Global Warming versus Green Architecture: African Experience

Ben Ugochukwu Iwuagwu, and Azubuine Chika Elijah

Abstract- Greenhouse gases (GHGs) are solely responsible for climate change and its associated effects in the world today. Studies reveal that the building sectors consume more than one third of the world's energy, and contribute to global warming. On average between 1980 and 1990, CO₂ emissions from buildings have grown by 1.7 percent per year with rates of growth noted to be four times greater in developing countries. Due to increase in urban population and attendant residential pressures, energy consumption is projected to rise in buildings especially in fast growing countries. With increasing building impact on energy consumption, it is necessary to address the challenges of unsustainable building practices by adopting more sustainable building approach such as ‘green architecture. Green architecture focuses on saving energy production and consumption through green buildings. Green buildings emit fewer greenhouse gases, consume less energy, use less water, and offer occupants healthier environments than the typical buildings. A typical traditional building of earth emits fewer greenhouse gases, consumes less energy, and maintains a high level of internal thermal comfort, regardless of prevailing solar radiation outside. It is therefore necessary to promote the construction of earth structures and combine its potentials with modern technology so as to produce a new generation of buildings that require no mechanical air-conditioning during hot days and nights. The paper studied the benefit of using natural and traditional building materials in housing delivery and discusses the relevance of local inputs to affordable and balanced housing and concludes by recommending fusion of traditional building materials and modern technology as a sustainable tool for reducing high energy production and consumption in the building sectors.

Keywords---Global warming, Greenhouse gases, Green architecture, Green buildings.

I. INTRODUCTION

The International Energy Agency released a publication that estimated that existing buildings are responsible for more than 40 percent of the world’s total primary energy consumption and for 24 percent of global CO₂ emissions. Studies reveal that the building sectors, which consume more than one third of the world's energy, are the single major or largest contributor to global warming. This implies that the building sector uses more energy than other sectors like the industrial and transportation sectors. Due to increase in urban population and attendant residential pressures, energy consumption is projected to rise in buildings especially in fast growing countries [1].

Ben Ugochukwu Iwuagwu is with the Department of Architecture, Abia State Polytechnic, PMB. 7166 Aba-Owerri Road Aba, Abia State, Nigeria. (Phone: +234(0)8030437477, e-mail: iwuagwben@yahoo.com)

Chika Elijah Azubuine is with the Department of Architecture, Abia State University, PMB. 2000 Uturu, Abia State, Nigeria. (Phone: +234(0)8036884078, e-mail: landmarkprojectsinternational@yahoo.com)

With increasing building impact on energy consumption, it is necessary to address the challenges of unsustainable building practices by adopting more sustainable building approach such as ‘green architecture that would cater to the growing impact in Africa.

Green Architecture in the African context is the indigenous approach of building practices with the goal of sustaining the ecosystem. It puts into consideration the easily affordable local resources and the development of concepts that sustain the socio-cultural value system within the building sector. Green Architecture approaches building construction (from design conceptualization and construction to its material usage all through its life-span) with the aim of minimizing harmful effect on human health and environment. It attempts to conserve environmental factors such as air, water and the earth by employing eco-friendly building materials and construction practices.

Buildings are the dominant energy consumers in modern cities but their consumption according to [3] can be largely cut back through improving efficiency, which is an effective means to lessen greenhouse gas emissions and slow down depletion of non-renewable energy sources. The designs of architects are very important in mitigating the problem of climate change. This calls for the concept of green architecture. This invariably forms the major concern of the architects in seeking sustainability in design. The concept of organic architecture which was the fundamental concept of great architects like Frank Lloyd Wright (1867–1959) has now been identified under the current climatic challenges as a most relevant approach amongst the schools of thoughts in architecture.

The paper studied the benefit of using earth and other natural and traditional building materials in housing delivery in other to reduce energy consumption and its resultant effects and discusses the relevance of local inputs to affordable and balanced housing and concludes by recommending fusion of traditional building materials and modern technology as a sustainable tool for reducing high energy production and consumption in the building sectors.

II. HOUSING PROVISION AND ENERGY CONSUMPTION

Energy becomes a fundamental need for human settlements right from construction, (roads, buildings, building materials and infrastructure), operation (homes, offices, transport networks) and living (televisions, air conditioners, cooking, computers, etc). Today, the residential household energy consumption is almost a third of all end-use energy. Households are also indirectly responsible for a large amount of energy use, required in production and freight of the goods.
and services they consume. Therefore, the households in some countries are ultimately responsible for over half of total energy use either directly or indirectly through the consumption of products and services. In countries with a temperate climate, more than half of this energy is typically used for heating [3]. Although energy use for space cooling is relatively less, it is on the rapid rise both in high-income countries as well as in emerging economies including India, China and some countries in the Middle East, South East Asia and South America. Energy demand for heating and cooling is greater than ever. As most available energy is based on fossil fuel, the increased energy demands contribute significantly to more greenhouse gas emissions [4].

III. RELEVANCE OF LOCAL INPUTS TO AFFORDABLE HOUSING

The impact of urban influx includes inadequate infrastructure, increased joblessness rate, poverty, environmental pollution, and housing problems. Inadequacy in housing provision is a major challenge posed by unprecedented urbanization in the developing countries. For example, Nigeria’s Housing Policy has been emphasizing public housing schemes with little success. “Provider-oriented approaches, such as public housing strategies, have failed to meet the housing needs of the vulnerable low-income households who require accommodation most” [5]. Previous low-cost housing schemes meant to provide shelter for low-income earners have failed to impact the housing situation of the majority of Nigerian households. The National Social Housing Scheme (NSHS) (offered as an alternative, for the less privileged citizens across the country) could encounter a recurring problem of effective implementation to make it work according to its stated goals [6].

Since the attainment of political independence in 1960, Nigeria has adopted several provider-oriented public-driven strategies such as Federal and State housing programs, slum clearance and resettlement, public and international donor-assisted settlement upgrading and sites and services. These have had very limited impact at best, on housing development and improvement in the country [7]. The economic recession of the 1980s and attempts to restructure the economy under the International Monetary Fund (IMF) stabilization programmes did not help housing provision either. The structural adjustment policies that were formulated to tackle broad economic problems were drawn up with little regard to the adverse effects on the housing sector [8]. United Nations Centre for Human Settlements has observed that there is no evidence of improvement in the housing conditions of lower income groups in terms of affordability, tenure, standards and access to service [9]. Despite heavy investment costs, several schemes have failed to reach their goals. Efforts to alleviate housing problems usually focus on cities with little attention paid to rural areas. The failure of urban housing schemes is primarily due to the high costs of non-indigenous technology and imported material usage, making it difficult to reach most intended recipients. The development of low-technological innovations and fusion of traditional building materials with modern technology could help alleviate housing problems in the urban and rural communities and reduce energy consumption and emission of greenhouse gas.

IV. GREEN ARCHITECTURE

In the African context, this study views “Green Architecture” as the indigenous approach of building practices with the goal of sustaining the ecosystem. It puts into consideration the easily affordable local resources and the development of concepts that sustain the socio-cultural value system within the building sector. Green Architecture approaches building construction (from design conceptualization and construction to its material usage all through its life-span) with the aim of minimizing harmful effect on human health and environment. It attempts to conserve environmental factors such as air, water and the earth by employing eco-friendly building materials and construction practices. According to [10]:

The construction and operation of buildings require more energy than any other human activity. The International Energy Agency (IEA) estimated in 2006 that buildings used 40 percent of primary energy consumed globally, accounting for roughly a quarter of the world green house gas emissions. Commercial buildings comprise one-third of this total. Urbanization trends in developing countries are accelerating the growth of this sector relative to residential buildings, according to the World Business Council on Sustainable Development (WBSCD). Reducing these emissions is therefore a cornerstone intention and responsibility of green building standards and initiatives.

Green architecture focuses on saving energy production and consumption. While buildings could be the highest carbon emitters, they could equally represent the best means of reducing environmental, economic impact and energy use, effectively. Synonymous with green architecture, sustainable architecture focuses on climate responsive or eco-friendly designs and construction techniques in buildings with positive impact on social, ecological economic and environmental sustainability. The consideration of environmental factors, tradition, culture and their effects must be given a high priority. This study relates the indigenous (traditional African architecture) with green architecture.

V. GREEN BUILDING

A sustainable/green building is an outcome of a design, which focuses on increasing the efficiency of resource use-energy, water, and materials-while reducing building impacts on human health and the environment during the building lifecycle, through better siting, design, construction, operation, maintenance, and removal. A green building is environmentally responsive and resource-efficient, reducing the impact of the built environment on human and the natural environment as well as waste, pollution, and environmental degradation. The importance of green building include:

A. Improving Energy Efficiency:

Any path to sustainability necessarily includes improving energy efficiency throughout the global economy [11]. Green building approaches buildings with the basic concept of creating energy efficiency and contributes to global economy
by extensively cutting down on energy consumption growth. Energy efficient technologies are imperative for a revolution in every sector.

B. Environmental Sustainability:

Green buildings are designed with environment management in mind. It takes drastic measures to reduce wastage as well as environmental degradation to a barest minimum. It also takes into consideration the comfort of the end-users. It aims at total safety and sustainability of the ecosystem and advocates the use of materials, methods, and technology that favour this primary objective.

C. Greenhouse Gas emission reduction:

The built environment contributes ultimately to global warming by its high rates of emitting greenhouse gases through energy usage (for cooling, heating, and lighting) and for construction. Green building projects a possibility of total reduction to a near zero carbon emission of buildings. Green buildings take on the initiative of improved technologies, to contribute significantly in mitigating global climate change.

VI. AFRICAN ARCHITECTURE

Its indigenous architectural practice had been shaped by ideologies of sustainability though according to [12] it was done in ignorance. Developed from naturally existing materials and cyclical possibilities of their regeneration, they impacted on the judicious use of earth’s resources in the construction of its villages and hamlets, the cities and urban centres as well as the temples, tombs, monuments and religious edifices. Predictably, earth/mud/adobe has been one of its most important and chief building material combined with timber (mostly from palm trunks) and palm/coconut/grass thatch and straw bales as roofing; all materials abundantly available in the settlements. In entirety, Africa’s traditional architecture made certain that its use of the resources neither diminished their availability, nor adversely affected the ecological balance upon which it relied on as an agrarian society.

Historically, Africa has a unique sustainable architecture. Its indigenous buildings share the same objectives with “green buildings” since its building materials favour the basic prerequisites of sustainable utilization of environmental resources. The architecture of Africa has been seen and labelled international. The definition of architecture as the art and science of building has over the years seen a lot of reforms to include usability, acceptability and comfortability. That African architecture does not have documented scientific approach to its design and construction does not mean that it fails to satisfy these conditions, because, for a building system proven to satisfy thermal comfort, aesthetics and sustainability and being a major part of the daily life of its occupants cannot be anything short of architecture. African traditional architecture is essentially sustainable and had evolved culturally to suit the people. Usually, earth, timber, straw, stone/rock and thatch were constructed together with the simplest of tools and methods to build simple, liveable dwellings. Although globalization has relegated them as being ‘primitive’, this ‘primitive’ classification comes partially from the building materials and their relatively low technological uses when compared to present day western (Architectural) construction techniques which result in skyscrapers. According to [13], Present interpretations of sustainability have given them a new status as likely technologies for the contemporary world.

Along with the others that have been re-devised, earth has of late gained acknowledgement as a suitable technology for contemporary buildings. Africa as a tropical continent between the Atlantic (west) and Indian (east) oceans has an over 5000 year’s old recorded history that shows buildings and monuments made of numerous natural materials available in abundance in its geographical landscape. Looking into history particularly on the African continent; Egypt, Nigeria, Kenya, Mali etc, we hear and sometimes carry out studies on the New Gourna Village by Hassan Fathi, the Ancient Kano and Zaria cities by the indigenous craftsmen, the Great Mosque of Djenné directed by Ismaila Traoré, and a few other examples. These buildings have lasted for over one hundred (100) years at the least and have proved themselves to be outstanding works of architecture that have not only stood the test of time but, are cheap, comfortable with little or no carbon footprint. Having such immense potential, traditional African architecture particularly building with compressed earth blocks (CEBs) is worth looking into.

The introduction of modern technologies such as the concrete blocks and slabs during the industrial periods had relegated traditional components and methods to the background and it became the goal of those in the wattle- and-daub houses to remake them with the new trend material; concrete blocks, in spite of the obvious truth that they did not present the same kind of thermal comfort. The native dwellers thus replaced their comfortable, low-cost and sustainable houses with the modern opposite which were the current fashion and expressed advancement, modernity and a show of affluence and status in the social hierarchy. Recently, amidst these unsustainable practices earth construction has received greater attention as a building material that can be very affordable and still deliver the same modern needs [14].

While tropical architecture that evolved around the mid 20th century paid emphasis on climatic conditions in the design of housing, this article suggest that current attention should be on enhancing the suitability of indigenous architecture in providing affordable and energy efficient housing. The cost effectiveness, energy efficiency, sustainability, and availability of local resources (like mud, bamboo and timber) call for re-adoption and re-integration of the indigenous values of housing provision in Africa. Acceptance and wide use of these suitable, climate responsive resources, with simple designs for residential buildings, is therefore paramount to African development, in terms of sustainable mass housing. This will require a rethinking of commitment to cultural identity in Africa. A holistic commitment to cultural values could help achieve a sustainable African society.

The three well-defined materials that are prominent in the building traditions of Africans are; stone, straw and earth which have been independently and jointly used and skillfully applied. In actual sense, in the history of its architecture, diverse areas to great extent have used materials peculiar to
them based on their availability and the developed technology of its artisans. Remarkably, irrespective of the materials used, their technologies have been advanced, developed and grasped with such ingenuity, substantiated by the remains of ancient cities and other archaeological sources. The very few structures that have lived through centuries of human dwelling, present lack of maintenance and abandonment clearly explains that, if they had been appropriately used and maintained, they would have served for few more centuries; a major quality in sustainable building practice indeed.

A. Straw/Thatch Architecture:

Various natives of Africa took to straw/thatch as a construction material in a comparable way choosing to great extent the appropriate materials for the most suitable use. In contrast to stone which is not easily renewed, straw/thatch is a byproduct of grown plants hence, a cultivated material. Even though, large quantities of this material could be sourced from the immediate surrounding and the wild, the villagers cultivated much of the straw as cereals in their farms which in turn provided them a building material. Although, large numbers of stone ruins remain, indicative of a predominant stone use, straw has in most case being used with adobe bricks or masonry walls or singularly. Even today nomad tribes within this region still use this form of construction. Straw construction uses matted or baled straw from wheat, oats, barley, rye, rice and others as walls or covered by earthen or lime stucco. Straw bale are traditionally a waste product; it is the dry plant material or stalk left in the field after a plant has matured, been harvested for seed, and is no longer alive. Two fundamental styles of straw bale construction have and it’s being used: wooden post and beam construction with straw bale infill, and structural straw bale construction.

B. Adobe Architecture:

Although stone architecture of historic periods have left remains for display, very little of adobe/earth/mud brick architecture have lasted, apart from some of the monuments, temples and mosques. Nevertheless, the enduring cultural practice of the rural people indicates that adobe surely has been one of the most common and abundantly obtainable materials that influenced and sustained the rural villages as a part of the environment which connected it to the cyclic and delicate eco-system responsibly and carefully, while using its resources and occupying the areas responsibly created. Local earth technologies of Africa have spanned form the employment of raw-earth, to refined earth brick. Generally employed was wattle-and-daub earth technology; a method in some cases which uses solid wooden post frame which is first made then filled with adobe balls to create a wall. Most often, the African builders construct the walls of their building layer by layer using the mud bricks and a slurry mixture of earth as the mortar. Once the wall dries up and binds into a monolithic structure, a dense mud plastic plaster strengthen with various additives depending on the people’s culture (cow dung, goat dung, beaten straw, animal hair, animal skin fat) was spread on by hands to smoothen the facade. This method had been used in building even the granary storage houses. The materials having being gotten from the environment, and the work force having been made available by the community, certainly made it a highly sustainable practice, that utilised small amount of energy and did not generate any greenhouse gas or harmful waste. As soon as it is plastered and properly covered with overhanging roofs, these earth buildings were structurally firm, environmentally sound and could exist for years as long as the day to day maintenance was adhered to. Africa’s socio-cultural practices had ceremonies and events integrated in them that guaranteed their renewal and maintenance thus ensuring the continuity of those sustainable building practices.

VII. COMPRESSED EARTH BLOCKS (CEBs): THE RECREATION OF EARTH BUILDING METHODS

Lately, the ushering of CEBs has caught the interest of many architects searching for sustainable building technologies, and have committed themselves to the task of building with earth as a modern material. A few fascinating projects have come in place from urban houses to tourist hotels. Nonetheless, the technology that has become widespread in the new system of re-invented buildings is the Compressed Earth Blocks that makes unbaked earth blocks. Compressed earth blocks are a creative, re-engineering of the adobe brick. Unlike the native adobe block, which is a mixture of soil, water and distinct cultural additives moulded to desired shape with the hand, the compressed earth block is supplemented in very small amounts (in most cases less than 10%) with either cement or lime component in its blending process. The blend is not worked to achieve a plastic state, but simply blended until the cement/lime and soil are thoroughly mixed. Afterwards, the mixture either machine pressed or placed in a mould and compacted with a high level of pressure applied through a hand-operated machine. After aeration, the CEBs gain a high compressive strength appropriate generally for three floors constructions but higher potentials can also be attained for up to five floors constructions [15]. Combining it with other contemporary technologies have ensured that earth buildings do not necessarily require dome vaulting and other forms of this nature, which are associated with earth constructed buildings [16]. These blocks; CEBs can be left un-plastered or covered with plaster or can be coated with watered earth (muddy plastic mixture), sometimes added with natural colouring. Its facades in comparison to the contemporary urban houses offer a feeling of a cooler interior in fact, the inside temperature is lower than many cement block houses.

Green innovations, beside the objective of mitigating climate change, have impacts on various issues that include social-economic, political and technological developments in Africa. It is imperative for developing countries to enhance their developments by concentrating on indigenous practices and values, in order to enhance the economy.

A. Economic Implication

Studies reveal that building materials generally constitute a large proportion of total capital investment up to 80% of total value of construction. [17], while arguing the
The contribution of building materials in economic development, asserts that:

The sheer size of its contribution to the economy and the positive correlation between construction and GDP observed in countries whose GDP per capital increased at fast rates means that the development of construction and building materials industry can enhance the economic development in general. The use of local materials and building methods will cut costs to its barest minimum. The impact of green technology on the state of economy observed from the standpoint of cost saving/effectiveness is immense. Household revenue in terms of disposable income increases as housing expenses reduce. Maintenance cost and general bills are minimized. Percentage of house ownership will increase as well as optimization of the national domestic economic performances. Entrepreneurship and multiple employments will result as well as improvements of occupational and institutional productivity, while poverty alleviation is enhanced. There will also be shaping and expansion of market opportunities for green products e.g., circulation within the system, and exports. Considering all factors, green designs within the indigenous framework would help the nation achieve this singular objective of economic prowess.

B. Political Implication

Regulations and related legal issues pertaining indigenous technology come to play by government agencies. Government in various levels-local, state and the federal could monitor various developments within their jurisdiction that guarantee public interest. All through the nations’ regions, there are certain legal regulations to follow whereby local materials and prices are controlled. By so doing, the objectives of these developments could be realized. Government’s initiatives will go a long way to implementing policies that are capable of promoting green technologies. It will formulate a basis for regulations and the application of policies that would lead to development.

C. Socio-cultural Implication

Improvising green technology in buildings in Africa would lead to an improvement in the overall quality of life. Its occupants admire the insulating property of mud for the comfort of living in a natural, eco-friendly building. Available, affordable, organic and safe buildings, which take care of basic infrastructural needs, like clean water, solar powered (energy)-electricity, and safe environment are what society requires for sustainability. Change in cultural value system is observed in the sense that the shared practice of indigenous potentials is given an expression, which is approved and rewarded accordingly. It is an added value for the cultural system as people become proud of their culture. This will find further expression in the people’s satisfaction with their met needs. It revitalizes indigenous practices. Awareness is enhanced as society advances in profitable adventures bringing about productivity through green-indigenous technology. It spurs morale and creativity, while ensued healthy competition results in a revolution.

D. Technological Implication

The United Nations Environment Programme's Atlas affirmed that "in rapidly globalizing economy, access to scientific and technological information has a critical role to play in sustainable development"[18]. Innovations in science and technology have brought major advancements globally. New discoveries in technology would make tremendous contributions towards sustainability, while making local resources integral in development processes would facilitate innovative ideas in developing countries. The Nigerian Building and Road Research Institute (NBRRI), which integrates applied research and development (R and D) in the building and construction sectors, is making tremendous improvements towards indigenous technology on local building construction. However, larger scale efforts by the government and stakeholders would be needed to enhance conspicuous developments in local technology. Green technology will promote research findings and advance educational values, as researchers, given adequate supports, would go extra miles for new discoveries. Indigenous technology will result in industrialization of Africa.

E. Environmental Implication

Environmental protective measures ensure reduction of operational energy in construction. Green developments’ eco-friendliness, climate responsiveness and organic protective measures safeguard as well as minimize environmental impact of hazards. Healthy in-door and out-door environment is secured. The thermal insulation, energy saving of green buildings and green roof’s ozone pollution reduction capacities all reduces negative environmental impact. Extensive use of recycled materials help conserve, restores, and preserves the eco-system. Green buildings’ waste management ensures resources and energy efficiency. The proximity of materials saves cost and reduces pollution by fuel burning through transportation.

VIII. Conclusion

The gradual return to traditional technologies within the conventional architectural practices in Africa has emerged as a result of the world call for proactive steps in managing the earth’s resources. It still behooves on architects of the continent to explore all the options available to be creative. Consequently, many need to return to local materials and technologies like the late Hassan Fathy who being innovative re-invented a number of traditional technologies to cater to the modern housing requirements. In many instances, the re-invention is not so much in the material itself, but the methods in which the material and its products are utilized for creating architectural splendor in structures. Really, these innovations are important in that collectively, they have evolved a methodology to architecture that is supported on the vernacular and traditions of the African building custom. It is necessary for African architects to stick to this approach and adopt the attitude and expertise on how to use materials and technologies of the past and re-create them for the contemporary world in a sustainable manner.
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