil is exposed. Grove (1956) stated that, erosion occurs when soil profile as a whole shifts downwards and the thickness of the top soil is maintained and for most purposes, the soil under an undisturbed cover can be regarded as being in a steady state. Ofomata (1988) maintained that, except for some of the forest reserves in the country, there is hardly any such soil under undisturbed state. Onyegbule (2005) described soil erosion as the process whereby the surface layer of the soil is detached and carried by agents of denudation and a lower layer in the soil is exposed leaving a topographic roughness on the resulting landscape. Stocking (1981) defined gully erosion as the response of natural forces to changing circumstances in such a way that the normal drainage channels such as rivers and streams extend themselves at a rapid rate. Igbozurike (1990) reported soil erosion as the removal of soil chiefly by running water and wave. Gullies are relatively permanent steep-sided watercourse which experience ephemeral flows during the rainstorms.

Egboka and Orajaka (1988) further explained gully erosion as representing the last or matured stage of erosion before the eroded area attains some degree of stability or becomes quasi-stable. The resulting gullies may cut across soils unconsolidated, creating large and deep channels that may assume canyon depts. In places, varying between less than 10meters and more than 45 meters, the rate of gully erosion depends primarily on the runoff producing characteristics of the water-shed. Heeds (1975) reported that gullies have relatively greater depth and smaller width, carry large sediments loads and display very erratic behaviour so that the relationship between discharge and runoff are frequently poor. The awareness of the existence and danger of soil erosion was brought into relief by the general review of soil erosion in Nigeria by Egboka and Orajaka (1984) review was followed by the special study of the phenomenon by Obidimma, Ezezika and Olorunfemi (2011) in parts of former Eastern and Northern provinces of Nigeria. Igbozurike (1990) asserted that gullies cover less than 0.1% of Nigeria's total land area, (924,000km2). The number of gully sites is large while the size of some individual gullies is astonishingly enormous. Gully erosion occurs in most parts of the country, although the incidence is greatest in the Southeastern part with Nanka gully erosion recording the single largest gully erosion in Africa. Okagbue (1988) reported that Nanka gully erosion is exacerbated by landslide. Ofomata (1987) classified the area as highly susceptible to erosion with weakly consolidated sediments of tertiary lignite formation; Bende-Ameke and Imo Clay/Shale group. Nwajide (1977), Akujieze (1984) and Ezechi (1987) described Nanka Sandstone (Eocene) as consisting of four sand sub-units separated by three Clay/Shale beds. Okonkwo (2002), identified four lithofacies namely; Planar-bedded Sandstone, Heteroclite Cross bedded Sandstone, Cross bedded Sandstone and Wavy bedded Sandstone faces. Igbokwe (2004) working with 625x625 pixels of Nigeria Sat-1 maintained that the areas prone to gully erosion in Anambra State, Nigeria is heavily populated with many residential houses located in the proximity of gully sites. Igbokwe (2004) also identified major problems of data acquisition and records in Nigeria as the image data obtained was compared with existing maps and show only 10-15% of the spatial information.

Ofomata (1978), resolved factors of soil erosion in Nigeria into two components; physical (Geologic or Natural) and Anthropogenic (Human or Accelerated) factors. Ofomata (1987) reported that allowing for interferences from single, two and three factors interaction among erosion variables in Nigeria, relief account for about 26% of variations against 14% by rainfall, 3% by surface materials and almost zero percent (actually 0.1% and 0.3%) respectively) by each of population density and vegetation. Ofomata (1987) further stated that single factor together contributes about 43% of variations in soil erosion. Up to two factors interaction contribute about 75% while up to three factors interactions contribute about 97% of variations in soil erosion. In areas of soft rock, gullies can develop with outstanding rapidity, and within only a few months, grow into a monumental gash, (NEST (1991)), Anyanwu, (1975)), Fournier (1960), attempted an empirical consideration of the relationship between.

Igbozurike (1975) divided Eastern Nigeria into nine vegetation zones. The area, falls within the tropical rain forest zone. Amah (2008) attempted to evolve an empirical equation relating erosion to rainfall and slope. While Amangabara (2014) gave account of the relationship between raindrop energy and soil erosion. In Southeastern Nigeria, erosion widens, deepens and extends head wards during the wet season. The rate being influenced by soil type and extent of vegetal cover Stocking, (1981).

3.1 Gully Initiation and Development

Gully erosion is initiated by overland flow or surface runoff taking advantage of minor irregularities on the surface to collect increasingly distinct but shallow channels called rills. Similarly, it could be initiated by increased runoff due to land use and climate changes. Okagbue (1992) concluded that once a gully is initiated the soil properties become responsible for their rapid propagation. This accounts for the no response of most gullies to afforestation control measure.

Most gullies are quite broad and have vertical walls. Increased pore pressure from groundwater moving towards the gully, coupled with some undercutting of the sidewalls by water causes deep rotational slumps along the sidewall.

Widening of the gully wall also occurs when the upper portions of the gully walls separate and topple into the gully. In the investigation of soil. Igbozurike (1990), cohesion and angle of internal friction have been lumped together and are represented by shear strength. However, the more significant shear parameter of the soil in the context of soil erodibility is cohesion. The degree of erosion is widely related to soil strength. Shear strength is considered the most important in the detachment process.

3.2 Characteristics of Gully Wall Profiles

Following shear stress based model concepts, Akudinobi. (2017) showed that shear stress of the flowing water controls the detachment process of soil. Akudinobi. (2017) therefore considered the transport rate up to the transport capacity as shear stress dependent uptake. The transport rate exceeding the transport capacity is considered as shear stress independent erosion caused by processes such as bank failure and head-cut retreat.

However, a common feature of gullies irrespective of their Geographical location is their steep angles which are generally above 45° (Nwajide, 1977). The slopes of the nearly vertical wall of the gullies vary from 45° to 88°. The gully floor slopes vary from 5° to 27°. The upper part of the profiles of the gully walls are nearly always 90°. Change in sedimentary sequence is often reflected in the gully wall profile.

4.0 Methodology

The study relied on field survey; direct observations and measurement from fieldwork, interviews and literature review.

5.0 Research Findings

5.1 Findings from the field work revealed the following;

Reduction in land area –The area has been reduced by the gully erosion.

Retaining walls - Many retaining walls constructed by individuals exist along the roads. Water reservoirs used in harvesting storm water are common in family compounds.

The reservoirs also act as control checks to erosion by reducing flood surface impact.

Gabion weir- Gabion weir was found which is used with granite by the construction company in tackling the gully erosion.

Drainage Channel – Drainage Channel was also discovered in the area for inflow of water.

Displaced settlement and abandoned building - It was discovered that many settlements have been displaced and people abandoned their buildings because of erosion

Undulating topography- The topography of the area is undulating

This reduces the impact of erosion.

5.2 Impacts of Gully Erosion in Nanka

1. **Social effect of erosion:** Erosion has resulted in the loss of ancestral homes, loss of school, loss of church building, loss of meeting hall or town hall, loss of sources of water supply etc.
2. **Financial implication:** Continuous check on gullies within Nanka areas has extensively depleted the financial allocation made by the state to the local government council capital amounts which are made for other capital investments has been invested in controlling gully erosion sites.
3. **Threat to human lives and property**: Several lives have been lost as a result of the erosion in Nanka and properties worth millions of naira have been eroded.
4. **Economic impact:** Several farm land masses in rural environment are totally eroded and economic trees are also washed away. In some built up areas, several houses and business premises are washed away. The total annual loss in revenue as a result of these runs in millions of naira.
5. **Reduction in ecological threshold:** Continual and accelerated activities of soil erosion in Nanka have led to the loss of large acres of land that is meant for developmental purposes.
6. **Environmental impact:** Following the advent of erosion menace in the area, there has been a serious damage in the aesthetic quality of the immediate environment. The natural order of beauty has been replaced by chaotic environmental disorder created by the gullies.

6.0 Recommendations

Recommendations can be adopted to mitigate the erosion menace in the study area (Nanka)

1. Proper construction of drainages and culverts during road construction.
2. Government should adequately fund the on-going Gibeon control method.
3. Terracing: This is the cutting of steps on hill sides to reduce the speed of running water down the hill.
4. Afforestation and landscaping: This is the planting of trees to control erosion, tress such as cashew; bamboo should be planted in the affected and susceptible area to check the erosion.

5. Contour ploughing: This involves the making of ridges across the slope to control erosion.
6. Cover cropping: This is the planting of legumes to cover the soil, so as to prevent erosion.
7. There should be deliberate efforts by the Ministry to refill and construct a proper drainage system that will be channeled to a safe discharge points down steam.
8. The local government authorities and the vulnerable communities should imbibe the culture of planting trees such as Bamboo and Cashew, in the affected areas, as vegetation cover will slow the rate of runoff as well as soil loss. This effort should be encouraged and supported by State and Federal Ministry of Agriculture.
9. The town planning department should not approve construction of buildings along water ways.
10. They should also recommend and prohibit new developers not to cement their compounds and also advise them to embark on rainfall harvesting
11. Legislation: There should be laws to combat erosion through soil conservation boards.
12. Controlled grazing: Few animals should be allowed to graze on an area to avoid soil erosion.
13. Improved farming methods: The practice of mixed farming, strip cropping and crop rotation helps to control erosion.
14. Enlightenment programmes: People should be educated on the effects of soil erosion and soil conservation measures.

6.1 Conclusion

Gully erosion represents one of the most serious environmental problems affecting the South-South and the South-Eastern States of Nigeria today. The effect is much more devastating in some states notably Edo, Delta, Cross River, Akwa Ibom, Imo, Abia, Anambra, Ebonyi and Enugu States. In these states, a large proportion of the land areas both residential and agricultural lands have been lost to gully erosion. It is one of the most striking features on the land surface of Southeastern Nigeria, especially in

Anambra States; only rare occurrences of the phenomenon are recorded in some other States of the Federation. Equally varied are the factors responsible for the inception and development of erosion, as well as the types that exist in several parts of the country. Soil erosion is a major environmental problem in Nigeria.

Our environment is a part of our social and economic survival and what happen within the environment we live can impact negatively to our survival. More so, for greater effectiveness, the solution to gully erosion impact is to treat it as a vital component of the broad issue of environmental management. This can be achieved with adequate knowledge of the environment. The effects due to gully erosion and other natural environmental disasters make the need for an integrated environmental planning and studies urgent. What is required is the creation of forum where thought would be harmonized and adequate strategy formulated to co-ordinate and sustain environmental programmes.

The magnitude of this geo-environmental hazard on the natural environment (social and physical) in the southeastern Nigeria, cannot be over-emphasized. The study has shown that the underlying soil strata in the study area consist of cohesion less sand and a cohesive top layer. The high void ratio of the cohesion less soil leads to high infiltration rates and this will obviously give rise to high flow velocities and internal erosion potential. The result of the study has also shown that gully development into the top red lateritic soil layer seem more controllable than the cut in the cohesion less sand. Soil properties among other factors contribute immensely to gully development. Soil that is predominantly sandy with high void ratio and low density are subjected most to severe gullying. The underlying soils with high void ratio and low density create gully erosion because of the high seepage pressures generated from the high flow velocities. The gully development increases once the underlying cohesion less soil with high void ratio and low porosity is penetrated. This is because of the loose nature of the soils and the inability of the plant roots to bind the soil particles together. Consequently, an adequate control measures such as installation of check-dams and bioengineering, can be taken when the geotechnical properties of the soil are known. However, without proper knowledge of the geotechnical properties of the soils, inadequate but commonly used control measures like construction of retention pits and ditches may be adopted.

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PASSIVE COOLING STRATEGIES FOR BUILDINGS IN SOUTH-EASTERN NIGERIA'S HUMID CLIMATE: A COMPREHENSIVE REVIEW

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Abstract

The hot, humid climate of South-Eastern Nigeria poses challenges for thermal comfort and energy efficiency in buildings due to reduced air movement. This extensive literature review examines a broad range of passive cooling techniques beyond basic cross-ventilation that can be implemented in this region to reduce reliance on air-conditioning. A rigorous systematic search provided insight on suitable strategies including solar control, thermal mass, natural ventilation, evaporative cooling, and vernacular bioclimatic design. Evidence indicates an integrated approach utilizing multiple methods tuned to the climate can create comfortable indoor conditions. Each technique contributes through unique mechanisms of solar gain reduction, thermal damping, convective heat removal, evaporative cooling, and earth coupling. Night flushing allows thermal mass recharge. Climate-responsive vernacular architecture balances heat gains and removal. Computational optimization facilitates design integration. Overall, passive cooling presents a sustainable solution to enhance occupant comfort while reducing energy consumption, costs, and environmental impacts of mechanical cooling systems. Further applied research and field testing of techniques is warranted for the specific South-Eastern Nigerian context. With proper implementation, the findings suggest substantial potential for passive cooling strategies to greatly reduce or potentially eliminate the need for air-conditioning in this region.

Introduction

The humid tropical condition of South-Eastern Nigeria presents challenges for achieving comfortable and sustainable indoor environments in buildings. Located near the equator, the region experiences consistently high temperatures averaging 26°C, abundant rainfall exceeding 2000 mm annually, and year-round high relative humidity (Alozie G.C, Odim et al. 2015, Adedeji 2018). The combination of persistent heat and humidity impacts human thermal comfort and leads to heavy reliance on air-conditioning for cooling in many buildings. Studies show that fossil fuel-powered air-conditioning constitutes 20-60% of total energy consumption in Nigeria's residential and commercial buildings as occupants seek to cope with the tropical climate (Ebohon and Rwelamila 2001, Mirrahimi, Mohamed et al. 2016, Ogbonnaya 2019). With rising incomes, urbanization, population growth, and shifts toward Western style enclosed structures, the penetration and use of air-conditioning is projected to increase dramatically in coming years (Ebohon and Rwelamila 2001, Ogbonna and Harris 2008).

The high energy intensity of conventional air-conditioning systems to provide cooling contributes significantly to Nigeria's greenhouse gas emissions, localized air pollution, and other environmental externalities. Fossil fuel power plants supplying the substantial electricity needs for air-conditioning also burden the nation's generators and grid infrastructure. In addition, the upfront capital costs and ongoing operating expenses of air-conditioners impose financial burdens for homeowners and businesses. The environmental impacts and energy costs of rising air-conditioning demand create a compelling need for alternative cooling solutions suitable to the South-Eastern Nigerian context.

This literature review examines passive cooling techniques as a sustainable approach to reduce or eliminate the need for mechanical air-conditioning and maintain comfortable indoor conditions in South-Eastern

Nigeria's hot, humid climate. Passive cooling utilizes non-mechanical methods relying on natural energy flows and resources to dissipate heat through strategic architectural design and material selection (Santamouris 2016). A range of passive strategies have demonstrated potential for this region beyond basic cross-ventilation, including solar control, high thermal mass, night ventilation, evaporative cooling, and vernacular bioclimatic architecture.

An extensive and rigorous review of the academic literature was conducted to synthesize current evidence on the techniques suitable to enhance building thermal performance in South-Eastern Nigerian conditions. The search methodology, inclusion criteria, and review structure are outlined in the following section. The body of the review is organized into sections examining solar control, thermal mass, ventilation, evaporative cooling, vernacular strategies, optimization, and integrated design. Each section presents a technique overview, implementation methods, benefits evidence, design considerations, and South-Eastern Nigeria-specific findings based on current literature.

The review concludes by identifying areas needing further applied research and field testing. But the overall findings highlight the substantial capability of passive cooling design strategies to greatly reduce or potentially eliminate the need for mechanical air-conditioning systems and their associated energy costs and environmental impacts. The results indicate passive cooling presents a highly promising sustainable solution to enhance occupant thermal comfort in South-Eastern Nigeria's humid climate if implemented properly through climate-responsive building design.

Methodology

A systematic search methodology was utilized to identify and analyze current research on passive cooling techniques relevant to the hot, humid climate of South-Eastern Nigeria. The following academic databases were searched extensively for peer-reviewed journal articles, conference papers, and theses:

Science Direct, Wiley Online Library, Taylor & Francis Online, SAGE Journals, Elsevier Scopus, Springer Link, JSTOR, Google Scholar

Search terms included combinations and variations of the following keywords:

"Passive cooling" OR "passive thermal design" OR "natural cooling", "South East Nigeria" OR "Nigeria" AND "climate" OR "hot humid", "solar control" OR "shading" OR "vegetation" OR "thermal mass" OR "night ventilation" OR "evaporative cooling", "vernacular" AND "architecture", "simulation" OR "optimization"

Relevant papers were identified through searches on these terms and thorough examination of abstracts and content. Source tracing of citations in the papers added further studies. In total, 89 sources meeting the following inclusion criteria were selected for review:

Peer-reviewed or scholarly sources, Focus on passive cooling techniques relevant to hot, humid climates, and evidence on implementation in South-Eastern Nigeria specifically or analogous tropical regions.

Solar Control Techniques

Solar heat gains through the building envelope constitute a major contributor to indoor overheating in hot climates like South-Eastern Nigeria. Solar control refers broadly to design strategies that block, limit, or prevent solar radiation from striking and transferring heat into the building (Chwieduk 2003). By controlling solar penetration, these techniques can significantly reduce heat flows into the interior to minimize thermal loads and cooling needs. This section reviews common methods for solar control along with considerations for effective implementation in the South-Eastern Nigerian context.

Shading Devices

External shading devices are considered the most effective solar control strategy as they intercept solar radiation before it impacts the building façade (Alanzi, Seo et al. 2009). Horizontal overhangs, vertical fins, egg-crate shading grids, movable louver systems, and other configurations can provide exterior protection on one or more building sides. The optimal depth, spacing, orientation, and geometry depend on the site latitude, sun angles, and required shading periods. Local climate analysis is critical to maximize solar blocking capability and inform more nuanced configurations.

Modeling studies focused on office buildings in Uyo, Nigeria determined that horizontal overhang shading minimized indoor temperatures most effectively in this hot, humid climate (Udom, Nnaji et al. 2020). Optimal overhang depth was 1.0m on the east, south, and west orientations. This reduced indoor temperatures by 2-3°C compared to an un-shaded baseline case. The study attributed the substantial heat reduction to lowering of solar gain through the building envelope. Vertical shading fins on the north and south facades were found to be less impactful.

In institutional buildings in Owerri, Nigeria, external shading reduced indoor temperatures by up to 5.9°C and lowered cooling loads by 65% compared to buildings with fully exposed envelopes (Mbamali and Okonkwo 2012). The optimal horizontal overhang design incorporated triangular projections and a 0.65m depth on all sides based on solar angle analysis. This provided full shading coverage during peak sun hours. The greatest cooling energy savings were achieved with horizontal overhang configurations.

Similar field tests and simulations in the Nigerian cities of Lagos, Akure, and Calabar affirmed reductions of 2-6°C in indoor operative temperatures solely from the addition of horizontal shading devices on building roofs and facades (Efeoma and Uduku 2014, Nduka and Ogunsote 2016, Nwokorie 2020). Optimal overhang depths ranged from 0.6-1.2m. The substantial temperature decrease demonstrates the capability of properly designed context-specific shading elements to minimize solar heat gains in South-Eastern Nigeria.

Vegetation

Tree canopies and other vegetation represent a natural mechanism for building solar control. The shading effects act like an organic exterior layer reducing transmitted radiation on underlying walls and roofs. Solar angles and sun path trajectories should inform vegetation sitting adjacent to critical building facades (Alozie 2020, Abdulkareem, Akintunde et al. 2022). In modeling for a South-Eastern Nigerian university building, trees reduced indoor temperatures by 6°C and lowered cooling energy use by 20-30% compared to un-shaded baselines solely through introduced shading (Abdulkareem, Akintunde et al. 2022). In additional studies quantifying vegetation impact in Nigeria, indoor temperature reductions of 1-7°C were recorded from tree shading of various residential, institutional, and office buildings (Efeoma and Uduku 2014, Nduka and Ogunsote 2016). Optimal configurations utilized larger canopy trees on the east and west sides to provide shade during intense morning and afternoon sun. Deciduous trees allow solar penetration in winter when heating is needed, while evergreens maintain year-round shading.

Beyond direct solar blocking, vegetation also contributes an evaporative cooling effect. Through the process of evapotranspiration, moisture evaporated from tree and plant surfaces absorbs heat. This reduces air temperatures around vegetation and below shading canopies. Field measurements at a Nigerian university found indoor temperatures in a building with added tree shading were 2.7°C lower than a non-shaded building, attributed partly to the evaporative cooling mechanism (Efeoma and Uduku 2014, Alozie 2020).

Reflective Surfaces

Solar-reflective “cool” materials minimize solar heat gains by reducing absorption and reflecting more sunlight striking the building envelope (Anwar, Rasul et al. 2020, Saber, Hajiah et al. 2020). Light colored, high-albedo paints, tiles, membranes, and other coatings on roofs and facades lessen surface temperatures by up to 10°C compared to traditional dark finishes. This decreased heat flow lowers indoor cooling demands.

Field experiments examined reflective white paint on corrugated iron roofs of residential buildings in Nsukka, Nigeria. Indoor temperature reductions of 2-3°C were recorded along with 13-21% drops in humidity solely from the higher roof solar reflectance (Efeoma and Uduku 2014). Similar tests in Lagos applying reflective paints and tiles recorded indoor cooling energy savings of 10-43% from enhanced solar reflection (Nwokorie 2021).

The cooling effect magnitude depends on factors like roof slope, underlying insulation levels, and product material properties. Solar reflectance potential is higher on more horizontal roofs receiving greater solar radiation. Radiant barriers, added insulation, and roof cavities further enhance the impact in modeling studies focused on this climate region (Hosseini and Akbari 2016). Potential drawbacks like glare can be mitigated through design integration.

Thermal Mass Techniques

Thermal mass utilizes materials with high heat storage capacity to passively moderate indoor conditions. Building mass with sufficient density and specific heat capacity absorbs excess heat during hot periods, dampening and delaying the peak indoor temperature rise (Santamouris and Asimakopoulos 1996). The stored thermal energy is then released at night when ambient temperatures drop. This daily heat absorption and discharge cycle stabilizes interior temperature swings. Reduced daytime overheating lowers cooling demands.

High Mass Materials

Common high thermal mass wall systems suitable for South-Eastern Nigeria include concrete masonry, insulated concrete forms (ICF), stone construction, compressed earth blocks, and rammed earth (Al-Sallal 2021). Phase change materials (PCMs) integrated into walls, floors, or ceilings provide added heat storage capacity. Modeling and field tests reveal the capability of these massive building envelopes to passively modulate indoor temperatures.

In heavy mass residential buildings in Uyo, Nigeria, indoor temperatures remained 2-6°C lower than the peak outdoor temperatures (Udom, Nnaji et al. 2020). This demonstrates the thermal damping effect. The time lag between external and internal temperature peaks averaged 2-3 hours due to the high envelope heat capacity. Similar field studies in Owerri recorded indoor temperature swings 50% lower in high mass buildings compared to lightweight structures (Onyeizu, Oluwole et al. 2018). Night ventilation enabled the full recharge of thermal mass by purging stored heat.

The optimal thermal mass depends on climate conditions and internal loads. Excessive mass can retain unwanted warmth and delay night cooling. Proper insulation balances the effect. Dynamic thermal simulations aid optimization of mass and night flushing rates. But overall, high heat capacity envelopes clearly assist in passively regulating indoor temperatures in South-Eastern Nigeria's climate conditions.

Earth Coupling

Increased contact with the thermal mass and stable temperatures of the surrounding soil provides another passive cooling mechanism. Partially or fully buried earth-sheltered structures benefit from this earth coupling effect, as do buildings with basement exposure. Heat absorbed by the massive building envelope dissipates into the ground.

Field tests of an earth-bermed residence in Owerri found indoor temperatures were up to 15°C cooler

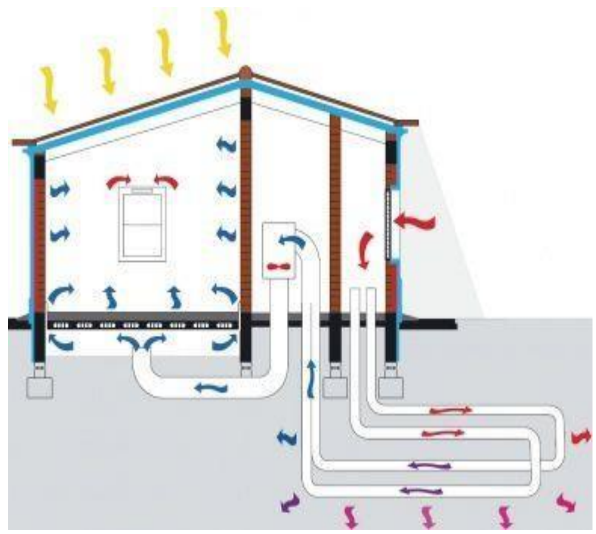

Figure 1: Earth to air heat exchangers

than peak outdoor conditions (Udo and Ekechukwu 2009). This demonstrates the capability of soil-coupled thermal mass walls to minimize heat gain and stabilize indoor environments. The thermal time lag exceeded 10 hours due to the high surrounding ground contact. Similar modeling of institutional buildings in Uyo predicted indoor temperature reductions of 10-12°C from earth sheltering and basement exposure (Udom A.E. , Olotuah A.O. et al. 2013). In addition to envelopes, earth coupling can be achieved through subsurface air tunnels that provide both cooling and thermal storage benefits. As shown in Figure 1, the stable temperatures of circulating ground-coupled air passively cool the structure while adding thermal mass. This dual-function system has substantial potential for South-Eastern Nigeria but requires careful moisture control.

Night Ventilation

Night ventilation enhances the potency of thermal mass strategies by purging stored daytime heat at night when exterior temperatures are cool. Opening windows, doors, or slats allows large flow rates to completely recharge interior mass capacity over the evening hours (Breesch and Janssens 2010). Automation can provide secure operation. The resulting cooled mass then absorbs the next day's heat gains.

In a Nigerian study, night flushing lowered indoor peak temperatures by up to 5°C compared to closed buildings (Efeoma and Uduku 2014). The optimal night ventilation rate matched the building mass and internal conditions. A 10°C indoor-outdoor differential is recommended to adequately recharge thermal storage for subsequent daytime cooling (Santamouris and Asimakopoulos 1996). Night ventilation is a critical complement to thermal mass in South-Eastern Nigeria's climate.

Natural Ventilation Techniques

Natural ventilation utilizes passive airflow to induce convective heat transfer between indoor spaces and the outdoor environment. Wind-driven cross-ventilation, buoyancy-driven stack ventilation, and mixed-mode strategies dissipate heat and remove moisture through airflow induced by natural pressure differences, without mechanical systems (Allard 1998). Large operable openings are required for sufficient airflow rates. This section examines natural ventilation techniques suited for South-Eastern Nigeria.

Cross Ventilation

Cross ventilation relies on wind pressures on the building's windward and leeward facades to drive lateral airflow through interior spaces. Openings on opposite sides of a room or building enable flow paths for this passive cross-flow. Orientation perpendicular to prevailing winds maximizes pressure differentials. Vent configuration, room depth, opening sizes and locations are primary factors influencing the air exchange rate and resulting convective heat removal (Liang, Zhang et al. 2010).

Field studies in free-running residential buildings in Nsukka, Nigeria recorded indoor air velocities increasing from 0.1 m/s to 1.5 m/s when cross ventilation openings were unobstructed (Chinweze, Olotuah et al. 2019). This boosted airflow lowered indoor temperatures by up to 5°C during hot periods. Cross ventilation was also shown to reduce relative humidity. Similar tests in Uyo confirmed temperature decreases of 2-4°C solely from cross-flow at adequate velocities (Udom, Nnaji et al. 2020).

However, cross ventilation performance declines significantly with lower wind speeds, which frequently occur during hot, humid periods in South-Eastern Nigeria. Stack and mixed-mode strategies can supplement wind-driven flows during periods of weak breezes when passive cooling is most needed. But cross ventilation remains a simple and effective heat removal technique making use of prevailing winds when present.

Stack Ventilation

Stack ventilation utilizes temperature differences between interior and exterior air to induce buoyancy-driven airflow through buildings. As warmer, less dense indoor air rises and exhausts through upper vents, it creates a pressure differential drawing cooler air in through lower wall or floor openings (Aldawoud 2017). This passive chimney action provides continuous airflow when wind speeds are low. Stack effect is strongest on upper floors where vertical temperature differentials are maximized.

Field measurements in Benin City, Nigeria recorded increased nighttime air velocities of up to 0.8 m/s induced solely through stack action, enabling notable indoor cooling (Uahengo, Cai et al. 2019). The impact was most significant on the third floor. Enhanced velocity from the stack effect also improved cross ventilation flows during low wind conditions. Similar improvements with increased stack ventilation were noted in institutional buildings in Nsukka (Efeoma and Uduku 2014).

However, the cooling capacities from pure buoyancy-driven stack ventilation may be insufficient to remove high heat gains in South-Eastern Nigeria (Efeoma and Uduku 2014). Combining with cross-flows and night flushing allows the stack effect to powerfully supplement wind-driven ventilation. Stack heights, atrium sizes, flue dimensions, and damper controls must be designed to enable unrestricted airflow.

Evaporative Cooling Techniques

Evaporative cooling aims to cool air directly or indirectly by evaporating. Direct evaporative cooling introduces water into the air stream to obtain cooling through latent heat extraction as the water evaporates. Direct injection of water droplets or mist sprays into the intake air can provide sensible cooling of 3-5°C through this conversion of sensible heat to latent heat (Riangvilaikul and Kumar 2010). Wetted media pads allow film type evaporative cooling with the air flowing through the moistened pads.

While direct evaporative systems have high cooling capacity, the increased moisture content and potential for condensation can limit applications in humid climates. However, modeling shows potential for direct evaporative pre-cooling of ventilation air in South-Eastern Nigeria prior to secondary cooling (Ogbonnaya 2019). The high wet-bulb temperatures pose challenges, and therefore the need for further exploration given the substantial heat transfer possible.

Indirect evaporative cooling aims to cool the supply air without adding moisture. In one approach, the primary air stream flows through one side of a heat exchanger while the other side induces evaporative cooling from a secondary air stream (Liang, Zhang et al. 2010). The heat transfer cools the main flow without direct contact. In Nigerian residential models, indirect systems provided 5-10°C primary air cooling while maintaining comfortable humidity levels (Ogbonnaya 2019).

In a second method called evaporative downdraft cooling, the flow passes over a wetted surface such as a cellulose medium. The cooling effect from surface evaporation is absorbed by the air through conduction. Nigerian field tests recorded temperature decreases of 2-3°C from this technique with no humidity increase (Onyeizu, Oluwole et al. 2018, Ogbonnaya 2019).

Passive Evaporative Cooling

Passive evaporative cooling relies on indirect techniques like external water spray systems or vegetation evapotranspiration. Water sprayed on overhead plants or building surfaces evaporates by absorbing heat, providing a passive cooling effect (Tablada, Rubio et al. 2009). Placing fountains or shallow pools nearby enhances natural evaporation. The humid climate promotes evaporative cooling potential in South-Eastern Nigeria.

Vernacular Passive Cooling

Climatic Design in Vernacular Architecture: Vernacular architecture in South-Eastern Nigeria evolved over generations to create built environments well-adapted to the hot, humid tropical climate. Traditional construction methods and materials were developed to maintain comfortable indoor temperatures passively through solar control, ventilation, evaporative cooling, and other techniques suited to site conditions (Ogoli 2003). Vernacular buildings offer inspiration for modern passive thermal design.

Solar Control in Vernacular Buildings: Studies of Igbo vernacular houses in South-Eastern Nigeria reveal integrated solar control strategies. Steeply pitched roofs with overhanging eaves shade the building from intense overhead sun while allowing ventilation (Oruwari, Oluwole et al. 2022). Opaque walls with small openings minimize solar gain. Surrounding trees provide additional shading (Alozie 2020).

Ventilation in Vernacular Buildings: Vernacular homes feature large operable windows, central courtyards, and clerestory openings stacked vertically to maximize cross and stack ventilation (Oruwari, Oluwole et al. 2022). Perforated mud walls enable natural airflow. Larger spaces with high ceilings enhance air circulation and heat dissipation.

Building Shape and Orientation

The rectilinear and L-shaped forms of local houses are oriented strategically for solar control, rain protection, and natural ventilation. Buildings elongate on the east-west axis to minimize sun-exposed facades (Ogoli 2003, Alozie G.C, Odim et al. 2015). Surrounding vegetation guides prevailing winds into interior spaces.

Thermal Mass in Vernacular Buildings

Thick earthen walls made of mud brick and plaster provides high thermal mass heat storage (Oruwari, Oluwole et al. 2022). The oversized walls dampen heat flow while stabilizing indoor conditions. Deep overhangs prevent unwanted solar gains into the mass.

Integration in Vernacular Design: Solar control, ventilation, vegetation, and thermal mass are harmoniously integrated in vernacular architecture to maintain comfortable environments. Local techniques and designs optimized for South-Eastern Nigerian conditions provide models for modern passive cooling implementation.

Simulation and Optimization

Passive Cooling Simulation: Computational building performance simulation offers powerful capabilities to model and optimize passive cooling strategies. Dynamic thermal modeling accounts for transient heat transfer under real weather conditions, internal loads, and design parameters (Negendahl 2015). This enables virtual testing of techniques to quantify expected thermal improvements.

Parametric Analysis: Parametric simulation automates variations in passive design input parameters like building mass, window ratio, shading depth, vegetation, etc. to quantify relative thermal performance sensitivity (Calautit and Hughes 2016). This facilitates optimization of techniques for specific conditions. Studies focused on hot, humid Nigeria may aid optimization.

Multi-Objective Optimization: Multi-objective optimization algorithms can generate optimal passive cooling configurations balancing factors like thermal comfort, cost, and aesthetics (Calautit, Aquino et al. 2018). This efficiently guides bioclimatic design. Sets of optimal solutions enable designers to select appropriate options. Further development and application of these powerful optimization methods is warranted in Nigeria.

Performance simulation provides insight on suitable passive design strategies and enables optimization for South-Eastern Nigeria prior to construction. This will reduce guesswork and risk while allowing extensive virtual experimentation to arrive at climate-tuned buildings.

Integrated Bioclimatic Design

An integrated bioclimatic design approach utilizing multiple passive cooling techniques in harmony is needed to address South-Eastern Nigeria's demanding climatic conditions. No single method alone can overcome the heat and humidity challenges. An appropriate combination of strategies tuned to the local climate provides the most potent passive thermal performance (Hyde 2012).

Load Reduction and Heat Dissipation

Solar control, thermal mass, and other techniques aim to slow heat gains and reduce cooling loads. Ventilation, evaporative cooling, and ground coupling remove and dissipate the remaining heat through airflows, phase change, and conduction (Hui and Cheung 1997). Balanced load minimization and heat removal optimizes indoor comfort.

Climate-Responsive Design Integration

Bioclimatic integration requires aligning passive strategies with the local climate context. Vernacular dwellings evolved configurations and components maximizing natural energies and resources in South-Eastern Nigeria (Ogoli 2003). Learning from these traditions can guide modern integration.

Achieving Synergistic Effects

Optimal combinations allow passive techniques to complement each other. For example, night flushing recharges thermal mass while stack ventilation aids cross-flows. Integrative design achieves positive synergistic effects maximizing total passive performance.

Tuning for Local Conditions

Passive cooling integration must be customized for each South-Eastern Nigerian project based on the particular building attributes, site microclimate, occupant needs, construction methods, materials availability, and other localized factors. Tuning to specific conditions and loads is essential.

Conclusions

This extensive literature review examined solar control, thermal mass, natural ventilation, evaporative cooling, vernacular techniques, simulation tools, and integrated bioclimatic design strategies to passively cool buildings in South-Eastern Nigeria's demanding climate. The evidence clearly demonstrates substantial capabilities to reduce or eliminate air-conditioning through proper passive design tuned to local conditions. The findings highlight capabilities to greatly reduce or potentially eliminate air-conditioning needs through: Solar control techniques by blocking solar gains, High thermal mass envelopes by damping heat transfer, Natural ventilation for convective heat removal, Evaporative cooling by adding a cooling sink, Vernacular bioclimatic architectures by maximizing natural energies, Simulation and optimization to guide integrated design.

However, further applied research and field testing focused specifically on the South-Eastern Nigerian context is critically needed. Each technique yearns for additional local evaluation and validation. The social factors influencing user adoption in Nigeria also require study. Ongoing research is critically needed to validate performance, optimize combinations, evaluate costs, engage users, and adapt to climate change for specific South-Eastern Nigerian contexts. With appropriate implementation informed by further applied studies, passive cooling presents a highly promising sustainable solution to enhance occupant comfort and wellbeing while reducing energy use, costs, and environmental impacts in this region. Meeting Nigeria's cooling needs through climate-responsive bioclimatic architecture could set an example for the broader tropics while supporting local prosperity and national development goals.

This extensive literature review synthesized evidence on the potential of passive cooling strategies to provide comfortable and sustainable indoor environments in South-Eastern Nigeria's demanding hot, humid climate. The evidence clearly indicates properly designed and integrated passive cooling can significantly enhance thermal performance and comfort in this region while decreasing energy use, costs, and environmental impacts of mechanical cooling systems. Passive strategies present a highly promising path toward more sustainable buildings in South-Eastern Nigeria. Further applied research, field testing, and design optimization can help fully realize this substantial potential.

Recommendations for Further Research

While this literature review synthesized extensive evidence on passive cooling potential in South-Eastern Nigeria, further applied research would benefit design implementation and field validation in this climate region. Specific recommendations include and not limited to:

Field Testing of Integrated Strategies

- Monitor full-scale buildings in Nigeria utilizing optimized combinations of passive techniques

- Quantify thermal performance, energy impacts, costs, and user perceptions
- Validate simulation predictions and identify real-world integration challenges

Computational Optimization

- *Refine bioclimatic optimization algorithms linking weather data, materials, and design variables*
- *Generate passive cooling design guidance specific for different South-Eastern Nigerian locales*
- *Develop optimization tools accessible to local practitioners*

Vernacular Building Research

- *Document additional traditional passive cooling features in Igbo and other vernacular architectures*
- *Evaluate thermal performance of existing vernacular structures*
- *Identify techniques applicable to contemporary buildings*

Social and Cultural Factors

- *Study user thermal comfort perceptions, expectations, and behavior in South-Eastern Nigeria*
- *Assess cultural influences on passive cooling acceptance and operation*
- *Identify strategies to encourage occupant engagement and proper utilization*
- *Develop educational resources on passive cooling for Nigerian students and practitioners*

Economic Assessment

- *Evaluate costs, payback periods, and life cycle impacts for different passive strategies*
- *Model future air-conditioning demands with and without passive cooling implementation*
- *Quantify potential nationwide energy and emissions reductions*
- *Perform cost-benefit analysis to inform policy and industry decision-making*

Climate Change Impacts

- *Project effects of climate change on passive cooling effectiveness in South-Eastern Nigeria*
- *Identify appropriate thermal design responses to rising temperatures*
- *Analyze risks and recommend resilient strategies*

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CONTEMPORARY ARCHITECTURAL CONCEPTS IN DEVELOPING SUSTAINABLE BUILT ENVIRONMENTS

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Abstract

This study explores the evolution and current state of sustainable architecture in developing environmentally responsible built environments. It traces the historical context of adaptive architecture from vernacular practices to modern sustainable design, highlighting the paradigm shift from energy efficiency to holistic sustainability. It examines contemporary approaches, including passive design strategies, active systems, and sustainable materials, while addressing energy management challenges in buildings. The report discusses the integration of sustainable architecture with urban planning, the role of policy and certification systems, and the challenges facing the field. Future directions, such as regenerative design, biomimicry, and the application of artificial intelligence, are explored. The study emphasizes the need for a multidisciplinary approach to create buildings and cities that not only reduce environmental impact but actively contribute to ecosystem health and urban livability.

Keywords: ***Sustainable Architecture, Energy Efficiency, Passive Design, Urban Planning, Green Building Certification, Regenerative Design***

Introduction

The built environment, particularly in urban areas, plays a crucial role in shaping human experience and environmental impact. Buildings, as fundamental components of this environment, contribute significantly to global energy consumption and greenhouse gas emissions. According to the United Nations Energy Programme (2019), the building and construction sector accounted for 36% of final energy use and 39% of energy and process-related carbon dioxide (CO2) emissions in 2018. These statistics underscore the urgency of developing and implementing sustainable architectural concepts to mitigate environmental degradation and enhance urban living quality.

This study examines the evolution of sustainable architecture, its historical context, and its current applications in developing sustainable built environments. The investigation encompasses various perspectives on sustainable design, energy management strategies, and the integration of these concepts into contemporary architectural practice.

Historical Context and Evolution of Adaptive Architecture

The concept of adaptive architecture, which forms the foundation of modern sustainable design, has deep historical roots. Rapoport (1969) Posits that vernacular architecture, shaped by cultural and environmental factors, represents early manifestations of adaptive building practices. These practices evolved from primitive shelters, such as caves enhanced by fire for warmth and animal skins for insulation, to more complex structures designed to withstand diverse climatic conditions (Dmochowski, 1990).

Ancient civilizations recognized the importance of adapting architectural styles to local conditions. Vitruvius, in his seminal work "Ten Books of Architecture," emphasized the necessity of varying building styles according to regional characteristics (Vitruvius, 1901). This principle is exemplified in the works of Fathy (1986), who demonstrated how traditional building techniques in hot arid climates could inform modern sustainable design practices. Fathy's pioneering work in New Gourna, Egypt, showcased the potential of using local materials and passive cooling techniques to create thermally comfortable environments without relying on mechanical systems.

The transition from vernacular to contemporary sustainable architecture has been marked by a growing awareness of global environmental challenges. The oil crisis of the 1970s catalyzed interest in energy-efficient building design, leading to the development of passive solar architecture and the incorporation of renewable energy systems in buildings (Bennetts, Radford, & Williamson, 2003). This period saw the emergence of influential works such as Olgyay (1963), which introduced the concept of bioclimatic design and laid the groundwork for contemporary sustainable architecture.

The Paradigm Shift: From Energy Efficiency to Holistic Sustainability

The evolution of sustainable architecture has been characterized by a paradigm shift from a narrow focus on energy efficiency to a more comprehensive approach encompassing environmental, social, and economic considerations. This transition is reflected in the changing definitions and approaches to sustainable architecture over the past few decades.

Early definitions of sustainable architecture primarily emphasized energy conservation and environmental protection. However, as the field matured, a more nuanced understanding emerged. Bennetts et al. (2003) Trace this evolution, highlighting how sustainability in architecture has grown to encompass a wide range of factors, including social equity, economic viability, and ecological integrity.

Guy and Farmer (2001) Provide a framework for understanding this multifaceted approach by identifying six distinct logics of sustainable architecture:

Eco-technic: Emphasizes technological solutions and high-performance building systems.

Eco-centric: Prioritizes harmony with nature and minimal environmental impact.

Eco-aesthetic: Focuses on the integration of sustainable design with aesthetic considerations.

Eco-cultural: Emphasizes the importance of local cultural context in sustainable design.

Eco-medical: Prioritizes human health and well-being in the built environment.

Eco-social: Addresses social equity and community development through sustainable architecture.

This framework illustrates the complexity of sustainable architecture and the diverse approaches that can be adopted to address environmental challenges in the built environment.

Contemporary Approaches to Sustainable Architecture

Modern sustainable architecture encompasses a wide range of strategies and technologies aimed at reducing environmental impact and enhancing building performance. These approaches can be broadly categorized into passive design strategies, active systems, and material selection.

Passive Design Strategies

Passive design strategies leverage natural processes to maintain comfortable conditions within buildings, minimizing the need for mechanical systems. Lechner (2014) Provides a comprehensive overview of these strategies, which include:

Building orientation and form: Optimizing building shape and orientation to maximize solar gain in cold climates and minimize it in hot climates.

Thermal mass: Utilizing materials with high heat capacity to stabilize indoor temperatures.

Natural ventilation: Employing techniques such as cross-ventilation and stack effect to promote air movement.

Daylighting: Maximizing the use of natural light to reduce artificial lighting requirements.

Shading: Implementing external shading devices to control solar heat gain.

A study by Bessoudo, Tzempelikos, Athienitis, and Zmeureanu (2010) demonstrated that proper implementation of passive design strategies could reduce heating and cooling energy consumption by up to 80% in residential buildings across various climate zones.

Active Systems and Renewable Energy Integration

While passive strategies form the foundation of sustainable architecture, active systems play a crucial role in further reducing energy consumption and environmental impact. These systems include:

High-efficiency HVAC systems: Advanced heating, ventilation, and air conditioning systems that minimize energy use while maintaining indoor comfort.

Smart building management systems: Automated control systems that optimize building operations based on occupancy patterns and environmental conditions.

On-site renewable energy generation: Integration of technologies such as photovoltaic panels and wind turbines to generate clean energy.

A meta-analysis by Hong, Koo, Kim, Lee, and Jeong (2015) found that the integration of smart building technologies could achieve energy savings ranging from 20% to 30% in commercial buildings.

Sustainable Materials and Construction Practices

The selection of materials and construction methods plays a critical role in the overall sustainability of a building. Key considerations include:

Embodied energy: The total energy required to produce, transport, and install building materials.

Life cycle assessment: Evaluating the environmental impact of materials throughout their entire life cycle, from extraction to disposal.

Recycled and recyclable materials: Utilizing materials with high recycled content and designing for future recyclability.

Local and renewable materials: Prioritizing materials sourced locally to reduce transportation emissions and support local economies.

A study by Thormark (2006) found that the choice of materials could influence a building's life cycle energy use by up to 17%, highlighting the importance of material selection in sustainable architecture.

Energy Management in Sustainable Architecture

Effective energy management is a cornerstone of sustainable architecture, given the significant contribution of buildings to global energy consumption. The United Nations Energy Programme (2019) reports that buildings account for nearly one-third of global final energy consumption and 55% of global electricity consumption.

Energy management in sustainable architecture encompasses several key strategies:

Energy-efficient building envelope: High-performance insulation, advanced glazing systems, and air sealing techniques to minimize heat transfer between the interior and exterior of buildings.

High-efficiency lighting: LED lighting systems combined with daylight sensors and occupancy controls to reduce artificial lighting energy consumption.

Energy recovery systems: Heat recovery ventilators and energy recovery ventilators that capture and reuse waste heat from exhaust air.

Demand response and load management: Strategies to shift energy consumption to off-peak hours and reduce peak demand on the electrical grid.

Building energy modeling: Utilization of advanced simulation tools to predict and optimize building energy performance during the design phase.

A comprehensive study by the New Buildings Institute (2018) found that net-zero energy buildings, which produce as much energy as they consume on an annual basis, are becoming increasingly feasible. The study identified 67 verified net-zero energy buildings in North America, with an additional 415 buildings targeting net-zero energy performance.

Challenges and Future Directions

Despite significant advancements in sustainable architecture, several challenges remain:

Cost perceptions: The perception of higher upfront costs for sustainable buildings remains a barrier to widespread adoption, despite evidence of long-term cost savings (World Green Building Council, 2013).

Performance gap: Discrepancies between predicted and actual building performance highlight the need for improved modeling tools and post-occupancy evaluations (De Wilde, 2014).

Adaptation to climate change: The need to design buildings that can withstand future climate conditions while maintaining energy efficiency Georgiadou, Hacking, and Guthrie (2012).

Integration of emerging technologies: The rapid pace of technological advancement presents both opportunities and challenges for sustainable architecture, requiring continuous adaptation of design practices.

Future directions in sustainable architecture include:

Regenerative design: Moving beyond net-zero energy to create buildings that positively contribute to the environment (Mang & Reed, 2012).

Biomimicry: Drawing inspiration from natural systems to create more efficient and resilient buildings (Pawlyn, 2019).

Circular economy principles: Designing buildings for disassembly and material reuse to minimize waste and resource consumption (Cheshire, 2019).

Integration of artificial intelligence: Leveraging machine learning algorithms to optimize building performance and occupant comfort (Bilal et al., 2016).

Biophilic design: Incorporating nature and natural elements into building design to enhance occupant well-being and environmental performance (Kellert, Heerwagen, & Mador, 2011).

Adaptive reuse: Repurposing existing buildings to reduce embodied energy and preserve cultural heritage (Foster, 2020).

The Role of Policy and Certification Systems

The development of sustainable architecture is significantly influenced by policy frameworks and certification systems. These mechanisms play a crucial role in promoting and standardizing sustainable building practices:

Building codes and regulations: Many countries have implemented stringent energy codes and sustainability requirements for new constructions and renovations (United Nations Energy Programme, 2019).

Green building certification systems: Programs such as LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and the Living Building Challenge provide frameworks for assessing and recognizing sustainable buildings (Cole, 2020).

Financial incentives: Governments and utility companies often offer tax credits, grants, and rebates to encourage the adoption of sustainable building practices and technologies (World Green Building Council, 2013).

Carbon pricing mechanisms: Some jurisdictions have implemented carbon taxes or cap-and-trade systems that indirectly incentivize energy-efficient building design and operation (Carlsson Kanyama, Nässén, & Benders, 2021).

These policy tools and certification systems have been instrumental in driving the adoption of sustainable architecture practices. However, their effectiveness varies across different contexts, and there is ongoing debate about how to best structure these mechanisms to achieve optimal outcomes (Cole, 2020).

The Intersection of Sustainable Architecture and Urban Planning

Sustainable architecture cannot be considered in isolation from the broader urban context. The principles of sustainable design extend beyond individual buildings to encompass neighborhood and city-wide planning strategies:

Transit-oriented development: Designing communities around public transportation hubs to reduce reliance on private vehicles and promote walkability (Cervero, 2020).

Urban heat island mitigation: Implementing strategies such as green roofs, cool pavements, and urban forestry to reduce the urban heat island effect and improve energy efficiency at the city scale (Santamouris, 2023).

Green infrastructure: Integrating natural systems into urban environments to manage storm water, improve air quality, and enhance biodiversity (Tzoulas et al., 2007).

Mixed-use development: Promoting diverse, multi-functional urban spaces that reduce transportation needs and create vibrant communities (Hoppenbrouwer & Louw, 2005).

These urban-scale strategies complement building-level sustainable design practices, creating a more comprehensive approach to environmental sustainability and urban livability.

Conclusion

Contemporary architectural concepts in developing sustainable built environments have evolved significantly from their historical roots in vernacular architecture. The field has progressed from a narrow focus on energy efficiency to a holistic approach that encompasses environmental, social, and economic considerations.

The integration of passive design strategies, active systems, and sustainable materials has demonstrated the potential to dramatically reduce the environmental impact of buildings. However, challenges remain in terms of widespread adoption, performance verification, and adaptation to future climate conditions.

As the field continues to evolve, the integration of emerging technologies, the adoption of regenerative design principles, and the implementation of urban-scale sustainability strategies offer promising avenues for further reducing the environmental impact of the built environment and creating buildings and cities that actively contribute to ecosystem health.

The development of sustainable built environments requires a multidisciplinary approach, combining insights from architecture, engineering, environmental science, urban planning, and social sciences. By continuing to refine and implement these contemporary architectural concepts, the building sector can play a crucial role in addressing global environmental challenges and improving the quality of urban life.

The future of sustainable architecture lies not only in technological innovation but also in a deeper understanding of the interconnectedness between buildings, their occupants, and the broader ecological and social systems in which they exist. As the field continues to evolve, it will be crucial to balance technological advancement with sensitivity to local contexts, cultural values, and the fundamental human need for connection with nature and community.

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