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Climate Change and Architectural Practice in Nigeria

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Abstract

This paper deals with Climate change and how it has impacted on the Nigerian Architectural practice. It discusses the effect of climate change on architectural design as well as how Architects design buildings that meet the social, economic, and environmental needs of the people it serves over time and changing needs. Since climate is changing and the effect on the built environment can only be reduced and not totally eliminated, there is need for Architects and other professionals in the building industry to produce buildings that are sustainable. While this situation poses a major challenge to the practice of architecture, there arises the need for designers to combat it through improved building design. The paper concludes by suggesting ways to combat the effect of climate change through design solutions.

Keywords: climate change, Architectural practice, design solution, sustainable.

1. Introduction

Climate change has become the primary environmental threat of the 21st century. It is now on the global political agenda as never before. The current concern is based on a number of recent scientific analyses that suggest that potential climate change effects are at a scale that adds urgency not only to the efforts to prevent additional change, but equally important, to efforts to adapt to the impacts already occurring. Science suggests that its effects are at a scale that adds urgency not only to the efforts to prevent additional change, but equally important, to efforts to adapt to the impacts already occurring.

Responding to climate change falls into two broad classes of action, mitigation and adaptation. Mitigation of human-induced climate change refers to measures that may either reduce the increase in greenhouse emissions (abatement) or increase terrestrial storage of carbon (sequestration). Although Nigeria, like other developing countries, is not required under the current global climate change negotiations to take on emission reduction commitments, it nevertheless has to adapt to the expected impacts of anticipated climate change. Adaptation refers to all the responses to climate change that may be used to reduce vulnerability.

Responding to climate change through adaptation initiatives will require Nigeria to engage in concerted efforts of seeking out opportunities and design actions to reduce the vulnerability of the people to climate change impacts. Nigeria needs to explore a number of opportunities that exist to build a climate-resilient society that is able to withstand or recover quickly from difficult conditions caused by the adverse effects of climate change, including climate-related hazards and disasters by strengthening its coping or adaptive capacity.

Architects over the years have reflected on the importance of having good quality environment. The quest for environmental values in architecture, for a harmonious balance between man and his environment is not new approach. It is so much that for centuries, mankind adopted this approach out of necessity, particularly in vernacular architecture. However, since the industrial revolution, this has been increasingly abandoned in favour of universal architecture, which in many parts of the world, Nigeria included has led to energy intensive buildings. The effects of global warming and Climate Change are increasingly becoming apparent, notably in Nigeria is the serious famine we are witnessing today, diminishing rains, drying rivers and power rationing just to mention but a few. Faced with these dangers, the public and policymakers alike must become conscious of the need to protect our environment. One response to these issues is to approach architecture in a way that respects the environment.

The aim of this paper is to identify how climate change has influenced the practice of Architecture in Nigeria. The objectives are to:

i. identify the causes of climate change in Nigeria;
ii. determine the effects of Climate change on the Nigerian Environment;
iii. examine how has Climate Change has affected architectural practice in Nigeria;
iv. determine the role of the Architect in combating the effects of climate change.

2.0 Literature Review

2.1 *Greenhouse Gases*

Greenhouse gases occur naturally in the environment and also result from human activities. By far the most abundant greenhouse gas is water vapour, which reaches the atmosphere through evaporation from oceans, lakes, and rivers. The amount of water vapour in the atmosphere is not directly affected by human activities.

- *Water Vapour*

Water vapour is the most common greenhouse gas in the atmosphere, accounting for about 60 to 70 per cent of the natural greenhouse effect. Humans do not have a significant direct impact on water vapour levels in the atmosphere. However, as human activities increase the concentration of other greenhouse gases in the atmosphere (producing warmer temperatures on earth), the evaporation of oceans, lakes, and rivers, as well as water evaporation from plants, increase and raise the amount of water vapour in the atmosphere.

- *Carbon dioxide*

Carbon dioxide constantly circulates in the environment through a variety of natural processes known as the carbon cycle. Volcanic eruptions and the decay of plant and animal matter both release carbon dioxide into the atmosphere. In respiration, animals break down food to release the energy required to build and maintain cellular activity. A by-product of respiration is the formation of carbon dioxide, which is exhaled from animals into the environment. Oceans, lakes, and rivers absorb carbon dioxide from the atmosphere. Through photosynthesis, plants collect carbon dioxide and use it to make their own food; in the process incorporating carbon into new plant tissue and releasing oxygen to the environment as a by-product. In order to provide energy to heat buildings, power automobiles, and fuel electricity-producing power plants, humans burn objects that contain carbon, such as the fossil fuels, oil, coal, and natural gas; wood or wood products; and some solid wastes. When these products are burned, they release carbon dioxide into the air. In addition, humans cut down huge tracts of trees for lumber or to clear land for farming or building. This process, known as deforestation, can both release the carbon stored in trees and significantly reduce the number of trees available to absorb carbon dioxide.

- *Methane*

Many natural processes produce methane, also known as natural gas. Decomposition of carbon-containing substances found in oxygen-free environments, such as wastes in landfills, release methane. Ruminating animals such as cattle and sheep belch methane into the air as a by- product of digestion. Microorganisms that live in damp soils, such as rice fields, produce methane when they break down organic matter. Methane is also emitted during coal mining and the production and transport of other fossil fuels. Atmospheric concentrations of methane are far less than carbon dioxide, and methane only stays in the atmosphere for a decade or so. But methane is an extremely effective heat-trapping gas.

- *Nitrous Oxide*

Nitrous oxide is released by the burning of fossil fuels, and automobile exhaust is a large source of this gas. In addition, many farmers use nitrogen-containing fertilizers to provide nutrients to their crops. When these fertilizers break down in the soil, they emit nitrous oxide into the air. Ploughing fields also releases nitrous oxide. Nitrous oxide traps heat about 300 times more effectively than carbon dioxide and can stay in the atmosphere for a century.

- *Ozone*

Ozone is both a natural and human-made greenhouse gas. Ozone in the upper atmosphere is known as the ozone layer and shields life on Earth from the sun's harmful ultraviolet radiation, which can cause cancer and other damage to plants and animals. However, ozone in the lower atmosphere is a component of smog (a severe type of air pollution) and is considered a greenhouse gas. Unlike other greenhouse gases which are well-mixed throughout the atmosphere, ozone in the lower atmosphere tends to be limited to industrialised regions.

- *Synthetic Chemicals*

Manufacturing processes use or generate many synthetic chemicals that are powerful greenhouse gases. Although these gases are produced in relatively small quantities, they trap hundreds to thousands of times more heat in the atmosphere than an equal amount of carbon dioxide does. In addition, their chemical bonds make them exceptionally long lived in the environment.

- *Chloro-fluoro-Carbons*

Human-made greenhouse gases include chlorofluorocarbons (CFCs), a family of chlorine-containing gases that were widely used in the 20th century as refrigerants, aerosol spray propellants, and cleaning agents. Scientific studies showed that the chlorine released by CFCs into the upper atmosphere destroys the ozone layer. As a result, CFCs are being phased out of production under a 1987 international treaty, the Montréal Protocol on Substances that Deplete the Ozone Layer. CFCs were mostly banned in industrialised nations beginning in 1996 and will be phased out in developing countries after 2010. New chemicals have been developed to replace CFCs, but they are also potent greenhouse gases. The substitutes include hydro chlorofluorocarbons (HCFCs), hydro fluorocarbons (HFCs), and per fluorocarbons (PFCs).

- *Aerosols*

Fuel combustion, and to a lesser extent, agricultural and industrial processes, produce not only gases but also tiny solid and liquid particles called aerosols that remain suspended in the atmosphere. Although aerosols are not considered greenhouse gases, they do affect global warming in several ways.

Diesel engines and some types of biomass burning produce black aerosols such as soot, which absorb the sun's energy and therefore contribute to warming. Conversely, coal-fired power plants burning high-sulphur coal emit sulphate aerosols, which are light-cultured aerosols that reflect incoming solar energy back to space. In this way, they have a cooling effect. Natural aerosols that also have a cooling effect are produced during volcanic eruptions and the evaporation of seawater. Aerosol particles also have an indirect cooling influence by acting as "seeds" for the condensation of water vapour into cloud masses. In general, the amount of solar energy reflected back to space is greater on cloudy days.

Overall, aerosols may roughly offset the net warming influence of noncarbonated dioxide greenhouse gases, half through their direct cooling effect and half through their indirect cooling effect. However, considerable certainty in aerosol processes means that their cooling influence could be much larger or much smaller. Aerosols are one of the least understood factors in climate change and their effects are still being debated. Scientists are more certain, however, about the net effect of all greenhouse gas and aerosol emissions, which is estimated to be roughly equal to the warming influence of carbon dioxide alone.

2.2 *Impact of the Built Environment on Climate Change*

According to the IPCC, buildings contribute about 31% of global CO2 emissions. This includes the emissions created during the construction and use of buildings, from heating, cooling and powering them. The built environment throws up a number of climate change questions bothering on how resources and energy are consumed, land developed, buildings and infrastructure constructed as well as services supplied and places connected.

It is estimated that the cement industry contributes about 5% to global anthropogenic CO2 emissions. CO2 emissions are produced through heating, cooling and powering the built environment. These emissions have been rising by almost 2% per year, thanks largely to bigger homes with more energy consuming devices in them.

Additional to warming due to greenhouse gases, the built environment has an influence on the albedo effect. Materials such as concrete and asphalt absorb greater amounts of heat than natural surfaces. This absorption leads to localized warming, known as urban heat islands. In large cities there can be as much as a $5^{o}C$ difference between the city centre and the rural environs. (Vidal , 2007)

3.0 The Nigerian Climate

Climate, that is macro - and micro - climate, is the sum of characteristic meteorological phenomena in the atmosphere. These are modified by topographic conditions of the earth and by the changes which civilization has made to its surface. Micro-climate is found in a more limited space like a room, a street, town or small landscape, while macro-climate is that found in a much larger space such as over a country, a continent or on oceans.

Climatic conditions include weather observations over the longest possible period of time, and must consist not only of temperatures and precipitation values, but also humidity, cloud, wind, air pressure and solar radiation. The Nigerian macro-climate may be classified into four zones according to Komolafe (1988) namely:

(i) Hot - dry,
(ii) Temperate dry
(iii) Hot humid and
(iv) Warm humid.

3.1 *Thermal Comfort Conditions*

For body comfort, the most important factor which affects the absence of discomfort in an enclosed space is the correct combinations of:

- The air temperature;
- The humidity;
- The radiation from or to surrounding surfaces;
- The movement of air and its freshness or stuffiness.

3.2 *Site Planning for Comfort*

The following fundamental rules for site orientations and solar control are generally valid:

- Open facades should face north or south as much as possible to avoid direct radiation from a low sun and the consequent intensive concentration of heat.
- In hot - dry or arid zones, screening of openings in mostly closed wall surfaces is indispensable.
- In hot - humid zones it is necessary to screen all openings and in some circumstances, complete facades against direct and indirect radiation from overcast skies.

A good design for thermal comfort in the Nigerian climate should observe the following considerations:

- Orientation of the buildings;
- Cross ventilation within the habitable rooms;
- Solar control and appropriate shading techniques;
- Use of appropriate properties of materials like heat storage and insulation;
- Appropriate and correct use of vegetation and
- Air humidification or evaporative cooling.

3.3 *Site Orientation of Buildings*

Correct site orientation of buildings for thermal efficiency must pay attention to:

- Solar radiation and the resultant heat load;
- Direction and force of the wind and
- The topography of the site.

3.4 *Solar Control and Shading Devices*

In the tropics, protection from the sun is always necessary. This is because the intensity, duration and the angle of incidence of solar radiation to a particular surface are the main determinants of the design precautions necessary for comfort. These factors affect the solar control measures such as:

- The time of the day and the extent of screening required and
- The calculation of the type, depth and separation of the screening elements required.

Except for other aesthetic reasons, there is little or no justification for using the same screening devices on all the four facades of a building. Screening is most effective if separately calculated to suit the solar angle of incidence and the requirements for each facade. The capital cost involved in providing appropriate and suitable sun - shading devices helps to minimize the heat load and consequently:

- reduce the cost of air conditioning,
- provide cooler indoor environment,
- ensure greater thermal comfort of the occupants and
- increase productive efforts (Odeleye, 1989).

3.5 *Effects of Climate on Building Elements*

Climatic factors do not affect people's comfort alone; they can also impair the safety of buildings and lead to building damage and premature fatigue of building materials, according to Komolafe (1988). In the tropics, for example, factors such as intense solar radiation, high humidity and condensation, dust and sandstorms and the salt content of the air affect building materials.

For walling materials, the comfort implication of heat storage capacity, where they are needed, are secondary to those of privacy, stability, protection and security against house - breaking. As a result of this, sandcrete block walling and thin mud walls, adobe or wattle and daub are commonly used in various climatic zones.

The picture is not better with respect to roofing materials in common use. For example, galvanized iron sheet absorbs 65% of solar radiation which increases to 80% when it gets old and dirty. Similarly asbestos – cement roofing sheets absorb as high as 61% of heat, which increases to 83% when old and dirty (Komolafe, 1988). Generally, the problem is not what is thermally desirable and efficient, but what is readily available and economically affordable to the people

3.6 *Green Architecture*

Green architecture refers to the creation or restructuring of buildings so that they have a minimal impact on the environment. There are a number of different approaches to green construction, with many of the ideas involving the responsible recycling of existing resources along with the efficient use of environmentally friendly systems to provide water and power services to buildings that are created using a sustainable design. As more people have become concerned about the wise use of the planet's resources, the concept of green architecture has gained in both acceptability and interest. Generally, a green architect will attempt to design or overhaul buildings so that they provide all the necessary functions but do not pose a great threat to the surrounding environment. In many cases, this means using building materials that are composed of organic compounds rather than synthetics. The building material may be wood, bricks, or other elements that are harvested from older buildings scheduled for demolition. These harvested materials are joined with newer technology to create structures that fit into the surrounding landscape with greater ease and make the best use of availed resources for heating, cooling, cooking and water supply to the edifice. The use of solar panels is a common element of green architecture. The panels, along with their storage tanks, make it possible to store energy for electrical needs such as cooking, keeping the temperature in the building at a comfortable level, and running necessary equipment such as computer. In recent years, coupling of a solar energy system with a wind system has been experimented with, effectively drawing on two renewable resources to create energy to meet the demands of modern life (Sustainable Architecture, 2010).

Another important aspect of green design is the strategic placement of windows around the facing of the building. Ideally, the windows are placed so that the most efficient use of sunlight during the day takes place. In addition to decreasing the demand for artificial light during the daytime, the windows can also serve as a means of allowing the natural sunlight to provide a degree of warmth to the interior of the building. This in turn makes it possible to utilize less of the stored solar or wind energy to keep the space at an equitable temperature. Depending on the placement of the building and its intended purpose, other aspects of green architecture may be included. The building may be recessed partially into the side of a hill, thus providing natural insulation. Composting toilets may be the ideal solution in areas where water is hard to come by (Sustainable Architecture, 2010). Finding ways to use whatever elements are native to the area also helps to keep the structure in balance with nature, such as creating blocks using local sand rather than shipping in bricks constructed elsewhere. While the process of creating green architecture may be more deficient in some areas, there is no doubt that just about any structure can be altered or designed to be more environmentally friendly.

3.7 *Green Architecture and Climate Change*

It is estimated that at present, buildings contribute as much as one third of total global annual greenhouse gas emissions, primarily through the use of fossil fuel during their operational phase and consumes up to 40% of all energy (Adeleke, 2010). This includes energy used in the production and transportation of materials to building construction sites, as well as the energy used to operate buildings. Given the massive growth in new construction in economies in transition, and the inefficiencies of existing building stock worldwide, if nothing is done, greenhouse gas emissions from buildings will more than double in the next few years.

Green architecture is creating structures and using processes that are environmentally responsible and resource - efficient throughout a building's life - cycle, from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability and comfort (U.S. Environmental Protection Agency, 2009). Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment. This is achieved by efficiently using energy, water and other resources, protecting occupants' heath and improving employees' productivity and reducing waste, pollution and environmental degradation. Energy efficiency and the reduction of greenhouse gas emissions must be the foundation of every national climatic change strategy and incorporated into all development plans including those pertaining to building policy (Obot, 2010).

3.8 *The Architect in Combating Climate Change*

The Architect as a key player in the Building Industry, play a very vital role in combating the effect of climate change on the built environment. According to Omotoso, (2011),the Architect can contribute to the reduction of the energy and demand on resources associated with construction and operation of buildings by the followings:

- Incorporating existing buildings and structures into design schemes as much as possible instead of demolishing such buildings and structures to make way for new buildings.
- Collaborating with Mechanical and Electrical Engineers to design for reduced consumption of energy in

buildings.

- Specifying recyclable, reusable, local, natural, durable and environmental friendly building materials.
- Creating high performance buildings that take maximum advantage of natural ventilation and lighting.
- Planning cities, part of cities and neighbourhoods in such a manner that people can live and work and take leisure within a single environment.
- Preserving biologically rich landscapes in master planning.

The Architect can contribute to the mitigation of the current and future effects of climate change on the built environment by:

- Improved planning and building design to reduce urban heat and temperature rise. Urban population will want more access to outdoor natural open spaces as temperatures rise.
- Climate modification using plants, siting of buildings and using different surface materials and topographic features either as they exist or as they could be constructed.
- Use of plants to enclose and modulate spaces of roads, buildings and forms.
- Extensive use of trees to shade buildings, people and road surfaces from solar radiation and reduce air pollution and ameliorate temperature.
- Use of vertical louvers, projecting fins, projecting eaves, horizontal canopy or awning, horizontal louvers, slates, concrete and metal grills to control sun penetration.
- Collaborating with members of the design team and the client to develop and update construction designs that provide increased durability and reliability in the face of changing temperature, relative humidity, levels of precipitation, wind speeds and frequency of extreme weather events.

4.0 Conclusion

Architecture is crucial in the present and future development of a country. As the number of buildings multiplies, there is an urgent need to adopt green building standards. This will ensure not just cost-effective buildings but also healthier and more productive living environment (Adeleke, 2010). It can make a major contribution to the pressing search to devise ways of life that are less taxing on the earth's resources, the relationship of buildings to their environment, their location with regard to public amenities, the burden their occupants will place on road networks are issues that will determine a building's green thumbprint.

The parameter of sustainable and environmentally friendly architecture is wide and the ability to control living environments exists as never before. Since buildings have a long life, the effects of decisions made today will be felt for many years to come. Thus, low environmental impact should be a built in feature of building design by all professionals, clients and developers who claim to be producing quality buildings since quality requires that today's buildings not only meet the needs of the present occupants but also be an asset rather than a liability for our children and future generations.

The following recommendations therefore become very necessary

- Architects, engineers and developers make a decisive attempt to combat global warming by putting up environmentally friendly buildings. At present, what we need is a new generation of buildings: low in energy consumption and environmentally friendly, that will set new standards in our urban centres.
- Environmental welfare that this will lead to reduction in CO2 emission, create better-Built Environments and help us to move towards sustainable development should be encouraged.

- As building professionals, we must take a keen interest in green buildings and always remember that the architecture of the 21st Century is about environmental design.
- Government should take the leading role to facilitate and encourage best environmental practice. So much so that practically all the new government buildings should be environmentally friendly and should be good case studies for "green" building principles.
- It is important that the government moves to the forefront and be seen to guide the construction industry by developing comprehensive targets to counter the challenges of Climate Change.
- Low environmental impact should be a built in feature of building design by all professionals, clients and developers To achieve this, we must 'touch this earth lightly'.

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