Urban Design: Energy Efficiency from Vernacular Architecture- Case Study of Kano City Northern Nigeria

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Abstract
For decades the architectural community has had a steady and continuing interest in traditional and vernacular architecture. This has been revived by the need to develop an architecture, planning and design that works with climate, in order to create more sustainable buildings. Most of earlier researches and prevailing publications on traditional and vernacular architecture have followed an anthropological approach, while works on climatic design and sustainable architecture incline to refer to current principles and models without direct reference to traditional and vernacular experiences. Similarly, where academics do address vernacular architecture, it usually involves historic documentations. This study adopts a methodology that carry out analysis, using study of energy efficiency of Hausa vernacular architecture and contemporary urban buildings based on field investigations an unobtrusive observation. The basis of this study hinges on the question: Will applying concepts from Hausa vernacular and traditional architectures help address the increasing energy consumption in today's modern urban Nigerian architecture? Thus, the study takes lessons directly from traditional and vernacular architecture of Hausa land of Kano state in North West Nigeria which aimed to offer to architects as guidance and inspiration for new and future buildings in an urban context. The appropriate technical, cultural, religious and social solutions provided by vernacular and traditional architecture in terms of energy efficiency in planning and design were analysed in detail. Indeed, the major findings include making urban building resources and energy efficient. It also contributes to making an attractive and unique contemporary image for a typical traditional urban built environment. Some of the recommendations comprise the intervention of the regulatory planning agencies to ensure the inclusion of the basic vernacular strategies discussed in this paper. There is the need for public awareness through especially, the media.

Key words: urban design; energy efficiency; vernacular architecture; courtyard; tropical climate

Introduction
During the historical period in the 18th-19th centuries, Kano state in Hausa land North-West Nigeria was the centre of commerce and intersection of a variety of cultures, knowledge and civilizations (Adamu M 1978). These cultures and civilizations, coming mostly across the Sahara, carried new building forms and concepts merged with local traditions to evolve what currently is known as Hausa vernacular and traditional architecture. According to Gordon, et al. (1998) changing climatic setting and raising temperatures are likely to subject nearly 70% of the poor and middle-class urban populations in Nigeria to thermal discomfort in their residences and places of work. According to Rodrigo (2015) half of the total energy produced in the developing world is used to heat, cool, ventilate and control humidity in buildings, to meet the increasing thermal comfort demands of the occupants. In similar terms, Givoni, (1998), observed that buildings are

large consumers of energy in all countries, especially in regions with extreme climatic conditions and a substantial share of the energy goes towards heating and cooling of buildings. Though there are multiple ways of reducing the heat and air-conditioning load in the buildings, notable among them are proper design and selection of building envelope and its components. Today, sustainable design, energy and new technologies in building are fundamental to the profession of architecture. With the ever-growing global concern for the use of sustainable energy and resources and accompanying climate change, architects have a greater responsibility to design buildings that are environmentally sustainable. Again, the increasing and unprecedented growth in population considering Kano state in North West Nigeria there is therefore, a projected demand for a higher growth in new construction activities especially in urban areas. However, due to rural to urban migration, it is evident that there will be a massive increase in the number of houses to be constructed. Not only the performance of these new buildings must ensure a comfortable and healthy atmosphere for their occupants but also the carbon emission from the buildings must be addressed using sustainable strategies.

Presently, in almost all urban centres and semi urban areas in Nigeria, there has been a reliance on energy-consuming technology in the form of cooling, ventilation and lighting systems to achieve human comfort in the interior of buildings. Unfortunately, these systems are often installed after the design, layout and materials of the building have been decided. It therefore, indicates lack of sufficient foresight and proper planning and design. This means there are deficiencies in the planning and design of buildings. It would more so, make the system costly and inefficient and consequently, increase energy consumption and carbon emissions of buildings. The consequences are often drastic for the occupants in terms of health and thermal comfort. However, according to Waraporn et al (2013), wrote that building energy demand could be reduced by as much as 28% through the use of low thermal conductance material alone for a building wall. It is therefore essential to study and understand the environment and the context of buildings and to perform a climatic classification of the region where the building will be designed and build, since the evaluation of thermal performance, energy, acoustics and luminosity is directly related between the built environment and the external environment. According to Givoni (1996) to evaluate the thermal performance, it is necessary to know how to vary the air temperature, the relative humidity, the direction, the wind speed and solar radiation not only along the seasons, but also their time strings. Vernacular architecture leans towards responding to undesirable climatic conditions using passive, low-energy approaches to provide for human comfort strategies that are fundamental to design, building form, orientation and materials of construction.

The Study Area

Located in the North West geopolitical zone of Nigeria, Kano state was created out of the defunct Northern region on May 27, 1967. Historically, Kano can be traced back to the 7th Century AD when migrants came in search of iron ore which they used in manufacturing farming implements. Kano State has 44 local governments and a land area of 20,131km2 with an estimated population of 11,056,300, according to the 2011 census. The Capital of Kano is Kano, and it borders Katsina State to the North West, Jigawa State to the North East, Bauchi State to the South East and Kaduna State to the South West. Originally, Jigawa State was part of Kano until it was made a separate State in 1991. Predominantly, the indigenous ethnic group is Hausa, although, there are other ethnic groups like Yoruba, Fulani etc. The major religion practiced is Islam, representing 98%; Christianity, 0.4%; others, 1.6%. The Hausa tribe are perhaps the most populous and among the most significant ethnic groups in Western Sudan. In Nigeria alone, Oumar (1997) wrote that, they number about 30 million in 1990, and there are substantial populations

in other West Africa countries, such as Niger, Ghana, Cameroun, Benin Republic and Chad. The Hausa language as the spoken language in the whole of Africa apart from Arabic, English and French. Furthermore, the Hausa have been famous for their architectural forms; their construction techniques, their wall structure and decorations (Oumar, 1997). The ordinary domestic or residential house is the dominant form of Hausa architecture as found for instance, in the old walled city of Kano. However, to date there is no serious, comprehensive study that deals in depth with the energy efficiency and its performance in the architecture of these important people. Most of what is known about the architecture of the Hausa people is largely generalized work with some aspects of architecture from other disciplines.

However, it is significant to realize that the domestic architecture is crucial to understanding any civilization. There is therefore the need to investigate deeper into the civilization of this group of people. One way of doing this, is through an understanding the details of their architecture, in terms of its energy performance.

Traditional Layout of Settlements of the Hausa People in Kano inner city

The vernacular dwellings in the inner city of kano for instance, stand very dense and the residential areas are often built around a narrow street from where dead-end alleys might not go through. Usually, along these alleys are clusters of dwellings. The vernacular Hausa dwellings are mainly known as houses with central courtyards ('Tsakar Gida'). The houses are built with indigenous available material and resources. The central location of courtyards is very important and where, all rooms are surrounding the courtyard. Almost all openings in the house are towards the courtyard and there are usually no or very few windows facing the street, in order to keep it as private as possible and to minimize the risk of strangers looking into the interior of the rooms thereby violating the privacy of the occupants especially, women. Another thing is that it also prevents wind-blown dusts and sun radiation into interior of the buildings.

Another factor is that the orientation of the entrance hall (Zaure). The size and location of the 'Zaure' are often angled to minimize not only the view from outside into the inner courtyards where the women usually relax and perform most household and domestic chores. It also reduces the heat from the sun radiation getting into the interior of the Zaure. It is as described by Adamu-Tal (2005) an embodiment of the expression of beliefs, power or status among its functions. Thus, it plays a symbolic role in a total spatial system of decorative elements, within its interior and exterior surfaces, serving to reinforce the social structures and the religious beliefs of the inhabitants.

Another lesson from the traditional architecture is that the use of the rooms is often non-explicit and can be used for various purposes such as relaxation, meetings and eating meals. For instance, the Zaure function as reception area for male guests and strangers. It also serves as sleeping area for boys and even male strangers. Often it is used as qur'anic school. A lesson to be learnt from the traditional architecture in terms energy efficiency is the few windows on the building facades that are facing the street which are small and are placed high up, so people on the street would not be able to view the interior of rooms. In addition, it also does not allow heat from the ground surface to reach the interior of buildings. This strategy usually, result in a facade that is very simple, with high walls to minimize visibility and rising heat and temperatures from the street. Thus, the small sized opening facing the street lets in light and air, and in dry and hot climate, the opening is important because it modifies the indoor climate and contributes to natural ventilation. The much wider window openings facing the inner courtyard also serves as protection from the sun and wind storm, because the walls are quite high the sun's rays doesn't reach the courtyard until the afternoon and then the warm air rises,

and convention is created which ventilates the inner rooms. However, studies such as (Harrouni, 2002; Gordon, Talbot, & Simonis, 1998) have shown that the opening above in the inner courtyards can be positive, especially in hot and sahel savannah climates. In tropical savannah climates, such as in the North West, the temperature in courtyards can be lower than outdoors because there is more wind movement and it can become airy inside the house (Harrouni, 2002; Gordon, Talbot, & Simonis, 1998). Givoni (1996) recommends that the facade should faces the prevailing winds at least an angle of 60 °, so that ventilation is captured. The openings positioned leeward are used as output ventilation, thereby promoting the ventilation cross effect. Therefore, the results showed that the speed of the internal flow is not directly related to the size of the openings. In addition to the different size of the inlet and outlet openings, smaller inlet openings towards the outlet provide higher air velocities. Thus, Givoni (1996) wrote that the following recommendations are to be observed in the hot tropical region:

a) ***Analysis of the building in relation to solar orientation and prevailing winds in the region:*** Buildings should be elongated in the east-west axis, so that the smaller facades are oriented east, west, north and south to larger and the prevailing winds from southwest to cross the building.
b) ***Study of sun exposure on building facades and sun protection elements:*** The facades and openings should be protected from solar radiation, with the use of sun breakers, pergolas, eaves, canopies, balconies or other protective elements against solar radiation.
c) ***Analysis of natural ventilation of indoor environments***: the position of the openings must allow cross ventilation in indoor environments where the internal temperature is higher than the outside, to ensure the thermal comfort of users and the withdrawal of hot air. The openings in the higher parts of the buildings remove the heat by natural convection, improving the thermal conditions in the interiors. The openings should be small, with an area between 10% and 15% of the floor area.

For openings, it is recommended that no windows in the east and west facades, thus avoiding sunlight to penetrate at low sun angles into the interior of buildings. In addition, openings should be considered important control elements with respect to ventilation and radiation. At night time, when the outside air temperature is lower, the small window openings can vent the interior of the buildings to cool it. On the other hand, during the day, when temperatures are higher, it reduces much ventilation to prevent internal heat environments. The orientation of openings in relation to the prevailing winds may help ventilation. As for radiation, the openings are also important elements in the control of heat gain. Glazed windows and openings can provide heat gain due to sun radiation, and if not appropriately protected, can cause an unwanted increase in temperature. The protection may be made through internal and external devices, such as sun shading strategies. However, external protection is more efficient to block solar radiation before penetration. However, there is a non-controllable air entrance known as infiltration. The air infiltrating the building is a function of penetrability and the change in pressure around the building envelope, due to the temperature difference of indoor and outdoor air and wind values. Infiltration is the air entering the room through cracks in the walls, roof, pipes, and even openings, which even though sealed, do not achieve total insulation. In artificially air-conditioned buildings, infiltration may be the principal cause of heat gains, thus influencing the increased power consumption.

The inner city of Kano state which is in Savanna region has a tropical climate with four separate seasons. The wet months are hot and humid with a typical temperature of 32°C. The wet season is mostly cloudy, while the dry season months are cold and dry with an average temperature of 21°C. The annual average temperature is about 16°C and the relative humidity varies from

20 percent to 40 percent. South-westly winds characterize the rainy season, thus bringing breeze and high humidity from the ocean, as well as rain for part of the season. North-eastly polar winds bringing cold, chill and harmattan characterize the cold and dry seasons.

Vernacular Materials and Construction

Vernacular construction in the inner city of Kano is characterized for example, with thick masonry construction with small window openings, a characteristic which, can provide daytime indoor temperatures cooler than outdoors on these two features alone, thus helping such buildings well in the hot seasons of tropical climatic region. In fact, what usually happened is that the thick masonry wall would reduce the rate of penetration of solar radiation into the interior of buildings during the daytime. This makes the building's interior to be cooler. While, the small sized openings reduce glare from the sun and minimizes the entry of harmattan dust getting into the interior of rooms. In dry season, however, the mean daily outdoor temperature hover around 13–17°C. Givoni (1998) observed that the small windows and thick masonry walls are at a disadvantage as they jointly prevent indoor temperatures from rising much above these values, which are below thermal comfort range considering the cold dry season. Thus, the objective of this paper is to achieve acceptable indoor environmental conditions for occupants by using sustainable strategies with the least expenditure in energy and materials, replacing non-renewable energy sources with renewable ones and doing away with environmentally unfriendly processes and materials. Materials such as clay, fired bricks, timber and stone are natural materials with good thermal properties. These materials could be applied as building components in the construction of contemporary architecture in cities and urban areas.

Given the above explanation, it is recommended by (Saad 1986) that for buildings in the tropical climate to use light colours on the outside walls, because they reasonably reflect solar radiation, as compared to dark hues. Thus, white colour can greatly increase the comfort of environment conditions, to increase the thermal mass of the wall, since it slows down the passage of heat flow to the indoors. It is also necessary to analyse the building rooftops. This element receives maximum solar radiation in low-latitude climates because the sunlight in this case falls almost perpendicular to the Earth's surface. Therefore, it is important to provide a suitable structural solution and the use of material with less thermal capacity. That is material with absorption coefficients and emissivity reflection, such as materials made of asbestos, resulting in a heat fluctuation attenuation into the building envelope.

The urban setting

The two fundamental issues of importance in the evolution of Hausa architecture, apart from the local resources, were the traditional concepts of privacy and the view of women's role in the family and in society. However, Adamu-Tal (2005) observed that these concepts were the results from Islamic prescriptions. Indeed, these concepts and prescriptions led Hausa Islamic urban morphology to have a three-layered organization: private, semi-public and public. Initially, houses were single storey in order to respect and reflect the religious notion of equality between people in society. This influence is still visible today in the inner city. The consistent height of the houses can be linked to the refusal to waste one's abundance and to respect individual privacy of neighbours. It is among the Islamic prescriptions that it is immoral to show off one's richness and it is avoided as a sign of respect for the neighbourhood and the community that might be offended. However, some rudiment of class was developed. Consequently, the evolution of Hausa society and its key classes, as it were, was directly translated into the architectural language. The poor continued living in the simple cubical structures, with minimal decorative features, while the rich, depending on their social and financial

standings occupied mansions which are richly decorated.

However, the colonial era, has affected modern and contemporary architecture to a large extent. A new settlement was built at the outskirt of the old city during the colonial rule, called Government Reservation Area (GRA) which resulted in strong colonial influences in the modern areas of the buildings. Much of the colonial culture persisted even after Nigeria gained independence. In the modern areas there are wide avenues and high-rise buildings, and the modern houses often have large windows or entire glass facades. It can be observed that many of the buildings have not only colonial design, but sometimes also some concept of vernacular details such as courtyards and the use of local building materials. One alien development in this area is that buildings are fenced with high solid wall with a gate. The language here is to warn uninvited visitors that they are not welcome.

Fig.1; showing an integrated conceptual approach. 'Gidan Makama', Kano city
Source: Sokoto caliphate ; htt://www.skyscrapercity.com/search (2011).

Cooling Techniques

Solar radiation is quite intense in Kano, especially in hot seasons usually from months of March--June when clouds disappear for some months. The nature of outdoor and ground surfaces, in the inner courtyard usually, reduce the solar load on indoor spaces. However, at the same time, outdoor areas can become too uncomfortable due not only to solar heat coming from the sun, but also to heat reflected from the sunlit surfaces nearby, especially the hard-lighted surfaces. Discomfort is increased by the blinding glare and the heat released from the heated surfaces. It is often the South West winds that usually bring relief, provided they are not too strong. Furthermore, water scarcity and the strong winds prohibit the growth of plants. For those reasons, solar protection in outdoor spaces was offered only by the shade of adjacent buildings or free-standing walls. Walls were also often used for wind protection. With such harsh conditions outdoors, it was only the indoor spaces which offered comfort in daytime. Walls are made to be heavy of mass mud and clay materials with low radiant temperatures. This strategy delays the process of the penetration of the sun radiation into the interior of rooms during the daytime.

Heating Strategy

At the beginning of cold season, the effects of reflectivity of the ground and wall surfaces is reduced by accumulated dust and moving sand from the desert. Solar heat would be welcome, but the small windows do not provide much solar heat indoors. Occupant thermal comfort must be achieved by other means as cold season is rather chilly in the city of Kano, also dry and windy. The only fuel for space heating and cooking was in the method of bush branches and fire wood, meticulously picked from the countryside. These items are commonly used to light a fire which keep the room warmly comfortable. However, due to the large heat capacity of the earth that dampens down diurnal and seasonal temperature

fluctuations, a satisfactory level of thermal comfort can be achieved in the indoor dwellings during most of the cold season, reducing the need for extra heating that is required mainly to lessen discomfort caused by dry winds. The small openings minimize heat losses, a vital benefit and at the same time they decrease natural light in the interior, where oil lamps and candles were left to provide the only light sources. Again, the massive solid walls delay the outward movement of the heated interior air. This continue to maintain the room temperature for comfort living.

Domestic water and Sanitation

Before the advent of bottled water, water borehole, water tankers, domestic water came only from the sky as rainwater, from wells, rivers or streams. Thus, rainwater collection was a key factor in the general layout, orientation and form of each building. The typical dwelling had one or more containers where rainwater was collected from roofs. Stored water was kept and used for domestic purposes. Alum was often used to disinfect the water which had to remain free of animal droppings and any impurity. The washrooms and toilets were built away from the main living areas, usually far away from the living areas. The toilets were usually pit latrines. They require less or no water at all. This help to maintain heath and sanitation of the occupant and the dwelling.

Recommendations

Therefore, an approach to design where building technology is integrated with conceptual planning and design has the potential to reduce the use for high-tech systems and decrease the energy consumption and consequently, the carbon emission of buildings thereby reducing the severe effects of global warming. Thus, planning authorities should ensure compliance by urban built professionals to introduce and integrate modern and traditional technologies and strategies in their design proposals.

Conclusion

What lessons could vernacular and traditional Hausa architecture continue to hold for architects? The paper particularly identified certain materials such as clay, wood, thatch materials and stone with good thermal properties with a potential to be incorporated in different parts of the building envelope to enhance thermal comfort. For instance, light colored external surfaces, reflective paints, window treatments and roof gardens as preferred options to help reduce the heat load of the building. Thus, the paper shows that there are ways in which vernacular architecture continues to be of direct and practical interest for architects and students of architecture today. Again, sustainable design approaches and techniques focused on improving occupant comfort with minimal energy use have always been an important component of traditional architecture especially in Africa. Unfortunately, these energy-saving lessons have not been extensively adopted or applied in new construction or renovation projects in Nigerian urban centres. Rather than learning from the extensive past in architecture, builders are creating unfortunate reproductions of imported architectural techniques that are not appropriate for the prevailing climatic and cultural conditions in Nigeria. Most present-day building materials involve large amounts of glass, and rely heavily on mechanical cooling and lighting system, all of which can lead to an increase in the energy consumption. The vernacular architecture is in fact the product of a long struggle for survival in an adverse environment by generations who have managed to squeeze their means out of the available natural resources in a sustainable manner. However, with increasing challenges from climate change and global warming architects and other practitioners and generality of populations in cities in Africa will do well to rely on local strategies to achieve comfort in buildings.

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