AN ASSESSMENT OF BIOCLIMATIC DESIGN PRINCIPLES IN OPTIMISING ENERGY EFFICIENCY IN DESIGN OF STATE CONVENTION CENTER, KADUNA

BY

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MARCH, 2015

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NIGERIA

MARCH, 2015

DECLARATION

I declarethattheworkinthedissertationentitled**'AN ASSESSMENT OF BIOCLIMATIC DESIGN PRINCIPLES IN OPTIMIZING ENERGY EFFICIENCY IN DESIGN OF STATE CONVENTION CENTER, KADUNA'**,hasbeenperformedby mein theDepartmentofArchitectureunderthesupervisionof**Arc.M. L Sagada(PhD)** and **Arc. R.B Tukur (PhD).**

Theinformationderivedfromtheliteraturehasbeenduly acknowledgedinthetextandalist ofreferencesandbibliography isprovided.Nopartofthisthesishasbeenpresentedfor anotherdegreeor diploma anywhere.

Faruk jaafaru

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CERTIFICATION

This dissertation entitled" **'AN ASSESSMENT OF BIOCLIMATIC DESIGN PRINCIPLES IN OPTIMIZING ENERGY EFFICIENCY IN DESIGN OF STATE CONVENTION CENTER, KADUNA'**"by Faruk,JAAFARUmeetsthe regulations governing the award of the degree of Master of Science of Ahmadu BelloUniversity,Zaria,and is approved for its contribution to knowledgeand literarypresentation.

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DEDICATION

Thisresearchisdedicatedtotheapexof celebrity, ProphetMuhammad P.B.U.H,tomy blessedparentsLate Alhaji Jaafar Ibrahim (Mai Iyali)andMalamaAmina Muhammad,tomy spiritualmentor Mallam Aminu Adamu (Dan nepu)andmy entire family members andbeloved friends–May Allahrewardthemabundantly andgrantthemfreeaccessto His templeof devine mercy,Ameen.

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ABSTRACT

Technology istakingovereveryaspectofhumanendeavorincludingarchitecture.Thus buildings are beginning to lose their architectural characteristics relative to their external climatic factors. This creates unfavorable comfort conditions within the building making it unbearable for the users without use of artificial means.

It has also been succinctly noticed that, building sector is responsible for a significant percentage of the total natural resources depletion and energy consumption as well as emission of household waste and toxic gases at global level. This was found to be attributed to the current development devoid of local considerations. The contemporary practice is projected to increase geometrically considering the rate of urbanization and industrialization. Based on the recent ultimate aim of reducing the environmental burden caused by the building sector in order to save the planet earth for the future generation. Many pragmatic measures have been made to evolve strategies that will upgrade the energy of the existing buildings and proper planning of the new structures as well as managing the natural resources.

Understanding the climate within and around the building offers the great chance of remodeling the current practice to save energy and other natural resources. Since climate varies, bioclimatic design provides the basis for a regionally distinctive architecture that is able to challenge globalization of architecture and technology to create a comfortable environment and reduce energy and resource consumption. The concept capitalizes on the characteristics of the site and climatic elements, modifying and harnessing them in the most natural way possible.

The methodology employed case study research approach and review of relevant literatures. Visual survey results of the buildings studied were documented out of a checklist drafted using the bioclimatic design principles to ascertain the nature and level

of application of the principles in regions having similar climatic characteristics with the region under question. Other buildings were considered to explore the nature of facilities, user space needs and activities in a convention center. From the inference emerged a design proposal for a state convention center Kaduna using the principles of bioclimatic design to evoke an architectural piece sensible to the environment climatic factors. This is done to optimize the energy consumed in the center and to create a unique building peculiar to the people's architecture of Kaduna state. These are among the critical contemporary trends of convention center design which the proposal will attempt to address. Finally, some of the recommendations are that ;(i) buildings should be designed to fit into its environment without been affected by the unfavorable climatic elements. Unfamiliar forms and international architectural technology should be minimally incorporated in designs. (ii) Energy efficiency measures should be actively considered to reduce consumption which is the current trend of architecture globally and to compliment the epileptic power supply in the country. Lastly, research in the field of sustainability and renewable energy should be one of the utmost priorities of the architects and other allied professionals in the construction industry.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Space creation is a key to architecture and a problem as well, because of its complexity does not have a precise general method of resolution (Lobos, 2010). This has affected the way architects design and conceptualize buildings. The activities taking place in a building determines the nature of space and building type.

Convention centres requirement and activities vary from one place to the other depending on the nature of the people (WHRS, 2011). However, there is a dramatic change noticed in how convention centers work, this change has been driven by rapid innovation, technology, globalization and ongoing demand of space quality (McQuade and Buford, 2006). The current trend of convention centers is accommodating large number of people engaged in different activities thereby generating a lot of heat resulting in thermal discomfort in the interior spaces. This has posted a challenge of energy efficiency for convention centers making it difficult for the users to achieve comfort without huge amount of air conditioning systems (Jhaveri et al, 2010). This is attributed to the nature of the building planning and adoption of international styles devoid of local climatic considerations of the building surrounding.

Roaf (2001) opined that, the driving force that act upon buildings to create comfortable space and shelter is climate. (Agboola, 2011) pointed out that, climate and weather are the major environmental factors directly affecting building form and design. Buildings are supposed to be modifiers of microclimate, a space isolated from the climatic temperature and humidity fluctuations and sheltered from other environmental elements (Olanipekun, 2002). This means building should take into account the climatic conditions of the location it is for optimal comfort to be achieved.

On the other hand, it has been noticed that, buildings are significantly contributing to the environmental impact resulting into global warming and greenhouse effect (Sassi, 2006). This is because of the constant modification of the climate resulting from the accumulation of microclimatic exchanges between impermeable surfaces, buildings and the surrounding environment. Thereby producing more CO 2 gas, generating pollution, consume more energy and waste more natural resources (Suzer, 2010). Considering the current issue of sustainability emerging in architecture, buildings should be designed to be energy efficient, reducing environmental impact and providing comfort through natural means. According to Lawal (2008), this can be achieved through introduction of climate responsive design parameters. These parameters are based on a way building form and structure naturally moderate the climate for human good and wellbeing (Michael et al, 2010). Buildings meeting up the above requirements are said to be bioclimatic responsive (Ajibola, 2001).

Bioclimatic design makes most of the climate including sun, wind and rain to design a comfortable building that works passively to heat and cool indoor space and even light the building (Susie, 2011). The design approach uses the energy of the climate of the locality to create condition of comfort for the users at low energy cost (Yeang, 2001). Talking about the recent quest of saving environment for the upcoming generation from impact by human activities and buildings. The recent convention centers are focusing on the green architecture improving recycling, environmentally consciousness, and energy saving heating, lighting and air conditioning (Sue, 2007). This has been in practice in some developed countries using environmental conscious and energy efficient designs. This study tend to employ bioclimatic design principles in solving this problem as it is perceived to be the architecture adopted to the environment which does not cause any sensitive impact in nature, and it seeks to minimize energy consumption and pollution.

This will contribute in suggesting measures in addressing the issue of environmental impact as well as energy efficiency in Nigerian architecture.

1.2 STATEMENT OF PROBLEM

The energy consumption in buildings is quit high ranging from the production of materials to the construction process. According to world watch institute, buildings consume about 40% of the world's energy production. On the other hand, it was also estimated to reach about 50% of the global energy (ERG etal, 1999).on the other hand, buildings contribute about 40% of the sulphurdioxide and nitrogen oxides, and 33% of annual carbon dioxide. This is expected to further increase because of improving standards of life and increasing world's population (Muhammad, 2012). Therefore, Energy saving is particularly important to protect the environment and to reduce emission from the building. The imperative of reducing greenhouse gases emissions has stimulated interest in the design of low energy buildings (Kevin, 2006). Buildings that will make climate optimal for human comfort, energy saving and reducing environmental impact. However, this has not been the practice in most cases of the contemporary architecture in Nigeria.

It has been observed from recent study that, Virtually most of the public buildings, industries, hotels and convention centers largely depends on mechanical means to achieve a favorable environment for human comfort (Roaf, 2001).this is the result of the in appropriate design decisions, choice of materials, and adoption of international styles of architecture, with minimal consideration of the local conditions. These are the key elements in the vicious circle that is creating global warming there by contributing to an environmental crisis which is threatening the survival of man (Wilson, 2002).

It was suggested by Roaf (2001) that, the way forward to curtailing this problem is bioclimatic design buildings that use minimal energy or energy from renewable source if possible.

1.3 RESEARCH QUESTIONS

I. In what ways do convention centres consume energy?
II. What principles of bioclimatic design can be applied in in a hot dry climate in designing a convention center to optimize energy efficiency?
III. How canbioclimatic design principles be applied in convention center design to achieve energy efficiency?

1.4 AIM AND OBJECTIVES

The aim of this study is to assess energy consumption in convention centers and how to minimize the energy demand through introduction of bioclimatic design principles. Thus; the objectives of this study are:

1. tostudy the concept of energy efficiency.
2. to investigate the source of energy consumption in existing convention centers.
3. toexamine ways through which bioclimatic design principles can contribute in minimizing energy consumption in convention centers.
4. to demonstrate the application of principles of bioclimatic architecture in achieving energy efficiency in convention centers.

1.5 SIGNIFICANCE OF STUDY

The research will first of all be important to the literature on bioclimatic design as it will contain recent information on the concept. On the other hand, in architecture, improving the comfort of the inhabitants of a building as well as reducing environmental impact is

the responsibility of the architect(Williams, 2007). However, the building industry have proved to be intensive energy consumers having direct impact on environment through use of raw materials, natural resources, production of pollutants and household wastes. Many efforts have been made to develop strategies that will lead to energy efficiency upgrade of existing buildings and the new structures to reduce the environmental burden caused by building sector. This thesis is trying to come up with a climate responsive strategy to achieve this thereby creating a building that will operate with far less energy than today's building at little additional cost at the same time improving the condition of the interior spaces. Owing to the fact that contemporary convention centers demand high energy supply which has not been met due to the inefficient power supply in the country. The thesis will take into account geographical location, orientation, natural ventilation, shading, and renewable energy making the building have use of active energy for economic viability. This will qualify architecture as a basic element of enhancing comfort and energy conservation for building inhabitants as well as creating solution to problems of environmental impact.

1.6 SCOPE AND DELIMITATION

The purpose of this research is not to focus on the study of all the problems that affect the smooth running of activities in convention centers, but to study literatures on convention centers at local and international level to address specifically bioclimatic design principles in the areas of environmental sustainability (microclimate aspect of the external environment) which are capable of improving the energy efficiency of the convention centers. Therefore the research involve field work inform of physical observation in similar buildings to ascertain the compatibility of bioclimatic design principles and energy efficiency in convention centers.

CHAPTER TWO

LITERATURE REVIEW

2.1 BIOCLIMATIC DESIGN

INTRODUCTION

In 1963 the term bioclimatic was used for the first time by Victor Olgyay. Among other achievements in bioclimatology, he developed aBioclimatic chart, which relates climatic data to thermal comfort limits, to identify designStrategies (Olgyay, 1973). So, bioclimatology relates the study of the climate(Climatology) to the human beings.

The development of architecture through history shows many relevant examples of responses to specific environment and climatic contexts, within the limits of the resources available, the technological advances achieved and the expectations of environmental quality. Although the relationship between climate, comfort and architecture has been a constant concern and buildings have responded to local specific conditions to a greater or lesser degree (John, 2007). The bioclimatic design approach implies an application of a logical sequence of analysis, the detection of appropriate strategies and the conscious environmental control in response to external impacts and rational use of resources. With this objective, the bioclimatic design strategies aim to take advantage of the favorable environmental aspects, while avoiding or moderating the unfavorable impacts through appropriate design decisions. It is argued that this concept, together with a rational procedure to select adequate strategies, allows the designer to optimize energy for occupants and users of the built environment (Goulart and Pitta, 1994; erg et al., 1999).If this approach is considered since the first design stages it has an even higher potential to save energy. Some of the key elements to be considered for successful implementation of bioclimatic design are shown in the diagram below:

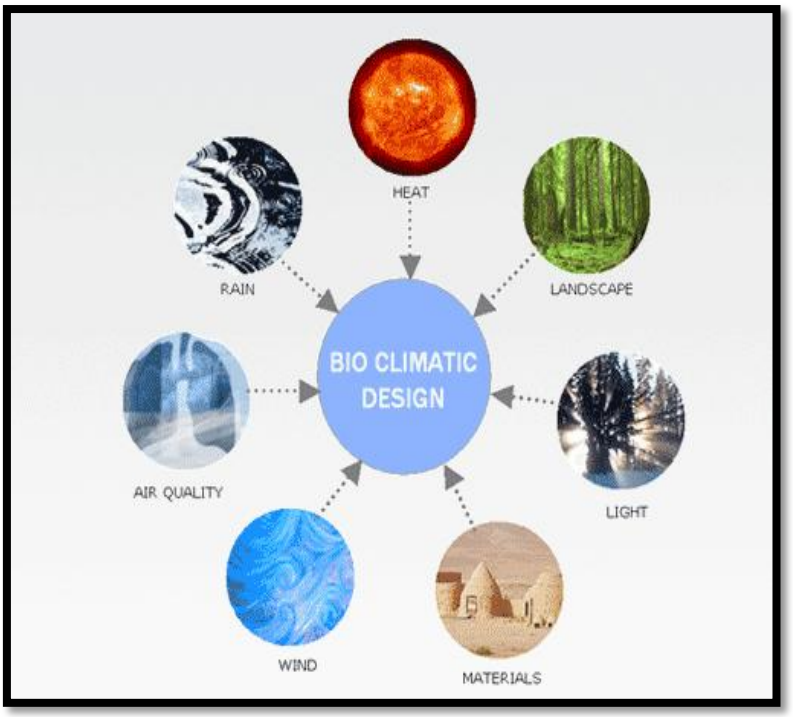


Figure 2.1 Bioclimatic Design. Source: (Googleimages.com/bioclimatic design)

Some of the concepts of Bioclimatic Designs are:

a) Site and climatic analysis,
b) Design strategies that reduce or eliminate the need for non-renewable energy resources and how these strategies specifically affected placement, orientation, and shading of the building (Susie, 2011).

Sergi (2011) lists 10 fundamental Bioclimatic Design concepts as follow:

a) Main facade face south which provides shade in the summer and sunlight during the winter time. The positioning of lower edges of roof are dependent upon the latitude of the building.

b) Home should be close to deciduous trees (trees that shed their leaves annually) which will provide shade in the summer.
c) Solid walls and materials allow greater “thermal inertia”-the ability of material to store heat and energy- which builds more heat to release steadily. A heat recovery ventilation system can be installed which includes: solar thermal panels, insulation, triple-glazed low-Energy windows, supply air, extract air, heat recovery ventilation system and ground heat exchanger.
d) Large glass should be installed in south side of house to allow solar energy to collect.
e) A thermo-wind self-suction hood should be installed in chimneys which expels fumes and excessive heat. It also prevents them being sucked back in to the home.
f) Abundant use of skylight and strategically placing them according to sun positions for best natural lighting. Skylights can light up hallways, bathrooms, attics and other rooms. Using hinged skylights allow the windows to be adjusted according to season. “Since they fold up and can be adjusted, when opened in summer they get rid of the hot air and create cross-ventilation,” (Sergi, 2011).
g) The use of natural insulation and breathable, waterproof materials for the roof.
h) Using local resources for building materials to cut down on transportation carbon energy.
i) Home’s electricity must meet a requirement of volts per meter. Synthetic and ferromagnetic materials should not be overused as they create electrostatic charges (Sergi, 2011).

In this case, the bioclimatic design is indeed specifically related to the understanding of local climatic features and to the application of passive strategies related to this understanding.

According to Givoni (1994), the term ‘passive’ does not exclude the use of mechanical equipment when necessary, if it is used to increase the performance of the system. Therefore, the bioclimatic design differentiates itself from what is called sustainable design. The sustainable approach is looked from the perspective of the impact of the building on the local environment in which it also embrace the embodied energy of the material and its durability and the use of water and energy. In the bioclimatic approach, energy saving and a lower environmental impact are consequences of the integration of the design solution to local climatic features to achieve better comfortable conditions and it is not necessarily limited by the building material. There is also the concept of solar architecture, which was “high-technologically” driven and mostly focused on thermal heating solutions. The term appeared after the oil crisis of the 70´s but gradually fade away because, such as Wines (2000) points out, the components of environmental technology were treated as “installed” rather than “expressed” elements of design. However, such as Tombazis (2000) says “there is no such thing as non-solar buildings. There are just some that are clever and others that are stupid.” The association of these concepts to building design since the first stages of the design process has an even higher potential to save energy while maintaining the comfort of their inhabitants. In the parametric evaluation of basic design parameters of four air conditioned buildings in Sao Paulo, Roméro demonstrates the potential of up to 12.1% of energy conservation (Alexandra, 2007).

2.2CLIMATIC CHANGE AND THE NEED FOR BIOCLMATIC DESIGN

The need to design with climate has always been a major consideration in architecture (Ogunsote, 2002). Olotuah opined that, the fundamental requirement of a pleasant architecture in Nigeria is established by the relationship between building and climate. Vitruvius pointed out the importance of climate in architecture in his book “Ten books on

architecture". In establishing the relationship between buildings and climate, olanipekun (2002), identified building as a modifier of the microclimate. On the other hand, it is perceived to be the physical shell that protect people from adverse climatic elements (Abigbola, 2000). This means buildings should take advantage of the climate and provide comfort conditions for the users without causing impact to the environment.

One of the most critical challenges now facing designers and one of the aspects that must be actively considered is the problem of climate change fueled by greenhouse gas emissions. Carbon dioxide is a key greenhouse gas and is a major product of our current building design, construction, and operation practice (Kwok and Grondzik, 2007). This product is causing detrimental effect to the environment. This is as a result of the adoption of international style of architecture consuming high energy. Hassan Fathy (1996), in his book natural energy and vernacular architecture described how adoption of international styles of architecture in tropical climate has forced the abandonment of traditional solutions to the local climate making it difficult to achieve comfort without use of mechanical systems. He further estimated that extensive use of glass wall of approximately 9sqmeter on a tropical day can let 2000 kilo calories per hour which maintaining the micro climate of the building within the human comfort zone will require 2 tonnes of air conditioning. This practice is causing serious environmental impact threatening the survival of man (Sassi, 2006). Therefore, architects using these concepts of design are approaching an environmental problem inappropriately (Fathy, 1996).

The continuous growing concern for climate change and environmental degradation has inevitably lead to the introduction of bioclimatic and environmentally friendly design principles to the already complex and demanding architectural design of public buildings. Since climate vary, Bioclimatic design provides the basis for a regionally distinctive architecture able to challenge globalization of architecture and international styles and its

aesthetics (Torban, 2009). Bioclimatic design incorporates three basic elements; Buildings (architecture), Environment (i.e. climate), and comfort. The relationship between these three elements is described by Vitruvius tri- partite model (Hawkes, 1996). This is shown below.

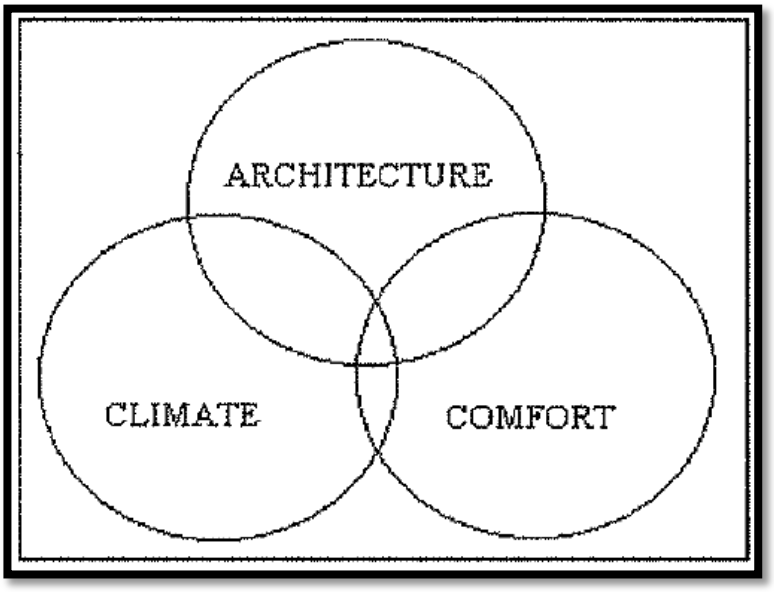


Figure 2.2. Vitruvian Tri-partite Model of Environment. Source: (Davies, 1999)

This model defines the architecture of a building as the primary link between external environment (climate) and the internal environment (comfort). However, this balance is mostly achieved in contemporary buildings using mechanical technological systems. This is as a result of failure of architects to keep buildings in order using traditional techniques (Reyner, 1984) thereby giving technology a greater influence in building industry devoid of local climatic consideration. This has prompted Olgay in 1960 to propose a development of the Vitruvian model and a method of achieving environmental control by working with climate at the same time considering the influence of technology (Davies, 1999). The model is shown below

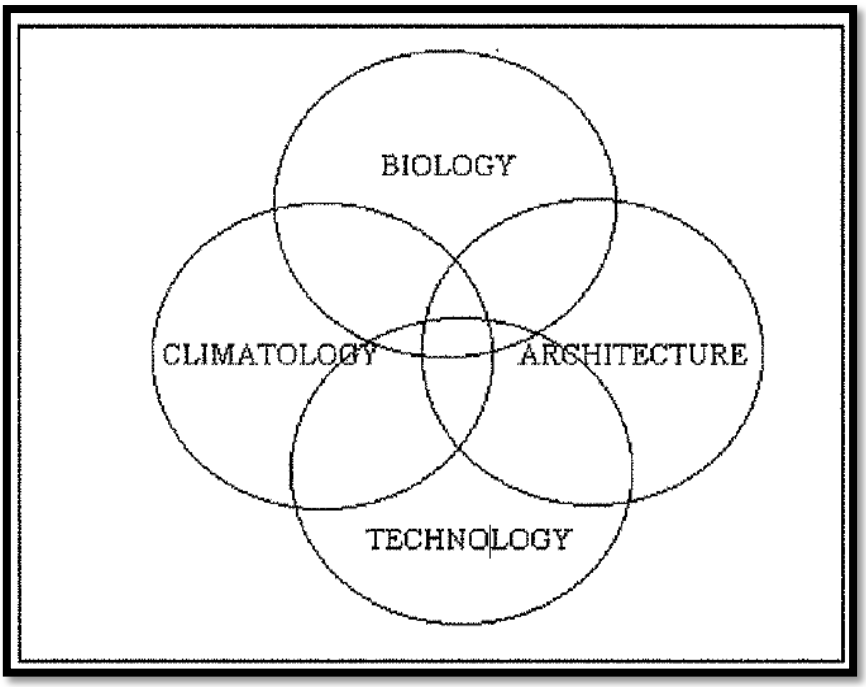


Figure 2.3. Olgay's development of the Vitruvian Tri-partite model. Source: (Davies, 1999)

The above model can be summarized as follows

Step 1. Survey the climate at the proposed building location. This should include temperature, relativehumidity, solar radiation and wind.

Step 2. Evaluate the climate and assess the relevant importance of each of the various elements.

Step 3. Propose a technical solution to solve each of the climate - comfort problems. The technical

Solutions should include site selection, site orientation, shading calculations, building form and shapes, air movement and indoor temperature balance.

Step 4. The first three stages should be incorporated in to the architectural solution.

This led to the high Quality design projects, such as London city hall (Foster + partners, 1998 -2002) and the Bologna Civic Offices (Mario Cucinella Architects, 2003- 2009), which incorporate passive heating and cooling, day lighting and renewable energy sources features that aim at minimizing conventional energy consumption.

Roaf (2003), has identified four main arguments for the need to utilize these recommendations.

1. The rate of change in the level of climate variability and modification is increasing, requiring human adaptation to a rapidly warming world.
2. The fundamental means to this adaptation in the built environment is the adoption of more effective, and widely used, methods for passively cooling buildings.
3. Air-conditioning systems are increasingly seen as part of the climatic change problem, as well as its solution, as the yawning gap grows between the amounts of fossil fuels used in the world and the falling amounts of fossil fuels that are available to run these machines.

   Not only is the rising cost of energy a problem, perhaps least to those who could not afford air conditioning anyway, but the energy used to run these systems is a major contributor to greenhouse emissions.
4. It is imperative to create a new 'cool vernacular' building approach which matches human and environmental needs.

2.3PRINCIPLES OF BIOCLIMATIC DESIGN

Research into bioclimatic issues has taken the form of passive low energy architecture research and is carried out worldwide, with a well- developed field, as is evidenced in the passive and low energy architecture (PLEA) conferences.

This research has led to the development of bioclimatic design principles, which are used by design professionals as a starting point for designing with climate in mind. These have been developed primarily for low and medium scale buildings. The rationale for this is that these types of buildings are relatively easy to make bio-climatically interactive. That is, the form and fabric of the building can be matched to human and climate factors in order to optimize climate response (Hyde, 2000). Bioclimatic principles in later years

have become a success in solving issues regarding visual and thermal comfort. This integrated approach focused on two main concerns: how to improve energy performance of buildings and provide occupants with maximum comfort. The key process is the interface where most of thermal exchanges take place. (Somfy technologies, 2007).Some of the bioclimatic design principles are:Building orientation, Building shape and forms, Facade design, Solar protection, Use of wind and natural ventilation, Trees, vegetation and landscape.

According to Yair (1994), bioclimatic design principles include; location, orientation, heat and air flow around the building, shading, renewable energy, day lighting and natural ventilation.

Davies (1996) also identified these principles to include building form, orientation, solar shading, landscaping, insulation, natural cooling, heating, ventilation and day lighting strategies. This he believed were applied in Yeang's design of bioclimatic skyscraper in Malaysia. Michaele et al (2010) added material selection, building mass, service core positioning, and renewable energy as part of the fundamental principles of bioclimatic design. Based on the above different views of literature, the common components of the principles include the following:

i. Building orientation
ii. Building shape and form
iii. Solar protection (shading)
iv. Proper landscaping
v. Passive design strategies
vi. Natural cooling, heating, ventilation and day lighting strategies
vii. Appropriate use of Materials
viii. Renewable source of energy

2.3.1 BUILDING ORIENTATION

Orientation strongly relates a building to the natural environment- the sun, the wind, weather orientation will have impact on the energy performance of the building over its life cycle. The main objectives in deciding upon a given orientation in hot climate regions is to minimize the impact of the sun on the building in summer (Hernandez, 2011).

Readorn (2008), stated that with good orientation the need for cooling is reduced, resulting in lower energy bills and reduced greenhouse emissions. Buildings should be made to maximize the site's potential and to achieve the best possible orientation for study areas. In hot humid climates orientation should aim to exclude sun year round and maximize exposure to cooling breezes. Where ideal orientation is not possible, as is often the case in higher density urban areas, passive cooling can still be achieved with careful attention to design.

2.3.2 BUILDING FORM

Building form is one of the parameters of its energy performance. Concerning passive building design, the energy efficiency of the building can be improved in the early stage of design using appropriate form (Marija 2013). This can greatly reduce the energy demand for cooling the building during summer and heating during winter.

Forms with large surface areas preferred to compact buildings. This favors ventilation and heat emission at nighttime. The main goal is the reduction of direct heat gain by radiation through openings and of internal surface temperature. The building should therefore be designed not only with protected openings, but also with protected walls. This task will be much easier if the building is kept low. In addition, the roof should extend far beyond the line of walls with broad overhanging eaves and other means of shading climate responsive building (SKAT, 1993).

In a study conducted by Marija (2013) on three different cases using simulation analysis to show to which extent the form affects the energy efficiency of the building and also reduction of negative environmental influence.

Case 1: Different Positions of the same building form

Rectangular building form with the dimensions 60 x 30 x 35m is presented in two different positions. Form A has a dominant length (l = 60m; w = 30m; h = 35m) and form B has a dominant height (l = 35m; w = 30m; h = 60m). Both buildings were observed as stand-alone, with identical floor areas, external glazing on one façade and building envelope fabrication. The energy performance of these building forms was simulated. It was found out that, building form A use less energy for heating and cooling than B.

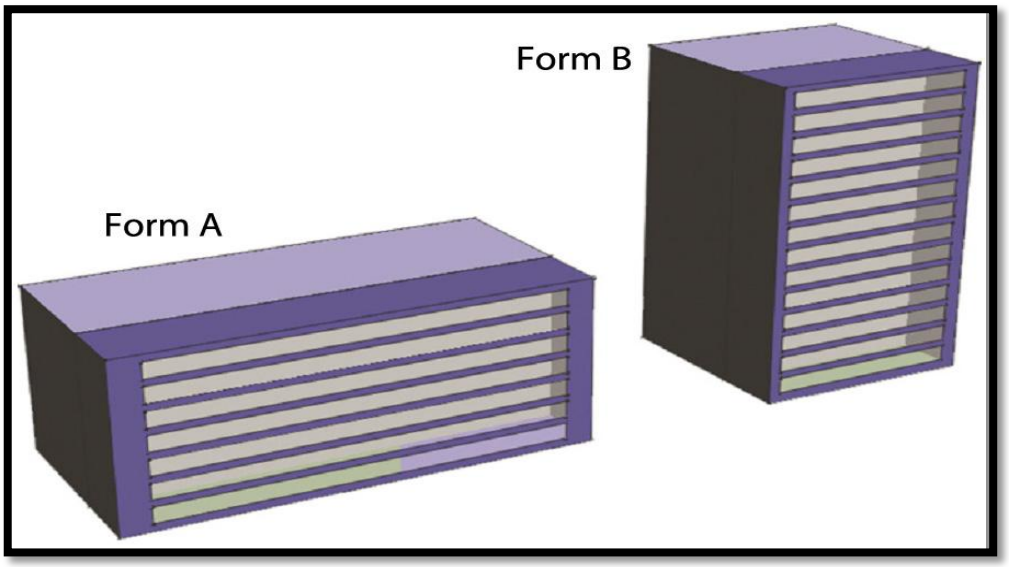


Figure 2.4: Building form A and B models for simulation. Source: (Futcher etal, 2013)

Case 2: The same building form with additional Elements Attached.

The simulation of the hotel building with rectangular form (Fig. a) was done in order to compare the results concerning energy performance to the same model with attached balconies (Fig. b). The proposed design of the building, besides the additional elements, was improved by insulation materials within the envelope. So,

the results presented in Table 2 below do not reflect the actual impact of the building form on achieving efficient energy use. But the real impact of the building form cannot be neglected.

The balconies on the proposed model have the role of preventing the direct sun. It is very important to shade the building in order to lower cooling load and improve the indoor thermal conditions.

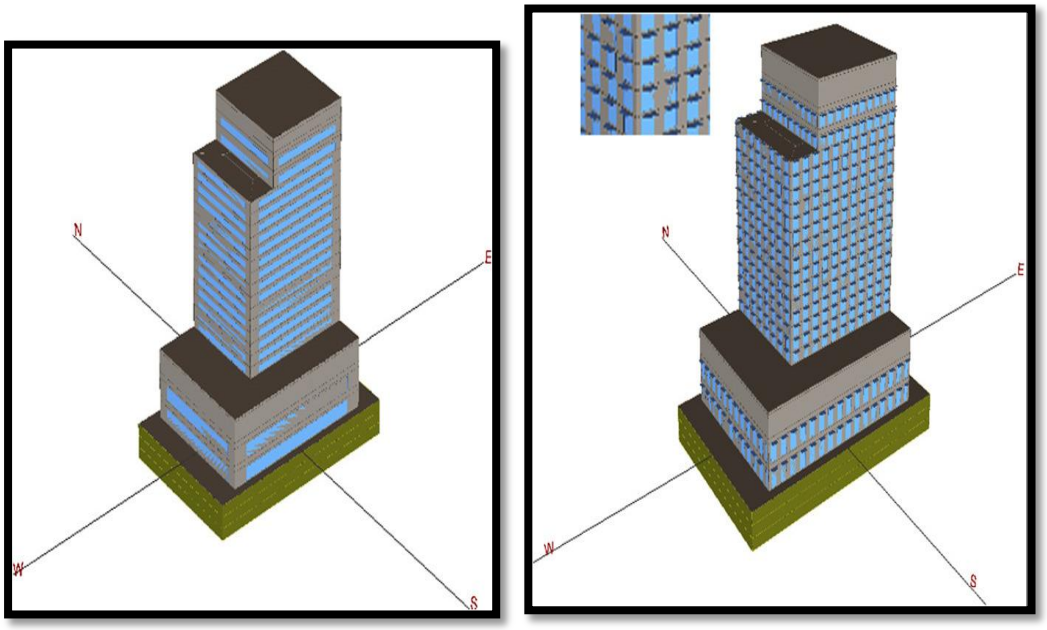


Figure 2.5(a) Original building form. Figure 2.5(b) Building form with attached balconies- Proposed model. Source: (Sozer, 2010).Table 2.1: Energy consumption for Original and proposed building design. Source: (Suzer, 2010)

	Space heating MBTU (Natural gas)	Space cooling MBTU (Electricity)	Total site energy MBTU	Reduction on space heating (%)	Reduction on space cooling (%)	Reduction on total site energy (%)
Original building	8493.8	6881.2	39102.1			
Proposed building	1167.6	2773.6	23430.8	36.25	60	40.1

Finally, it was realized that the proposed building reduces energy consumption by 40% for both heating and cooling as can be seen in the table above.

Case 3: Different Building Geometry with the same cubature

In order to examine how the geometry of a building can affect its energy performance, two models were created. The first model is the prismatic-polygonal, original building of the Geodynamics Institute in Athens, Greece, and the second building envelope is orthogonal, consisting of vertical walls and flat roof. The buildings are identical in terms of volume, wall areas, floors, materials and openings. Only the shape differs.

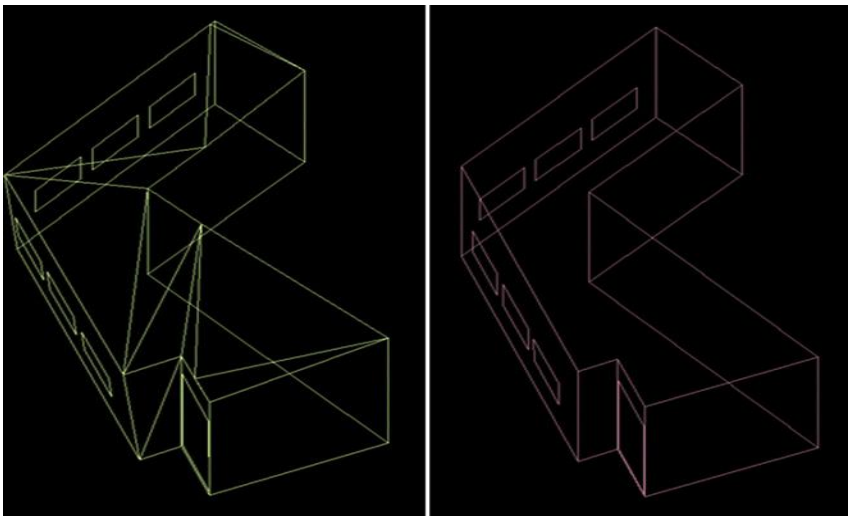


Figure 2.6: Comparative geometrical models for prismatic polygonal building (left) and Orthogonal Building (right) Source :(Zerefos etal, 2012)

Comparative geometrical models are shown, and the results for annual energy consumption of the three modeled thermal zones for heating and cooling are computed. Based on the results, prismatic geometry shows better energy performance compared to orthogonal buildings. They also perform better in fields of incident solar radiation. This is due to the fact that inclined roofs and walls decrease incident solar radiation, which is of significant importance for the cooling period. Conclusively, it was calculated that the total energy reduction was 7.88% favoring prismatic building form (Futcher etal, 2013).

Based on the above three different cases, it can be deduced that the recommended building form to be used should have minimal exposure of its longest side to solar radiation, protective balconies and inclined roofs to protect against sunlight penetration.

Other forms evolved are self-shading forms. According to Capeluto (2003), self-shading geometry forms could provide the best solution for a better use of energy in buildings.Self-shading strategy can have a significant impact onpreventing direct solar radiation that could cause less heat gain. By applying this strategy, the amount of daylight that can penetrate inside the building would be reduced (Mansour etal, 2012).



Plate 2.1: A type of self-shaded building- free view section. Source: (Capeluto, 2003).

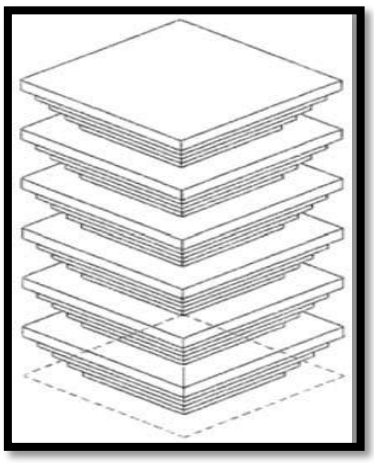


Figure 2.7: Self shaded high rise building. Source: (Chia, 2005)

The researchers demonstrated that circular form with width to length ratio of 1:1 would be the optimum shape because this form would receive the lowest annual solar isolation among high rise buildings (Chia, 2007). Okeil (2010) identified a special urban block form which can be highly energy efficient and showed how forms can be optimized to enhance energy performance

2.3.3 OPTIMAL SHADING

Sunlight falling on a building raises indoor temperature in different ways ranging from direct and indirect radiation (Ajigbool, 2011). Umoh (2000), highlights that the solar radiation level in Nigeria is between 110kg - Cal in South and 190kg - cal in the North. This is causing interior temperatures to rise above comfort range, thereby adding occupant's discomfort. Therefore, shading of the building is paramount. It is the most cost effective way to reduce solar radiation and cut air conditioning cost (DOE, 1995). This is achieved using various strategies. Below are some of the principles to be applied in exclusion of solar radiation in buildings:

- Shading.
- Thermal properties of materials.
- Ventilation.
- Forms and orientation (Ajigboola, 2011).

Well-designed sun control and shading devices, either as parts of a building or separately placed from a building facade, can dramatically reduce building peak heat gain and cooling requirements and improve the natural lighting quality of building interiors. The design of effective shading devices will depend on the solar orientation of a particular building facade. For example, simple fixed overhangs are very effective at shading south-facing windows in the summer when sun angles are high (Mohammad, 2012). Some of the different shading devices are shown below.

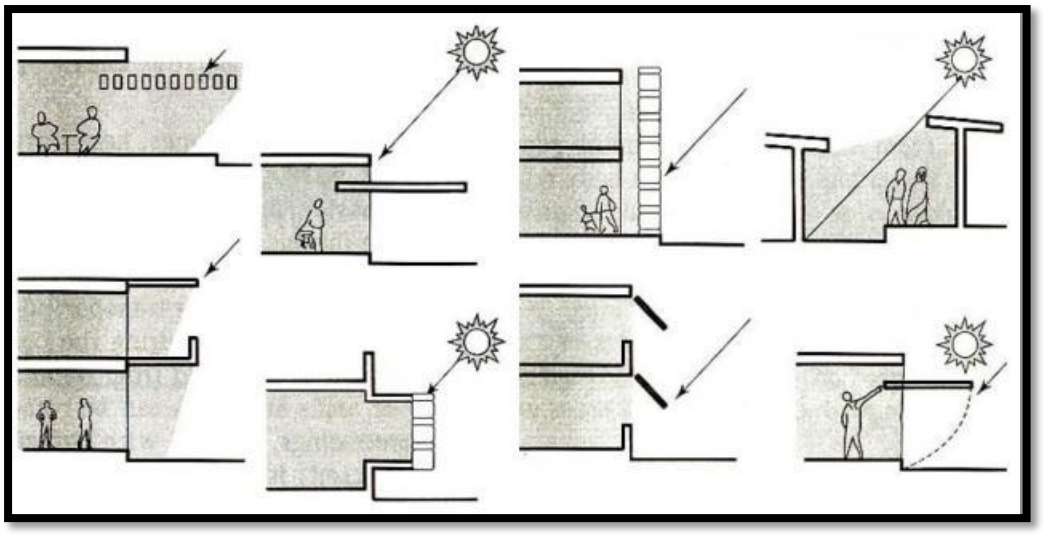


Figure 2.8: Different types of shading devices. Source: (Mohammad, 2012)

Different building elements need to be shaded for efficient protection from solar radiation.

Shading of roof

Shading the roof is a very important method of reducing heat gain. Roofs can be shaded by providing roof cover of concrete or plants or canvas or earthen pots etc. Shading provided by external means should not interfere with night-time cooling. A cover over the roof, made of concrete or galvanized iron sheets, provides protection from direct radiation. Disadvantage of this system is that it does not permit escaping of heat to the sky at night-time.

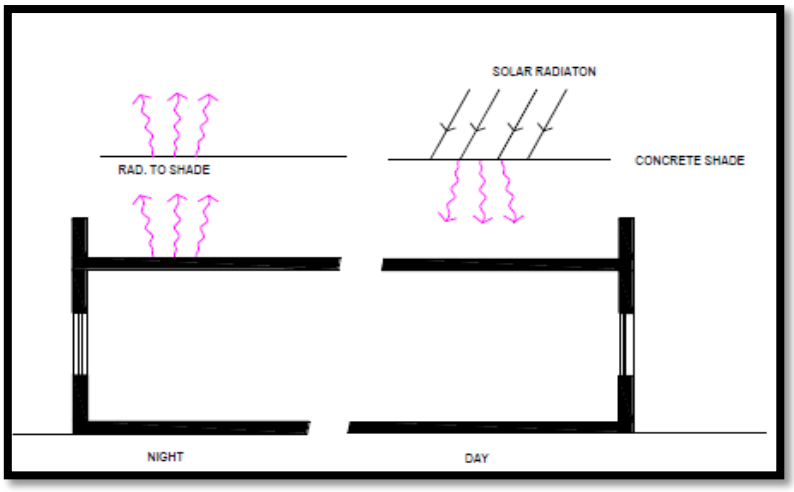


Figure 2.9. Roof shading by solid cover. Source: (Mohammad, 2012)

A cover of deciduous plants and creepers is a better alternative. Evaporation from the leaf surfaces brings down the temperature of the roof to a level than that of the daytime air temperature. At night, it is even lower than the sky temperature.

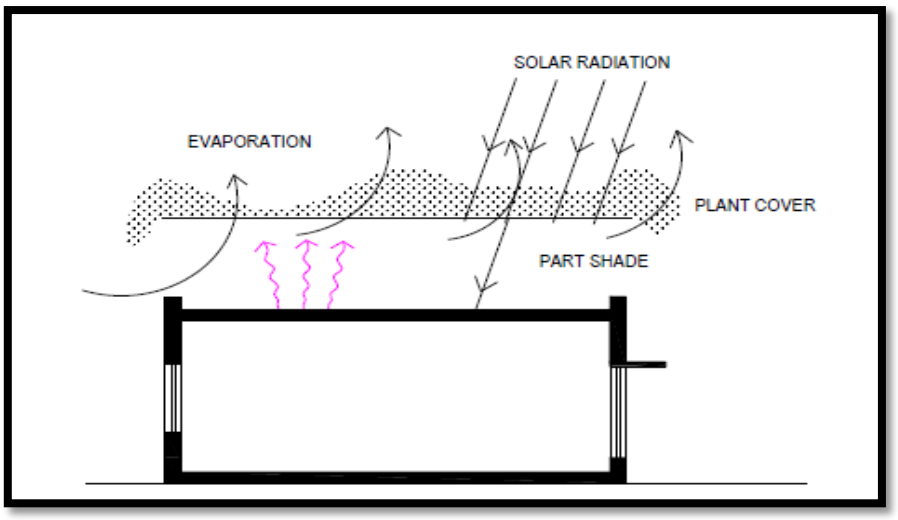


Figure 2.10: Roof shading by plant cover. Source: (Mohammad, 2012).

Another inexpensive and effective device is a removable canvas cover mounted close to the roof. During daytime it prevents entry of heat and its removal at night, radiative cooling. Fig. 2.14 shows the working principle of removable roof shades. Painting of the canvas white minimizes the radiative and conductive heat gain (Gupta, 1984).

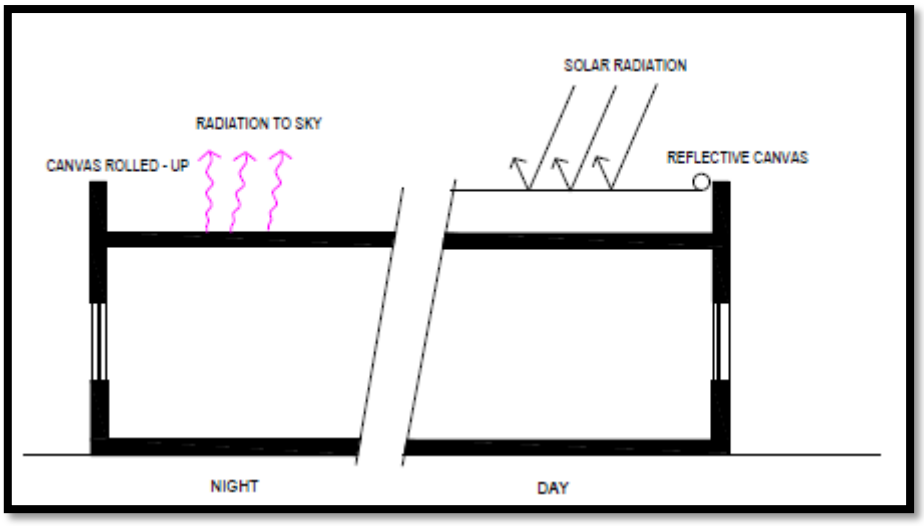


Figure 2.11: Removable roof shades. Source: (Mohammad, 2012)

Shading by trees and vegetation

Proper Landscaping can be one of the important factors for energy conservation in buildings. Vegetation and trees in particular, very effectively shade and reduce heat gain. Shading with trees reduces ambient temperature near outer wall by 2°C - 2.5°C (Bansal etal, 1994). Trees can be used with advantage to shade roof, walls and windows. Shading and evapotranspiration (the process by which a plant actively release water vapor) from trees can reduce surrounding air temperatures as much as 5°C. Different types of plants (trees, shrubs, vines) can be selected on the basis of their growth habit (tall, low, dense, light permeable) to provide the desired degree of shading for various window orientations and situations. The following points should be considered for summer shading.

1. Deciduous trees and shrubs provide summer shade yet allow winter access. The best locations for deciduous trees are on the south and southwest side of the building. When these trees drop their leaves in the winter, sunlight can reach inside to heat the interiors.

2. Trees with heavy foliage are very effective in obstructing the sun's rays and casting a dense shadow. Dense shade is cooler than filtered sunlight. High branching canopy trees can be used to shade the roof, walls and windows.

3. Evergreen trees on the south and west sides afford the best protection from the setting summer sun and cold winter winds.

4. Vertical shading is best for east and west walls and windows in summer, to protect from intense sun at low angles, e.g. screening by dense shrubs, trees, deciduous vines supported on a frame, shrubs used in combination with trees.

5. Shading and insulation for walls can be provided by plants that adhere to the wall, such as English ivy, or by plants supported by the wall, such as jasmine.

6. Horizontal shading is best for south-facing windows, e.g. deciduous vines (which lose foliage in the winter) such as ornamental grape or wisteria can be grown over a pergola for summer shading (Kamal, 2003).

Also, a trellis with climbing vines can shade the building wall and patios.

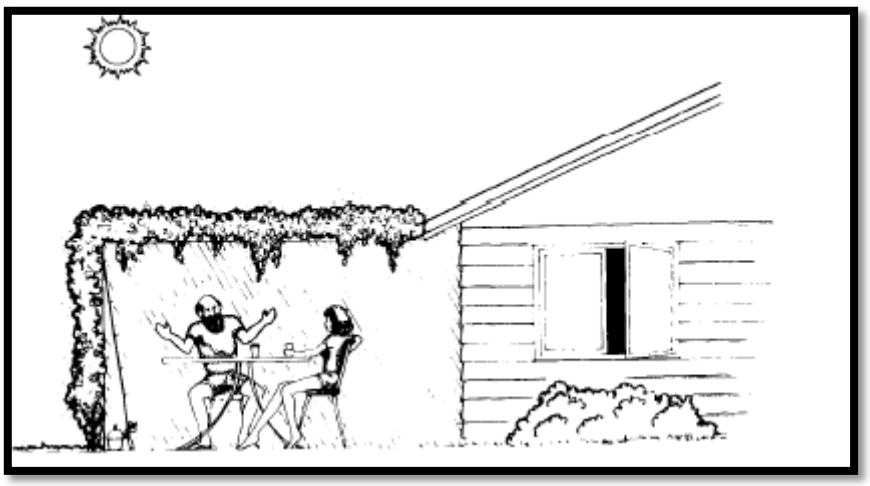


Figure 2.12: A vine on a trellis for shading. Source :(Kansas 1982)

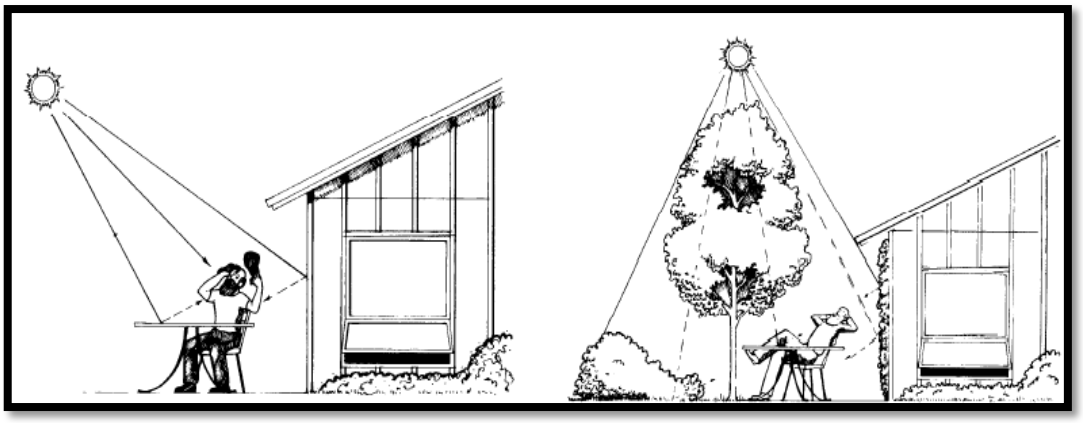


Figure 2.13: Shading of external walls using trees. Source: (Kansas 1982)

Direct and reflected radiation is reduced greatly with the use of plant material on the wall and surrounding environment of the building.

2.3.4 NATURAL VENTILATION

The purpose of a ventilation system is to provide acceptable microclimate in the space being ventilated. In this context, microclimate refers to thermal environment as well as air quality (Hashim 2003). These two factors must be considered in the design of a ventilation system for a room or a building, as they are fundamental to the comfort and wellbeing of the human occupants or the performance of industrial processes or social activities within these spaces.

Natural ventilation is the process of supplying and removing air through an indoor space without using mechanical systems.It is the most common ventilation method of allowing fresh outdoor air to replace indoor air in a building (Department of energy USA, 2011). Natural ventilation is a cost-effective way of improving air quality within a building and cooling during the night, especially during summer time. Automating windows during the hours when a building is unoccupied means that a controlled flow of cool air can pass through the façade, significantly reducing the accumulated temperature of the building mass and improving the quality of the indoor environment the following day (Somfy technologies, 2007)

It depends solely on air movement to cool occupants. Windows openings on opposite sides of the building enhance cross ventilation driven by breezes. Since natural breezes can't be scheduled, designers often choose to enhance natural ventilation using tall spaces within buildings called stacks. With openings near the top of the stack, warm air can escape, while cooler air enters the building from openings near ground.

Stack ventilation is perceived to be the upward movement of air through openings in a building fabric due to thermal buoyancy and / or negative pressure generated by the wind over the roof (Ismail, 2012). While others often defined it as the process of removing unwanted moisture from buildings (Stephen etal, 1994).

the most common techniques are the static type openings on top or upper part of the building like ridge, static and dormer vent, chimney flue, jack roof and roof monitor (Figure 2(a)), which most of them deal with the function to ventilate the trapped hot air underneath the roof, thus reduce the internal heat gain.

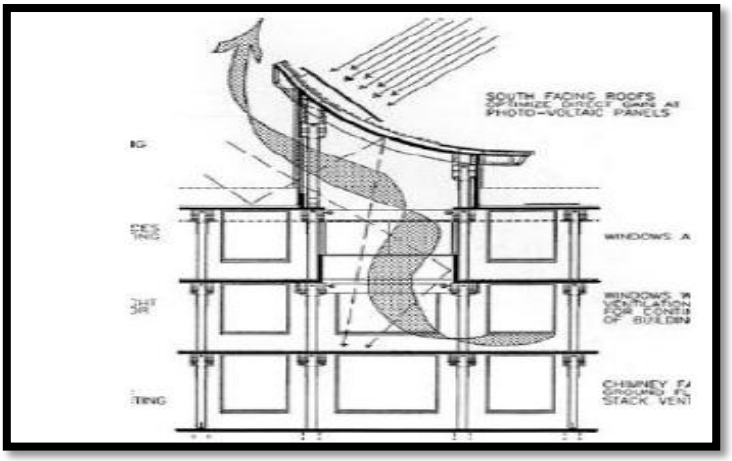


Figure 2.14(a) Natural stack ventilation strategies in modern building; roof monitor at CK Choi Building, USA Source: (Choi, 2009)

In some conditions, these static types of stack ventilation strategies could be enhanced by the use of atrium, stack devices and ventilation shafts. An atrium is a space with glazed

roofs which is usually incorporated in the middle of a deep-plan building for both day lighting and ventilation purposes. This architectural feature could enhance the stack ventilation performance by increasing high differential pressure through the use of the glazing elements at the upper part.

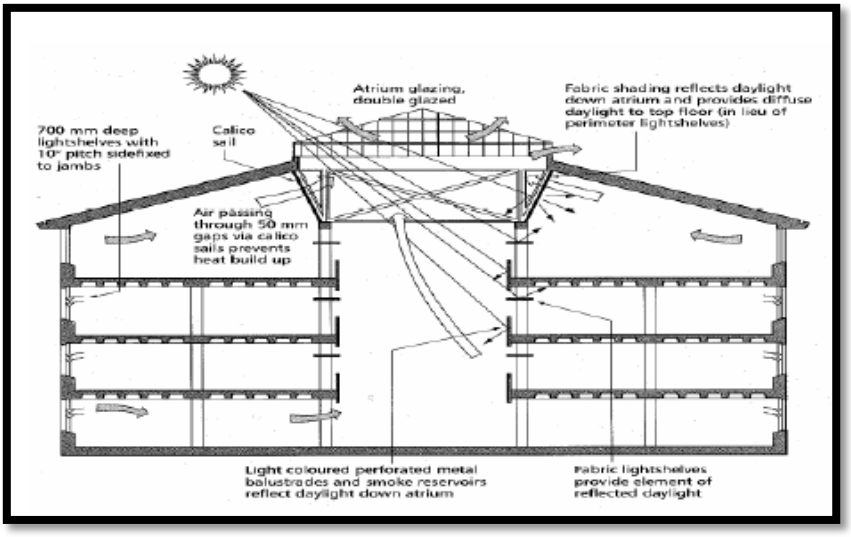


Figure 2.14(b): Double glazed atrium at Power Gen Headquarters, Coventry, UK.

On the other hand, stack ventilation towers like a stack device is another conventional architectural feature which usually associated with stack ventilation strategy. With the high vertical façade above the roof, this element is not only effective in increasing the buoyancy pressure available to drive an upward flow, but also effective to drive ventilation in lower floors of the multi-storey building. See the figure below



Plate 2.2: Actual application of stack ventilation towers at the De Montfort University, UK. Source: (Ismail, 2012).

Advanced stack-ventilated buildings have the potential to consume much less energy for space conditioning than typical mechanically Ventilated or air-conditioned buildings. (Kevin, 2006).

Convective cooling may be natural, mechanical or hybrid. Natural ventilation is due either to wind forces, temperature differences, or both (Allard, 1998). A serious reduction of cooling potential is observed in dense urban environment as a result of the dramatic decrease of the wind speed in cities (Geros, et al., 2001). Careful positioning of the openings in naturally ventilated buildings is a crucial parameter that determines the effectiveness of the process. A review of the sizing methodologies is given by Santamouris (Santamouris, 2002).

Air movement is the most important element of passive cooling. It increases cooling by increasing evaporating rates. Generally, cross ventilation is the most effective for air exchange (building cooling) and fans for air movement (people cooling). Air provide useful cooling in all climate but may be less effective in tropical climate during periods of high humidity. The humidity level in Kaduna is not as high as the coastal areas.

According to Reardon (2008), an air speed of 0.5m per second equate to a 3 degree drop in temperature at relative humidity of 50 per cent. This is a one off physiological cooling effect that occurs when still air is moved at 0.5m per second in higher humidity, greater air speeds are required to achieve the same cooling benefits.

2.3.5 PASSIVE DESIGN

Ortner (2001) describes passive solar energy design as architectural means of constructing comfortable interior environments by building with natural equipment, without the use of mechanical equipment. According to Lawal and Makinde (2007), all buildings are expected to be passive to the extents that without the use of mechanical systems driven by

remote energy sources all buildings should produce comfortable interiors climate". Passive design is about taking advantage of natural energy flows to maintain thermal comfort. It is about using the appropriate building orientation, building materials and landscaping (Agboola, 2011).

A ‘passive’ solar design involves the use of natural processes for heating or cooling to achieve balanced interior conditions. The flow of energy in passive design is by natural means: radiation, conduction, or convection without using any electrical device (Mohammad 2012). Passive solar strategies use energy from the sun to heat and illuminate buildings. It also makes use of the building components to collect, store, distribute, and control solar heat gains to reduce the demand for fossil fuel-powered space heating. (WBDG, 2011).

The goal of passive design is to maximize solar gain while minimizing conductance. Passive cooling removes or rejects heat from the building, keeping temperatures cool (Stephen, 1999).Avoiding any mechanical operations to moderate temperature achieves energy and cost savings by alleviating the cooling load demanded. Shading devices can also reduce unwanted solar gains by blocking the sun during the summer months, while natural ventilation, which relies on natural airflow and breezes, can reduce the need for mechanical cooling when the building is occupied (Stephen, 1999).

The following five elements constitute a *complete* passive solar design. Each performs a separate function, but all five must work together for the design to be successful: aperture, absorber, thermal mass, distribution, and control (US DOE 1999). See the diagram below.

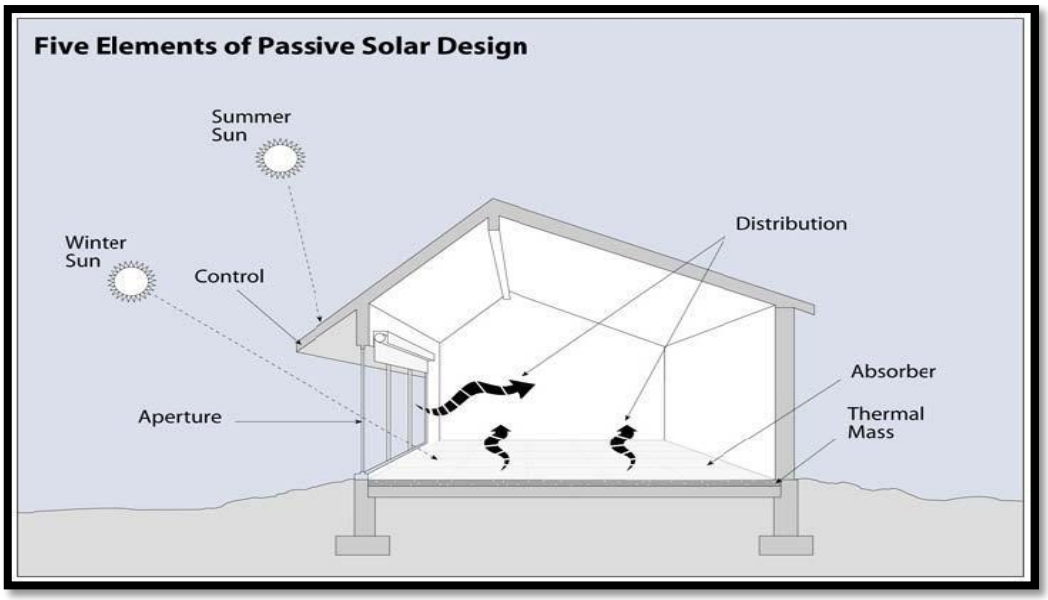


Figure 2.15: Five Elements of passive solar design (Source: US DOE/EERE, 2009)

Some of the techniques of passive design include

Air vents

Curved roofs and air vents are used in combination for passive cooling of air in hot and dry climates, where dusty winds make wind towers impracticable. Suited for single units, they work well in hot and dry and warm and humid climates. A hole in the apex of the domed or cylindrical roof with the protective cap over the vent directs the wind across it. (See figure below). The opening at the top provides ventilation and provides an escape path for hot air collected at top. Arrangements may be made to draw air from the coolest part of the structure as replacement, to set up a continuous circulation and cool the living spaces. The system works on the principle of cooling by induced ventilation, caused by pressure differences (Muhammad, 2012). This is practically applied in central atriums to provide effective ventilation and day lighting into the interior spaces

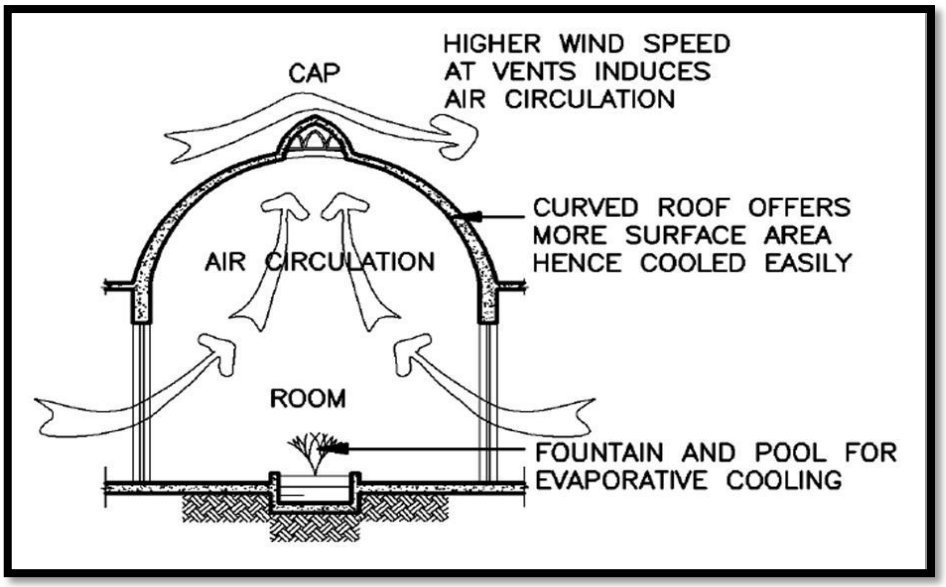


Figure 2.16; Induced ventilation through curved roof and air vents. Source: (Muhammad, 2012).

Roof pond

In this system a shallow water pond is provided over highly conductive flat roof with fixed side thermal insulation. The top thermal insulation is movable. The pond is covered in day hours to prevent heating of pond from solar radiation. The use of roof pond can lower room temperature by about 20°C. While keeping the pond open during night the water is cooled by nocturnal cooling. The covered pond during the day provides cooling due to the effect of nocturnally cooled water pond and on other side the thermal insulation cuts off the solar radiation from the roof (Mohammad, 2012). The system can be used for heating during the winter by operating the system just reverse. The movable insulation is taken away during day so the water of pond gets heated up by solar radiation and heating the building. The pond is covered in night to reduce the thermal losses from the roof and the hot water in the pond transfers heat into building (Jain, 2006).

Evaporative cooling

Evaporative cooling is a passive cooling technique in which outdoor air is cooled by evaporating water before it is introduced in the building. Its physical principle lies in the

fact that the heat of air is used to evaporate water, thus cooling the air, which in turn cools the living space in the building. However passive evaporative cooling can also be indirect. The roof can be cooled with a pond, wetted pads or spray, and the ceiling transformed into a cooling element that cools the space below by convection and radiation without raising the indoor humidity (Mohammad, 2012).

2.3.6 MATERIALS

The climatic requirements can be met through the use of appropriate construction materials and methods.(Agboola, 2011)

The choice of building materials affects the environmental impact of a house. All building materials are processed in some way before they can be incorporated into a building. The processing may be minimal, as in the case of a traditional cottage constructed from materials found locally, or it may be extensive, as in the case of prefabricated construction. This processing of materials inevitably requires the use of energy and results in waste generation.

In the UK it is estimated that the production of building materials is responsible for about one-tenth of energy consumption and emissions.

The single most important measure of material's environmental impact is provided by the concept of 'embodied energy'. 'Embodied energy' describes the amount of energy used to produce a material. It is difficult to find accurate published figures for the embodied energy of materials.

However, previous research (West et al., 1994) has indicated that, for most building types, the following materials will contribute significantly to the embodied energy of a building:

• Steel, Concrete, Timber, Bricks, Cement, Aggregates, Glass and plaster.

These materials account for a large proportion of the volume or mass of most buildings, and the designer can significantly affect a building's embodied energy by paying close

attention to their specification. Selecting materials from local sources will reduce their embodied energy and emissions because of reduced transport.

Also, the selection of materials used in the design of buildings can make a significant impact on reducing green-house gas emission by choosing environmentally preferable products. (Agboola, 2011).

In relation to this, a good knowledge of thermal properties is required before selecting the materials. The thermal properties of materials which affect the rate of heat transfer in and around the building and consequently affect the thermal condition and comfort of the occupants include the following:-

i***Thermal conductivity:*** this is the ability of materials to conduct heat.

ii***Thermal stability:*** the ability of materials to retain its basic physical and mechanical properties and inner structure when heated.

iii***Thermal resistance:*** this is the ability of material to resist heat flow.

iv***Heat capacity:*** this is the ability of material to absorb heat when its temperature is raised.

v***Surface coefficient:*** this determines the rate of heat exchange between the surface and the surrounding air.

vi***Surface characteristics:*** this determines reflectivity, absorptive and emissive of a material, for example, colour, texture, etc. (Agboola, 2011).

However, effective application of building materials is encountered by certain problems. Lesiuk (2002) also identifies special problems of materials choice and assemble details because of high humidity in the warm insects and pests must be included in materials tasks. Choice of building materials should recognize that high humidity accelerates mould and aid algae growth, rusting, rotting and organic decay.

2.3.7 LANDSCAPING

Landscape vegetation can reduce the amount of sunlight reaching the outer surfaces of a house. It thereby reduces the temperature difference between inner and outer building surfaces in summer when heat is being conducted rapidly *into* the home. In winter, however, sunshine on the building's outer surfaces can help reduce heat loss, and winter shade would interfere. Only deciduous plant material should be used close to the house on the east, south, and west exposures. (Kansas, 1982). Deciduous trees block the summer sun but let the winter's warming sun through. Plant the trees approximately 15 to 25 feet apart and 10 to 15 feet from the house.

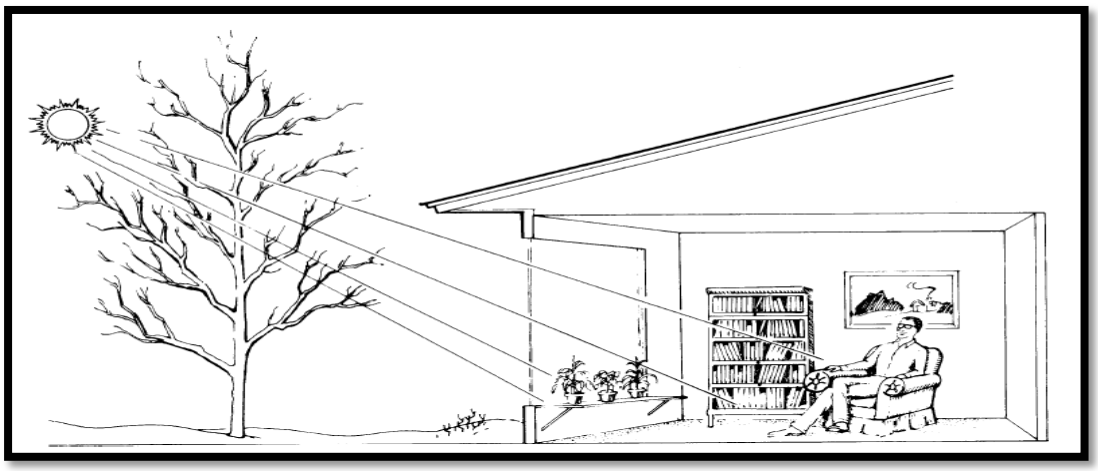


Figure 2.17: Deciduous trees lose their leaves in the winter, allowing the sun's rays to enter and heat the house. Source: (Kansas, 1982)

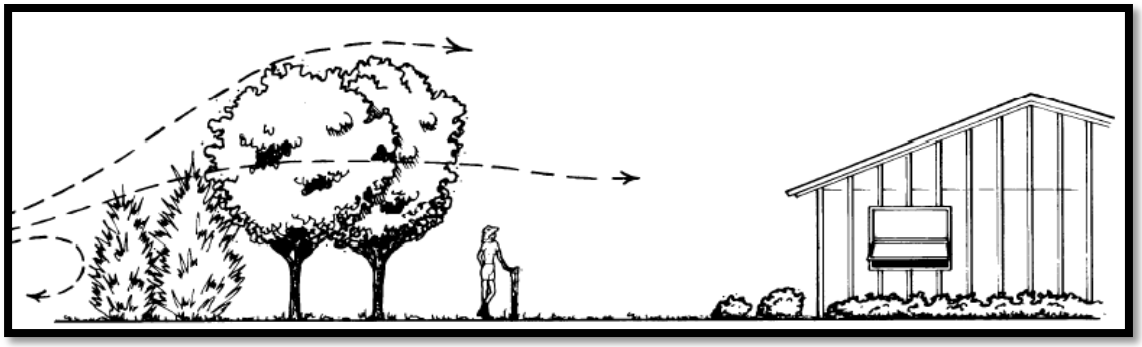


Figure 2.18: Windbreaks alter and direct the wind flow pattern to protect the house from the wind's full force. Source: (Kansas, 1982).

2.3.8 DAYLIGHTING

The use of daylight for interior illumination can reduce energy use within buildings and has a positive effect on visual comfort. It is inevitable that artificial light must become the primary light source where efficiency of vision is combined with an economic analysis of building function. Natural lighting is becoming a luxury, (Derek, 2004).

If considered at the design stage, the use of daylight allows for a significant reduction in electricity used for lighting and can reduce the overall energy consumption. Day lighting depends on the availability of sunlight, location, size and orientation of windows. Several strategies can be used to achieve visual comfort when using daylight including: roof lights, atria, glazing, transparent insulation, light pipes and Light ducts and shading (European Union, [EU], 2001).

Daylight must be incorporated into the building design in such a way that the building and its indoor spaces would provide satisfactory visual and thermal environment (Agboola, 2011)Daylight affects the Architect's choice of the basic building section, the building in indoor space and architectural elements to be incorporated into the design. Plant et al (2002), stressed that the following design factors must be taken into account in order to use daylight to an advantage.

- Variations in the amount and directions of the incident daylight.
- Luminance (photometric, brightness) and luminance contribution of colour, partly cloudy and over cast skies.
- Variation in sunlight intensity and direction.

2.4 ENERGY CONSUMPTION IN BUILDINGS

Energy is the capacity of matter to perform work as a result of its motion or position in relation to forces acting on it (Encarta dictionary, 2009). As Shehiel Alam (2006) points it, Energy is the indispensable force driving all economic and social activity. This is to

say, all forms of construction and other economic processes depends on energy to be carried out effectively. Energy is fundamental to all human activities and it exist in various forms and quality (Uyigue etal, 2007). Some energy are considered naturally free (waste energy and renewable energy) but still they are used. In Nigeria, the various energy resources ranges from petroleum, natural gas, solar, wind, biomass and hydroelectricity (Adegbemi, 2013). These form of energy should be harnessed to reduce the cost incurred in using other forms of artificial energy (Kwee, 2011).

The rapidly growing world energy use has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts (ozone layer depletion, global warming and climatic change). The global contribution from buildings towards energy consumption has steadily increased reaching a reasonable figure exceeding other major sectors. This consumption is beyond just electricity used in the building for its operation but also branches into materials used for construction of the building and other environmental resources. Ago (1999) opined that, building energy consumption accounts for nearly 27 percent of all energy related greenhouse gas emissions. This emission is predicted to increase by an estimated value of about 48% emissions by 2010 (Richard, 2008). Buildings use at least 50% of all the energy produced in our planet (ERG etal, 1999). This is uniformly distributed globally in different countries depending on the level of development and construction technology. According to department of energy, buildings account for an estimated 40% of the total energy consumption in the United States. On annual basis, these buildings consume 39% of America's energy and 68% of its electricity. Buildings emit 38% of the carbon dioxide (the primary greenhouse gas associated with climate change), 49% of the sulphurdioxide and 25% of the nitrogen oxides found in the air (WBDG, 2012). In France, the building industry consumes about 43% of the total energy consumption and contributes 25% of

greenhouse emissions (Tiberiu etal, 2011). Also in India, the building sector represents about 33% of the total electricity consumption in the country (BEE, 2009). While Nigeria is currently consuming 0.2% of total world energy consumption (Oluseyi, 2006). Growth in population increase the demand for building services and comfort levels of the inhabitants, thereby assuring the upward trend in energy demand will continue in the future (Perez and Ortiz,2008).

For this, energy efficiency in buildings is the contemporary main objective for energy policy. The new design trend is looking forward to reducing the amount of energy consumed in the buildings (Mc Gowan, 2002). This is in response to the environmental damages arising from the current energy use pattern. Energy consumption in buildings can be reduced in three different ways; reducing the demand for energy service, increasing technical energy efficiency and integrating renewable source of energy to reduce cost of heating, cooling, ventilation, lighting and electricity (Schwarz, 2009). The above measures can be appropriately applied in bioclimatic design principles to curtail the level of energy consumption in contemporary buildings.

2.5 ENERGY CONSUMPTION IN CONVENTION CENTERS

The major energy consumption comes from areas of electricity and crude oil (Gbadebo, 2009). This is for smooth running of operational and construction activities within and outside the building. In Nigeria, the building sector largely consumes electrical form of energy for running the activities in the building. However, only 40% of the population are having adequate access to it (EIA, 2007). This is majorly supplied to the urban areas. The supply is estimated to have an average installed capacity of 6000MW (EPIC, 2004) and per capita consumption of 82KW (Gbadebo, 2009). The demand for electricity in Nigeria is squarely for industrial, commercial and residential purposes (Udo etal, 2010). By studies, residential sector is the largest consumer of electricity in Nigeria followed by the

Commercial sector then industrial (Ekpo, 2010). The figure below shows the trend of electricity consumption in Nigeria.

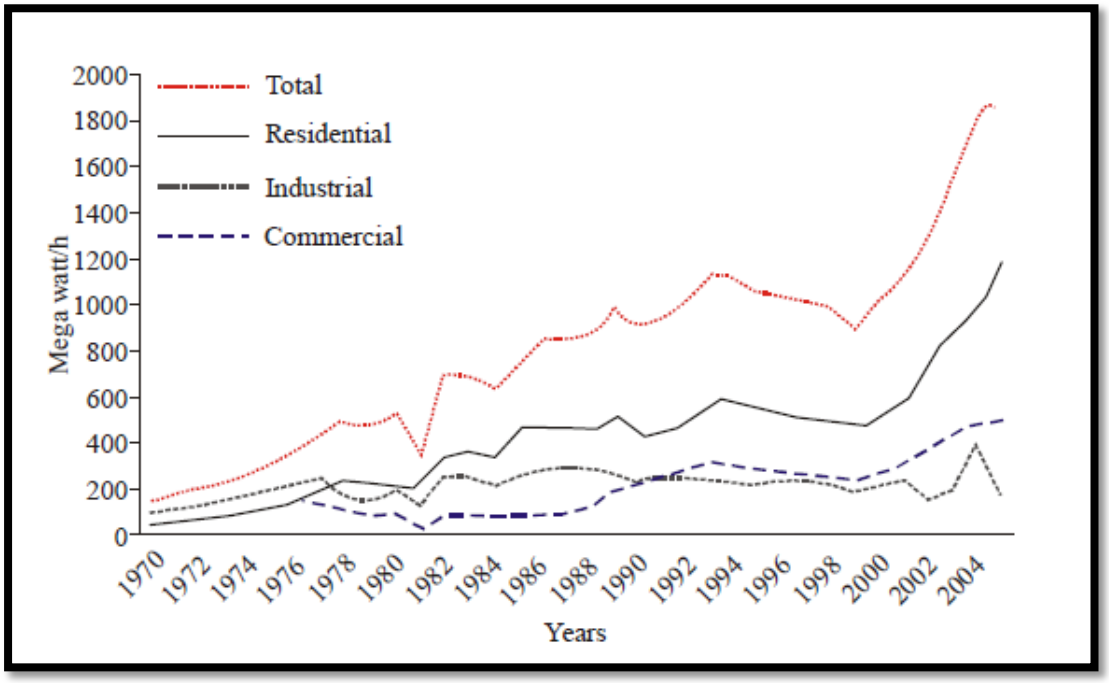


Figure 2.19: Trend of electricity consumption in Nigeria (1970-2005), CBN Statistical Bulletin (2009) Source: (Udo, 2011)

From the figure above, the consumption by residential sector has dominated the other sectors since 1987 to 2005, while the industrial sector has witnessed continuous downward trend. This was noticed to continue up to date. The erratic and epileptic power supply has compelled major firms, industries and institutional buildings into self-generation of electricity using generators. The World Bank survey of firms and institutional buildings in Nigeria in 2002 shows that, averagely 98.2% of buildings owned and operate private generators. This has contributed a lot in causing serious environmental impact through generation of gases depleting the ozone and causing pollution. Therefore, environmental integration of the building design through passive and bioclimatic strategies to reduce the use of generators for cooling, heating, lighting and construction will present a very good potential for energy saving as well as reducing

impact to the environment. This is paramount considering the energy consumption of a single office building shown in the figure below

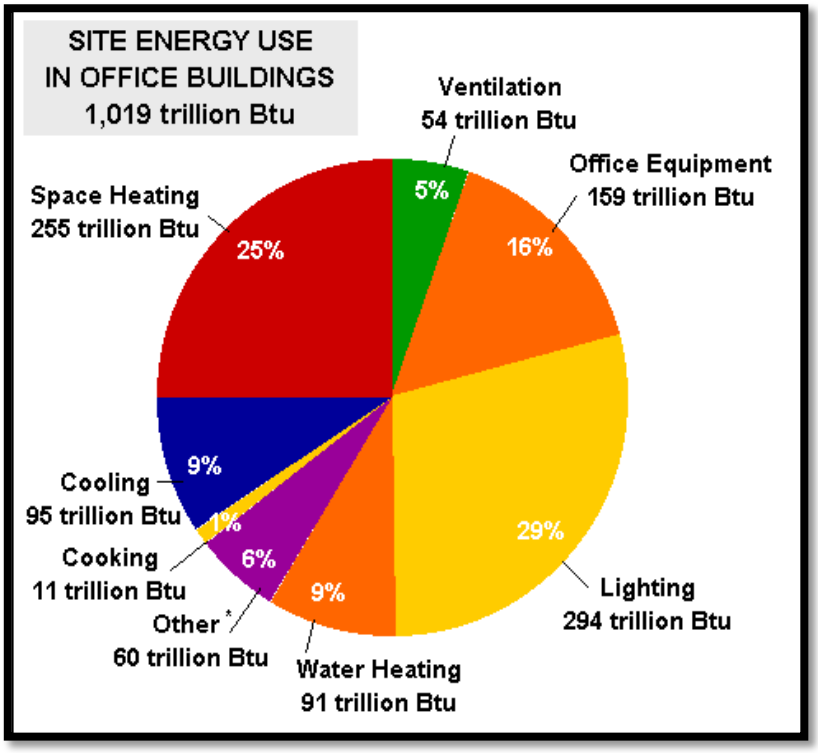


Figure 2.20: Commercial buildings energy consumption survey. Source: Energy information Administration 1995.

2.6 ENERGY EFFICIENCY

Energy efficiency is using less energy to provide same level of energy services. It is any action that reduces the energy per unit output without affecting the level of service provided.it is the indispensable component of any effort to improve productivity (Ovieniuwo, 2006). For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain comfortable temperature. It is the quantitative relationship between output of performance service goods or energy and the input of energy (Kwee, 2011). According to international energy agency, energy efficiency is a way of managing and restraining the growth in the energy consumption. It offers a powerful and cost effective tool that helps in achieving environmental benefits by reducing greenhouse gas emission and local air pollution. Improving the energy efficiency

means getting more from the energy that we use. Energy efficient buildings are those designed to provide significant reduction of energy needed for heating and cooling independently for the energy and of the equipment used in heating and cooling of the building (Gobain, 2008). According to US Environmental Protection Agency (2008), the goal of energy efficiency is to reduce a buildings negative impact on the environment, this can be achieved through innovative heating and cooling technologies and cutting out wasted energy. The benefits of energy efficiency identified by Edward (2012) include

i. Economic growth: through installation of energy efficiency measures, employment opportunities are created to boost the economy
ii. Emission reduction: to deliver against our greenhouse gas emissions target over the coming decades in most cost effective way.

Other benefits of greater energy efficiency in buildings include the following:

iii. Reduction in cost of building operation and maintenance
iv. Cost saving in life-cycle of the building
v. Reduce greenhouse gas emission and other environmental pollution
vi. Enhance building design
vii. Improve comfort conditions of the inhabitants (Hui, 2007).

Contemporary design of convention centers are taking pragmatic measures to reduce energy consumption. This is in the best interest of this thesis. One of the examples is Baltimore Convention Center, this convention center is an energy efficient design, it embarked on energy performance contracting (EPC) with constellation in energy efficient project. According to Theodore Atwood, director of the Baltimore city department of general service “the convention center project is a step to reducing the energy usage by 20% by 2015”. It is expected to save about 18 million dollars over 18 year’s period, reduced 20% electricity usage by 2015 and also avoid the creation of 6,508 metric tons of

carbon dioxide annually (Michael, 2012). The measures adopted include; energy efficient LED lighting and lighting controls, HVAC repairs, cool roof membrane to regulate heat, building envelope improvement. However, all energy efficiency measures adopted in buildings are affected by certain factors which determine the effectiveness of the strategies. Subramanian (2007) identified these factors to be attributed to what constitute the bioclimatic design principles. They are as follows:

- Orientation and planning of the building
- Day lighting
- Wall shading
- Building shape, form and envelope
- Passive ventilation

2.7 DEFINITION OF A CONVENTION CENTER

The word convention, according to Encarta Dictionary (2009), can be defined as a gathering of people who have common interest or profession, people attending formal meeting or meeting to select a candidate. Sander (2005), defined conventions as big places attracting free spending visitors booking down town hotel rooms, eatery, theatres and other facilities. This necessitated the incorporation of these facilities in convention centers overtime. Industry standard definition for a convention center typically indicates a large event venue with three distinct types of space suitable for exhibition, meals and meetings. Typically, venues are referred to as convention centers if they include, at least, 2,250 square meter of dedicated exhibition space plus at least one ball room and one block of break out meeting rooms. Venues without any meeting or banquet space are usually referred to as expo centers. Venues with meeting and banquet rooms, but no exhibit hall, are usually referred to as conference centers. Most, but not all, convention centers are municipally owned and construction costs are financed through the use of

tourism related tax revenues such as hotel/motel, prepared food and beverage, car rental, and other related taxes. The primary intent of these venues is to attract out-of-town visitors and related spending to their host community.

2.7.1 Elements of a successful convention center

Asresult of the proliferation of convention centers, the competition to draw conventions is intense. The selection process for a convention site is complex and typically occurs three to four years before the convention takes place (Oppermann and Chon, 1997). When a site selection committee searches for a convention site it evaluates a myriad of factors such as the size of the center, the services offered by the center and the city, hotel accommodation accessibility, affordability, and the attractiveness of the city.

Size

The size of a convention center should be tailored to the segment of the convention market the city is attempting to attract. Size is a key consideration for national conventions and trade shows (Graveline, 1984). In an attempt to draw the nation's largest conventions there is a contest to see who can build the bigger, better convention center. Cities in the hunt for prize include Chicago, Orland, Las Vegas, New York, Dallas and Los Angeles.

Despite this trend among the major convention cities to expand their facilities in exponential proportions, bigger is not always better. Although size is an important factor, " It may, however, be less essential to attracting convention business than people generally realize, for there are, in fact many more small meetings than large ones (Luyacono, 1991).

Services

A convention center must also offer other qualities beside adequate exhibition space. As the competition to draw regional, national, and international conventions grows fiercer.

Convention centers need to be equipped with sophisticated technological capabilities such as interpretation equipment for multilingual conventions (Graveline, 1984). The convention center itself should be staffed with a professional management team experienced with facility operation and promotion. In order to increase revenue, some convention centers provide parking, exhibitor rental utilities, food and beverage services etc. (Kveline, 1984). Providing these services are not a necessary function of a convention center, however, in most cities businesses provide these services.

Hotel space

When evaluating a city as a possible convention site, a selection committee also takes into account the hotel accommodation offered by the city. David Peterson, managing director of the accounting firm price water house, maintains that a plentitude of high-quality hotel rooms within walking distance of the convention center is the essential requirement for attracting professional associations (Ghitelman, 1995). Therefore, convention centers should provide adequate accommodation facilities. In conjunction with that, it must offer a variety of restaurants and cafeterias.

Accessibility

In addition to providing adequate accommodation, a city convention center must also be accessible via major modes of transportation and have a good transit system within the city in order to draw large conventions. Convenience is a characteristic committee's look for during the site selection process. The location of the airport in relation to the convention center and the hotel is paramount. This makes it easy for convention attendees to cut distances in commuting between these facilities.

2.8 CONTEMPORARY TRENDS IN CONVENTION CENTER DESIGN

According to Professional Meeting Management (PMM5), fifth edition, (2007)), Michael McQuade and Julie Burford discuss convention centers and their operations. They further

discuss current trends affecting convention center design and operations; and discuss, in detail, the types of technology readily available at convention centers. The contemporary trends in convention center design thus include the following:

i. **Location:**

Convention centers are being built in better locations. Marla Lenhart quotes David O'Neal, chairman of a convention center development consulting firm, in her article Better design: "At one time, convention centers were built in blighted or outlying locations in hopes that they would encourage other developments. Now convention centers are being built in prime areas and on prime sites near hotels and attractions. They are part of an overall downtown package that makes the destination competitive". (Lenhart, 2007). They (convention centers) can be emblems of a city as well as useful for groups from all over the country", says Paul Peterson of phoenix convention center (Bjrtklie, 2007). In order to compete with large convention hotels, Convention centers have to package themselves with nearby hotels, restaurants and retail to create the "under one roof" convention experience. Proximity to all of the city amenities is key to a center's success. Prime real estate is now being utilized for convention Centre development and waterfront settings are becoming increasingly desirable (Professional Meeting Management, fifth edition, (2007)).

ii. **Sense of Environment (Place):**

Convention centers are incorporating local features and culture. Convention centers have a reputation of being big boxes. However that aspect is fast becoming a myth. For example the Palm Springs Convention Center has NativeAmerican and desert-inspired architectural details. During its 2005 renovation, the buildings entrance was re-oriented to face the surrounding mountains. Rick Leson, director of sales for the convention center states in Better by Design, "The aesthetics are important to attendee. They don't want to

plop down in a box. We give them sweeping views of the mountains in the pre-function areas" (Lenhart, 2007).

Convention centers are paying attention to interior and exterior architecture that reflects the culture of the community and the natural environment they are surrounded by.

iii. **New Form and New Function:**

As alluded to above, convention centers are no longer being designed as big boxes. Atriums, windows, grand entries and other design elements are incorporated into the latest architecture of convention centers. The traditional focus (or misconception) that convention centers are focused only on large meetings changes. While convention centers are purpose built spaces designed to hold meetings, trade shows and conferences, they are not only suited for large meetings. Some convention centers offer a range of space allowing a convention center to attract small meetings, smaller conferences. Many have separate meeting rooms on multiple levels and many breakout rooms. (Krist, 2007).

iv. **Small is the New Big:**

These are small conventions centers, in terms of both size and market. New facilities are being built in second and third tier markets. This small convention centers are typically built in cities or areas that attract less patronage andattendance. Below are international examples of small convention centers:

a) Bay front Convention Center (Pennsylvania)

b) Lancaster County Convention Center (Pennsylvania)

c) Branson Convention Center (Missouri)

d) Mississippi Telecommunications Conference and Training Center

The design proposal of this research is also for a convention center of this kind (Small in terms of size and market). In Nigeria, where level of patronage does not necessitate an international standard convention center.

v. **Package appeal**

Convention centers, as purpose-built space for meetings, make their money on meeting space. And in most cases that is all they control – their meeting space. However, convention center staff recognizes the importance of destination appeal, hotel pricing, attached hotels, hotel proximity to convention center and shopping facilities and restaurants in the area. Convention centers are also focusing on creating a more appealing meeting and trade show environment through attention to loading efficiency, building access, traffic separation, better sound and lighting systems and full-service business centers. This is, summarily, the use of high tech techniques for exhibition and tradeshows.

For example, the Georgia International Convention Center (GICC) is installing a high tech project that will allow convention- goers to fly into the airport, disembark their plane and arrive at the GICC without ever getting into taxi, bus or shuttle. The service is scheduled to begin late in the fourth quarter of 2008 (Mitchell, 2007).

The new Tahoe convention center facility when finished in 2009 will feature 56,000 square feet of retail and dining space (Bay, 2007).

vi. **Green**

In response to meeting planners and the communities they serve, convention Centers are focusing on the greening of meetings. They are making Improvements in recycling, environmentally conscious landscaping and energy saving(Sustainable) heat, lighting and air-conditioning.

Some centers have received the Leadership in Energy and Environmental Design (LEED) certification from the US Green Building Council.

For example, in Pittsburgh, the Lawrence Convention Center opened in 2003 following an international design competition and years of civic planning that set out to create a leading edge facility. With its gold-level LEED certification, the convention center

features natural ventilation, carbon monoxide sensors, a water reclamation system and skylights and glass walls that diffuse light and uniform temperature.

"This building makes you a little bit healthier" said Debbie Smucker, the center's director of sales and marketing. "Our public areas are blessed with natural light, the exhibit halls all have natural light and we have a ventilation system that can cool the building by pulling air from the Allegheny River." (Farmer, 2006).

The Metro Toronto Convention Center recently partnered with a show, Construct Canada, to produce a "zero waste" show. The event which drew nearly 23,000 attendees and 1,100 exhibits, recycled 26 tons of waste at a diversion rate of 95 percent. The remaining 5 percent consisted mainly of carpet scraps left by exhibitors. (Convene, 2007). Green roof technology is allowing facilities to contain heating and cooling cost and collect water for re-use in the facility operation. The Vancouver Convention and Exhibition Centers expansion project features a 6 acre living roof that when completed, will create a natural habitat for a wide range of native plants (Smith, 2007).

Indoor pollution is another concern. The World Health Organization and the U.S. Environmental Protection Agency have identified polluted indoor air as a significant public health concern associated with asthma, allergies, developmental and reproductive disorders, and cancer. According to Professional Meeting Management, fifth edition (2007), many convention Centers are working to improve indoor air quality by upgrading their ventilation systems.

2.9 SUMMARY OF FINDINGS FROM LITERATURE REVIEW

The chapter explored concept of bioclimatic design and confirmed it as one of the fundamental tool and strategy to achieve energy efficiency. The concept was perceived to be design of a building taking into account specific climatic conditions of a place to reduce environmental impact and optimize energy. It further studied the principle of

bioclimatic design and pointed out the role the trend utilizes in defeating the aim of the study.

Furthermore, it also reviewed in general the sources of energy consumption in buildings to be able to analyse how they can be modified to effectively realise the objectives of the research. Concept of energy as it relates to bioclimatic design was also studied to establish the common denominator between the trend and the proposed design. The result shows that, the bioclimatic design principles derived from the relevant study which include orientation, shading, passive ventilation, natural daylighting, renewable energy and appropriate materials are squarely the major factors that determine the effectiveness of any energy efficient strategy in buildings. These principles are hence the variables to be used for the case study analysis and subsequently the design proposal. The main objective of the orientation is to minimize the impact of sun on the building and the recommended orientation for hot climate is North-South. This improves the natural ventilation and lower energy bills. Proper shading also lower cooling load and improve thermal condition of the interior. This can be achieved using projected/recessed balconies, shading devices and landscaping. Natural ventilation can be achieved by having large window openings along the wind ward side of the building. Atriums, ventilation shaft and courtyards can aid stack ventilation. Also, water body and pool can enhance evaporative cooling and improve microclimate. These ventilation techniques have potential of saving energy. Lastly, appropriate choice of building envelope materials significantly affects the building thermal properties. Materials with low thermal conductivity and U-value should be used to reduce heat gain, improve indoor temperature and reduce cooling load. This makes the building energy efficient.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

Research methodology serves as the blue print of the research. It is the plan and strategy conceived so as to obtain answers to the research questions posted (Olaofe, 2010). For this study the case study research approach was adopted. Also, an evaluative research was used to test the effectiveness or otherwise of existing buildings as related to the concept under research.

In explaining what a case study is, Yin, (1993) suggests that the term refers to an event, an entity, an individual or even a unit of analysis. It is an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence. Anderson, (1993) sees case studies as being concerned with how and why things happen, allowing the investigation of contextual realities and the differences between what was planned and what actually occurred. It is also perceived as an intensive analysis of an individual unit stressing developmental factors in relation to context (Flyvbjerg, 2011). Thomas (2011), identified case study as the analysis of persons, events, decisions, projects or other systems that are studied holistically by one or more methods. Study by Lenmark (2005) showed that case study is a research approach, suited between concrete data taking techniques and methodological paradigms. Case study is not intended as a study of the entire organization, rather is intended to focus on a particular issue, feature or unit of analysis.Case studies become particularly useful where one needs to understand some particular problem or situation in great-depth, and where one can identify cases rich in information (Khairul, 2008).For the purpose of this study, the case approach therefore gives the opportunity to assess the research facilities on the issue related to bioclimatic design principles and energy efficiency.

Similarly, Kendra (2010) categorizes case studies into six types as thus; Exploratory, Descriptive,Intrinsic, Collective,and Instrumental. According to Yin. (1993), there are three types of case study research exploratory, descriptive, and explanatory.

This research adopted the descriptive type of case studies so as to compare the existing case with the pre-existing theories or principles of bioclimatic architecture or design and its effects on the energy efficiency in convention centres. Descriptive research asks questions about the nature, incidence, or distribution of variables; these are factors to be considered in any case study for proper analysis. In this research the factors to consider for example the bioclimatic design concepts or elements present in the building, nature of their applicability and its suitability to the environment (Jagdev, 2010).

3.2 POPULATION OF STUDY.

Population means aggregate area, object or element the research is expected to cover having interested characteristics to the researcher (Olaofe, 2010). The population for the study included three convention centres selected at local and international levels, and two office buildings and one institutional building from the region with similar climatic characteristics.

3.2.1 Sampling

Sampling involves selecting population elements which will represent the population of study (Amin, 2005). For the purpose of this research, the type of sampling used for the selection of the case studies was purposive sampling or deliberate sampling base on the following:

1. The bases of being a convention centre.
2. Climatic similarities
3. Presence of bioclimatic design features.

3.3 INSTRUMENT OF DATA COLLECTION.

The instruments of data collection used in this study are listed below:

3.3.1 Photographs

Photographs were taken of relevant case studies to ascertain the features of bioclimatic architecture they possess as well as the extent, to which they were applied, that is to say, if their extent of application was excellent, very good, strong, weak, very weak or non-existent.

3.3.2 Sketches

Sketches were made of some parts of the selected case studies. These sketches showed the spatial organization of some of the case studies.

3.3.3 Notes

These notes are in form of field forms outlining the variables of bioclimatic design in architecture as it relates to a convention center and some other public building types. Other methods of data collection in this study includes participant observation, and documentation analysis.

3.3.4 Visual survey

This is a method of data collection which uses physical observation and study of existing interested features using a checklist. The checklist is drafted out of a detailed literature review pointing out the critical issues. For the case of this research, it was done by looking and identifying what has been achieved by the already existing convention centers with reference to the applicable principles of bioclimatic architecture. The result is tabulated and buttressed with sketches and figures.

3.4 PROCEDURES FOR DATA COLLECTION

The procedure for data collection involved visits to three local case studies and taking visual analyses of their architectural features paying more attention to bioclimatic design principles. These buildings were then evaluated on the created field forms or field paper. However, the foreign case studies were gotten through the internet and their features evaluated on the field forms as well.The buildings will be documented and evaluated based on the bioclimatic design principles and features noticed in the cases, energy efficiency measures as well as building facilities of the convention centres visited as cases. Other relevant secondary data such as electric consumption records, design parameters, weather/climatic data will be collected and recorded accordingly to help in analysing the energy performance of the buildings using suitable method or software.

3.4.1 Case Studies

In this research, the case study is qualitative, the buildings chosen were based on their nature and individual characteristics with related peculiarities to the topic in concideration.The case studies selected for this thesis were sampled purposively on two bases:

1. As convention centers
2. As buildings having bioclimatic architectural design features.

3.4.2 Case Study Selection Criteria

When selecting a subject for a case study, researchers will therefore use information-oriented sampling, as opposed to random sampling (Flyvbjerg, 2006). According to Schon (1991), architectural solutions in practices are based on knowledge repertoire of cases either from personal experience or established model cases. The cases were purposively selected as suggested by Veal, (2006), which he described as purposive sampling. This

suggested that cases are identified for study due to their inherent qualities which were in consonance with the phenomenon under investigation. Oluigbo, (2010).

The case studies have been analyzed based on two aspects:

1. Descriptive analysis as convention centers
2. Analysis as buildings with bioclimatic design features.

3.5 VARIABLES OF STUDY

Scientists tend to call the properties they study variables.(Osuala, 1987). They are the parameters that researcher investigate. They are dependent on the research principles bringing out interested features in the case study. The variables to be used to assess the case studies are those that satisfy the research questions and found in the literature review. These variables will find out the bioclimatic design principles applied in the cases and their effect in optimizing energy efficiency. For the purpose of this research, it will be found under the major principles of bioclimatic architecture summarized below:

Variables

i. Orientation

i. Shading devices to reduce direct glare from the sun

ii. Use of passive design techniques for comfort

iii. Landscaping: use of water permeable landscape features, use of gardens and other soft landscape elements.

iv. Building materials: Rapidly renewable materials such as straw, bamboo and some woods and so on.

v. Photovoltaic system: solar panels to generate electricity for use when there is power failure on in interior lighting to reduce energy consumption.

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.

VARIABLES	FEATURES	METHOD OF APPLICATION	WEIGHT FACTOR	REMARKS
Orientation	Positioning of building in relation to climate	-	-	-
Shading devices	Use of shading devices to direct sun glare and heating.			
Passive design	Sufficient day lighting requirement.			
	Effect cross ventilation.			
Landscaping	Trees shading around and within the environments.			
Building materials	Materials that can be recycled which are locally available should be used to reduce impact.			
Photovoltaic systems	solar panels to generate electrical energy			

Table 3.1: Sample of the variables used for the analysis of case studies.

3.6 DATA ANALYSIS

Data collected on each case study was analyzed and represented in different forms this includes: A general documentation of the convention center; an assessment on the application of bioclimatic architecture principles and level of energy efficiency.

The method of study can be viewed in two aspects

i. As a case study unit of analysis:

The convention centers were studied and analyzed individually by the use of field forms which had a table containing design elements broken down under the applicable principles of bioclimatic architecture to convention center design. This study is to analyze each building studied and how each has applied the principles of bioclimatic architecture.

ii. As a case study research assessment method.

Based on the selected buildings, an assessment table on applicable principles of bioclimatic architecture was used to conduct a comparative analysis of all the convention centers studied in order to find out the extent to which bioclimatic architecture principles have been applied in the buildings.

3.6.1 Tables

Data collected on this research were documented and presented on the bioclimatic architecture case study assessment tables. Refer to tables under case studies (chapter five).

3.6.2 Figures

Data collected on the case studies were also documented in form of drawings, such as the convention centers site plans and floor plans if possible. Refer to figures under case studies (chapter four).

CHAPTER FOUR

CASE STUDY

4.0 INTRODUCTION

This thesis aimed to take a study of certain convention centres two local and one international and two office buildings and a building in Africa having similar climatic characteristics. As proposed earlier, the thesis would conduct a comparative study between the elemental factors of principles of bioclimatic design also looking at methods to optimize energy efficiency. It would also pay attention to other techniques used in energy consumption reduction.

4.1 CASE STUDY SELECTION CRITERIA

The case studies would be selected based on criteria of sampling technique known as purposive sampling. This method of sampling involves efforts which are made to verify that the object of study does in fact meet the criteria for being in the sample.

Case studies are the qualitative aspect of the research and were selected through purposive sampling by considering the selection criteria highlighted below. This method of study was seen in two ways:

i. As a unit of analysis where each selected sample were analyzed based on the breakdown of elements under the application of the principles of Bioclimatic design.

ii. As a research assessment method where a comparison were made of all the studies and the extent to which the principles of bioclimatic design have been applied.

4.2 CASE STUDY VARIABLES

Case study research in Architecture goes beyond the documentation and description of the physical characteristics of the built environment. Therefore, to give a full assessment of the selected case studies in the research, they have to be judged based on the research question or proposed design problem. This can be in the form of variables (dependent) that seek to point out certain features associated to the research principles as identified in the visual survey. The parameters for the variables which satisfy the research questions and are to be used to assess the case studies are;

i. Orientation
ii. Shading devices to reduce direct glare from the sun
iii. Use of passive design techniques
iv. Landscaping
v. Building materials

Other parameters or features that will be considered in the case studies include;

vi. Architectural Expression: this refers to the design form and concept applied in the design and its significance in energy reduction.
vii. Existing energy source: the present source of energy used in the running operation of the facility to be studied. If the facility is self-sustaining in energy usage, it will be regarded strong otherwise it will be regarded as weak.
viii. Renewable energy

ix. Scope of the facilities provided*:* this is basically referring to the spaces and equipment (that make up the whole facility) provided to ensure the facility functions `fully as intended.

4.3 METHOD OF ANALYSIS

The method of analysis of the case study is analytical and comparative study. A general documentation was done and analyzed based on the applicable principles after which conclusions are drawn out of analysis. The result are presented in tabular form and charts.

4.4 CASE STUDY ONE: INTERNATIONAL CONFERENCE CENTRE ABUJA

i. Location: Abuja, Nigeria.

ii. Architect: Albert Speer.

iii. Climate: Guinea Savannah

iv. Building Type: Conference Centre

v. Style: Modern architecture

vi. Construction system: Steel, Glass, concrete and aluminium



Plate 4.1: showing site view of ICCA. Source: Authors Google image 28/12/2013

4.4.1 Background

The Abuja international conference centre (AICC), was built in 1991 to host the extra ordinary session of the organization of African Unity Heads of Government meeting in Nigeria. As a magnificent edifice it overlooks the Radio House, "moulded" and lying in its own lovely garden filled with historical shady pine trees and well paved driveway. The new wing was designed by Albert Speer & Partner and built by Julius Berger Nigeria Ltd. However, it is a fully air-conditioned centre with interlinked but separate halls: the African Hall and Gallery, Foyer, the Mezzanine floor and Banquet hall.

The conference center is about 40km (25miles) from the Nnamdi Azikiwe international Airport and within a 5km radius of the major hotels in Abuja. The ICCA can accommodate up to 5,000 guest. Around 25-45 events are held in the centre on monthly bases.

In the last decade and a half the Centre has played host to several International, Regional and National political, social, cultural, economic and religious conferences, summits, meetings, seminars, ceremonies and programmes.

4.4.2 Architectural Expression.

The Abuja international Conference Centre embraces the high tech architectural quality of the use in glass and steel, it has a simple linear plan concept with a central lobby serving as the main access to the halls. The centre is a frame structured building covered by a lattice steel roof carried on certain number of large cylindrical columns while the wall was of aluminium cladding material.



Plate 4.2: Entrance View of Abuja ICCA Centre Source: Researcher's field survey

The building has a parabolic shaped roof of aluminum sheets with the national coat of arms on the facade and extensive glazing with four anodized double swing doors providing entrance to the building. The walls are covered with padded paper, carpe and concrete panels. The swing doors and windows are aluminum with floor finished in granite, ceramic tiles and rug carpets. The centre is architecturally designed to complement its surrounding environment, and enhanced by magnificent landscaping, complementing the Peace Park located adjacent to the centre.

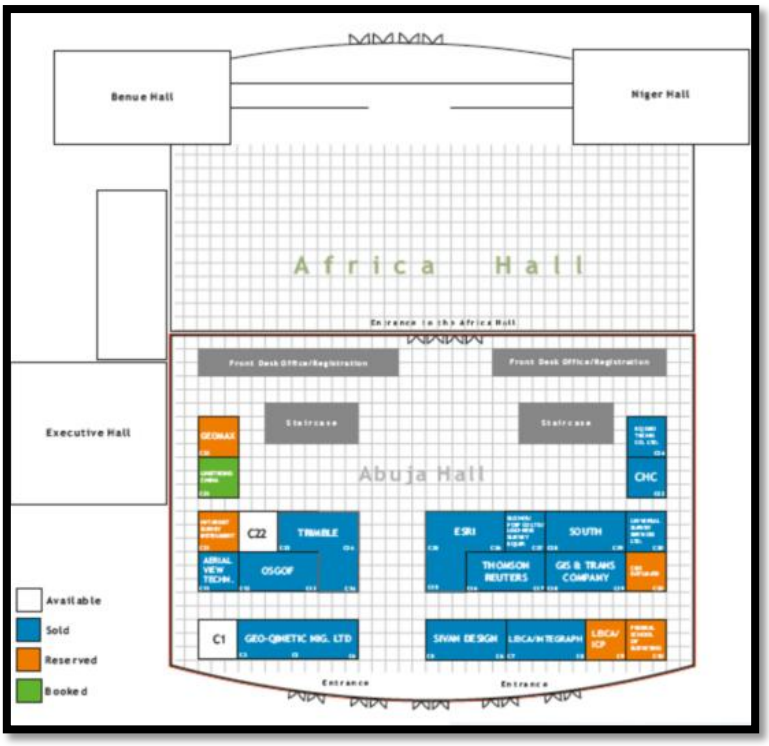


Figure 4.1: Sketch floor plan of international conference centre Abuja Source: Researcher's field survey 2013.

Orientation

The building is oriented towards the north and south of the cardinals with the shorter sides facing the east and west. This provides little exposure to excessive solar radiation and takes optimal advantage of the prevailing winds. The figure below shows a sketch of the positioning of the building on site with reference to the sun and prevailing winds.

4.4.3 Shading devices to reduce direct glare from the sun

The projected overhang of the parabolic roof shades the exterior walls and entrance of the centre from excessive incident solar radiation as the building entrance is oriented facing the west. The figure below shows the roof overhang shading the exterior wall.



Plate 4.3: Roof overhang shading the exterior wall. Source: Researcher's field survey

4.4.4 Use of passive design techniques

1. Natural ventilation

The functional spaces within the conference centre are virtually ventilated using mechanical system of central air conditioning system. The design was conceptualize to be ventilated mechanically. This increase the cooling and heating cost of the centre and other energy consumption equipment.

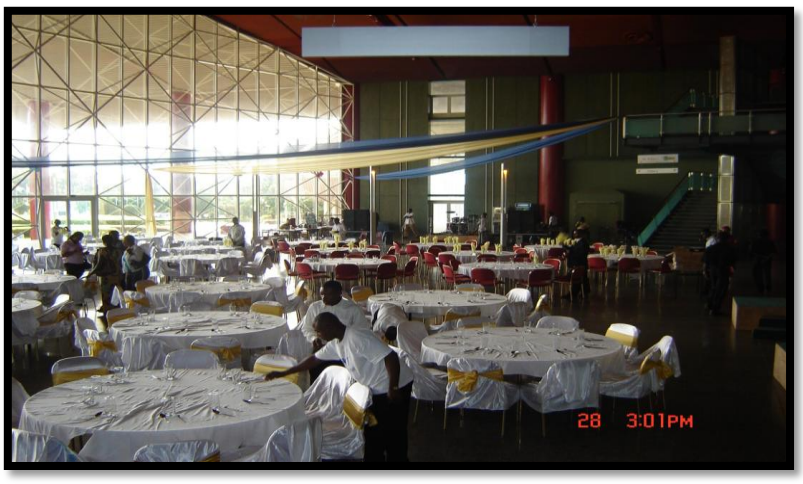


Plate 4.4: A view of the main entrance hall showing glazing for adequate daylighting
Source: Researcher's field survey

4.4.5 Landscaping

Soft landscaping elements are used to reduce urban heat island effect. Trees are used to reduce direct solar radiation and control wind speed as well as providing oxygen and fresh air. Other landscape elements are used to provide good vista and achieve green environment.



Plate 4.5: A view of the landscaped environment at the centre. Source: Researcher's field survey

4.4.6Building materials

The building materials are chiefly concrete for the panels and columns and steel structure supporting the glazing at the centre. The roofing is made from aluminum which is carried and supported by steel truss. The concrete walls are covered with padded paper.

4.4.7 Facilities at the Conference Centre

A Foyer with 2 Nos. offices, An outdoor Arcade, An Executive Session Room, VIP Lounge, Africa Hall (2000 seat main conference hall, occasionally converted to Banquet Hall) with attached kitchen facilities,Gallery (above Africa Hall 900 seat capacity), Snack Bar, 2 Nos. Committee Rooms (40-60 seat capacity), Aso Hall (100-250 persons

capacity) convertible to Press centre and communications studio. Other halls include niger and Benue halls with 100 capacity theatre sitting and finally the abuja hall with 700 capacity theartre sitting and 600 banquet sitting. There is also adequate landscaped parking spaces.



Plate 4.6: interior view of Niger Hall. Source: Researcher's field survey



Plate 4.7: Interior view of Benue Hall. Source: Researcher's field survey

4.5 CASE STUDY TWO; YAR'ADUA CENTRE

i. Client: Shehu Musa Yar Adua Foundation.
ii. Location: Maitama- Abuja.
iii. Architect: Triad Associates.

iv. Contractor: Julius Berger Nigeria Plc.

v. Construction date: 2000 – 2002.

vi. Context: Urban.

vii. Climate: Tropical.

viii. Construction : concrete, steel, glass and blocks



Plate 4.8: Site view showing Yar'adua centre. Source; Google earth, 28/12/2013

4.5.1 Background

The yar'adua centre was founded in March 2002, Musa yar'adua international centre is located in the central area of Abuja about 500 meters from the Sheraton Hotel, Abuja. Has a size of 110 x110 meters providing a floor area of approximately 10,000sqm. The centre provides an exhibition hall with an impressive and professional permanent exhibition presenting the life story and achievements of the late Shehu Musa Yar'adua.

The building has an architectural feature at the facade which is an unfinished bridge, however during an interview according to the director "late Yar'adua was a bridge builder" and the bridge stands as a symbol of Shehu Musa yar'adua's life, work and legacy to remind Nigerians of the need to continue the struggle for fairness and social harmony in the society.



Plate 4.9: Exterior view of Shehu Musa Yar'adua Centre. Source; Researcher's field work

4.5.2 Expression.

Shehu Musa Yar'adua centre is structure with all its facilities being accessed through the central atrium. The architecture is modern, having an open square plan covered by large dome of glass material. This provides natural illumination into the atrium.

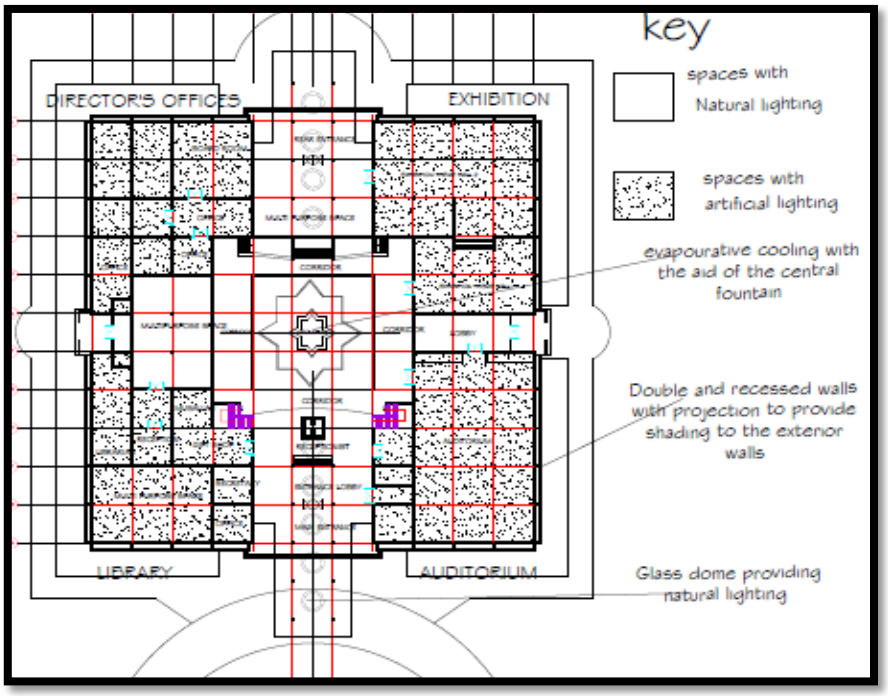


Figure 4.2: A sketch plan of Yar'adua Centre Source: Researcher's field work

4.5.3 Orientation

The building is square in shape occupying about 25% of the site. It is positioned to take advantage of the prevailing winds and north light. Hence effective lighting and ventilation is achieved in the atrium. This is shown in the figure below.

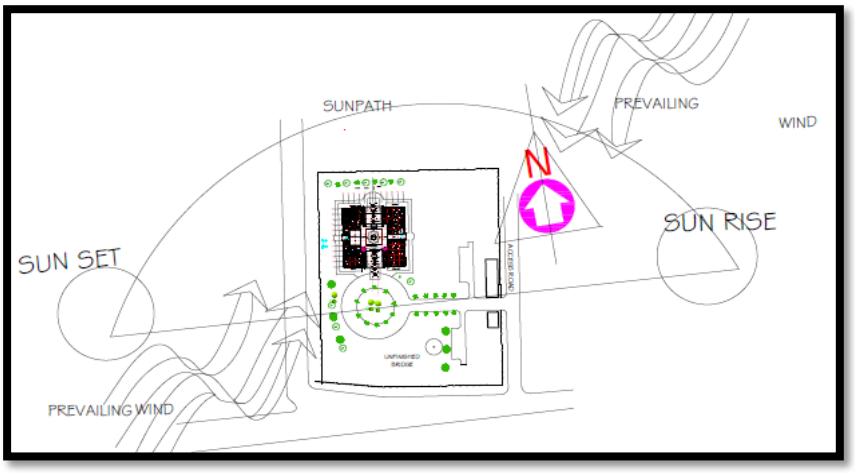


Figure 4.3: Sketch site plan of the centre Source: Researchers field work

4.5.4 Shading devices to reduce direct glare from the sun

The centre is designed to have double walling system with recessed walls to shade the external walls against excessive solar radiation. Centre's dome possess shading projection which protects against solar glare.



Plate 4.10: Double walling with exterior recess. Source: Researcher's field work

4.5.5 Use of passive design techniques

a. Natural ventilation

The cooling system in the central atrium is natural using stack ventilation. This is achieved through the openings at the sides and entrance which are usually opened. The high level windows in the glass dome. (See figurebelow).

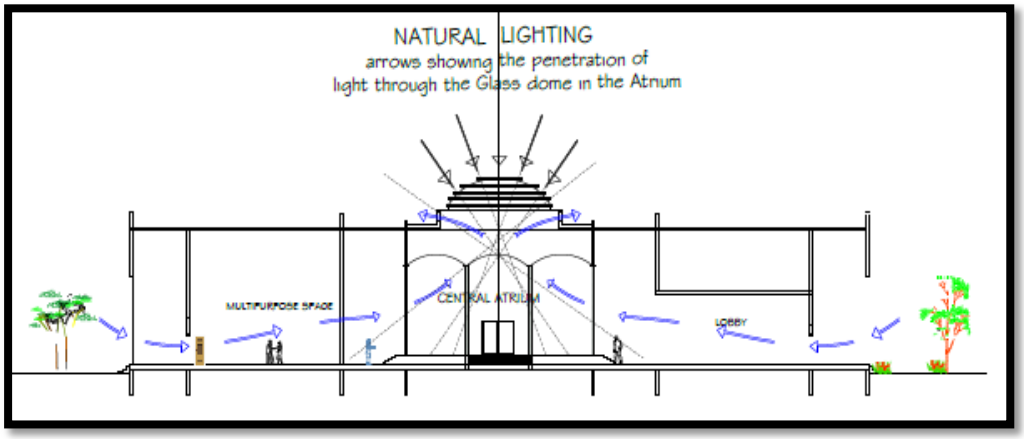


Figure 4.4: A sketch section through the centre Source: Researcher's field work

Evaporative cooling is also achieved in the atrium with the aid of airflow in the fountain. On the other hand, the cooling strategy in the auditorium and other offices is artificial using central air conditioning system.

b. Day lighting

The glass dome was used to achieve adequate lighting in the central atrium which has a capacity of 1000 plus for banquet activity and exhibition. This is used as energy saving measure to cut down the cost of lighting the huge spaces. In the interiors of offices, auditoriums and library, artificial lighting is mainly used.



Plate 4.11: Glass dome in the central atrium Source: Researcher's field work

c. Landscaping

Soft landscaping elements are used to reduce urban heat island effect. Trees are used to reduce direct solar radiation and control wind speed as well as providing oxygen and fresh air. Other landscape elements are used to provide good vista and achieve green environment.



Plate 4.12: Soft landscaping and pavements in the center. Source: Researcher's field work



Plate 4.13: site view showing soft landscape and pedestrian paved way. Source: Researcher's field work

d. Building forms

Design concept is to be simple, elegant and oriented towards the Central Mosque. It echoes the central mosque square plan form and some architectural features such as the dome only in this case made from glass to symbolize Yar'adua's legacy of transparency in public affairs.

4.5.6 Building materials

Glazing materials used such as acrylic skylight dome and window glazing and openings. Flooring material of polished ceramic floor made of recycled earth. Masonry and concrete block work from processed earth material. Glass, aluminum cladding, Sand Crete double wall.

i. Facilities Provided

Exhibition Halls; The exhibition halls at the Shehu Musa Yar'Adua center are designed to accommodate up to 800 guests. It also showcases an inspirational multimedia presentation of the life of Shehu Musa Yar'Adua titled " A Life of Service" against the backdrop of Nigerian history, from colonialism to present day democracy.



Plate 4.14: Interior view, at entrance lobby of Yar'adua Centre, Abuja.
Source: Researcher's field work

Olusegun Obasanjo Research Library

The Research library entail the collection of books, journals and periodicals aided by the expansive reading room serve as a resource for students and scholars

engaged in research in the areas of economic development, education, gender equality, democracy, governance, conflict resolution, human rights, Nigerian, African and world history as well international and Nigerian law.

Atiku Abubakar Auditorium

The Atiku Abubakar Auditorium is capable of seating 450 people comfortably in a conference arrangement and seating 250 people in the banquet style arrangement.



Plate 4.15: An interior view of the Auditorium Source: Researcher's field work

Meeting Rooms

The Shehu Musa Yar'Adua center has 3 meeting rooms which have the capacity to hold 50, 20 and 15 people respectively.

4.6 CASE STUDY 3: AHMADU BELLO UNIVERSITY SENATE BUILDING

i. **Client:** Ahmadu Bello University.
ii. **Location:** A.B.U- Zaria.
iii. **Architect:** Yusuf Muhammad and Associates
iv. **Contractor:** share and partners
v. **Construction date:** July 1980.
vi. **Context:** Urban.
vii. **Climate:** Tropical.
viii. **Construction :** concrete, glass and blocks

4.6.1 Orientation

The building is oriented along NE (North east) and SW (South west) of the cardinal having minimal exposure to solar radiation. It is oriented to take advantage of the prevailing winds to achieve natural ventilation as can be seen in the figure below:

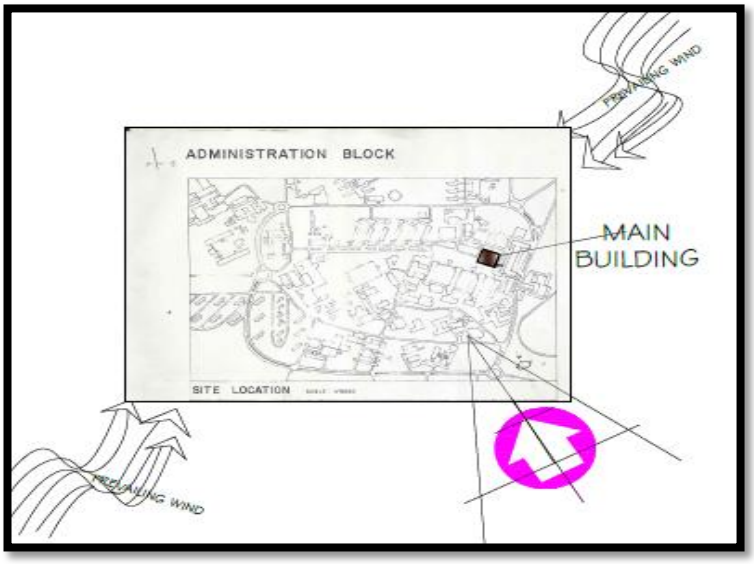


Figure 4.5: Building location. Source: Estate Department, Ahmadu Bello University Zaria.

4.6.2 Shading devices to reduce direct glare from the sun

Vertical and projecting horizontal concrete louvers on all elevations were used to reduce solar radiation in the building. (See plate and figure below). Also, insulated concrete roof with reflective finish to build up roofing insulation and reduce heat absorption.



Plate 4.16: concrete louvers for shading the building in all facade. Source: Researchers field work 2014.

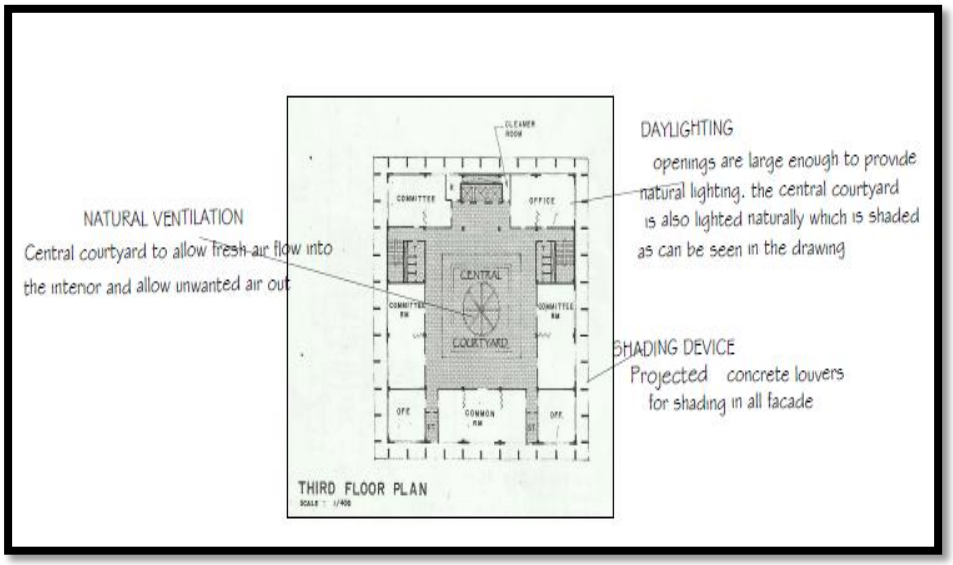


Figure 4.6: Floor plan of ABU Senate building. Source: Estate Department, Ahmadu Bello University Zaria.

4.6.3 Use of passive design techniques

4.6.3.1 Ventilation

The ventilation system is natural only for some offices that uses mechanical system. The central air condition is also used in the offices from second floor to eight floor. Natural ventilation is achieved by use of central courtyard and horizontal windows.

Stack ventilation is achieved in the central hall connecting the stairs and lift lobby as well as the first floor using the podium and tower as can be seen in the figureBelow

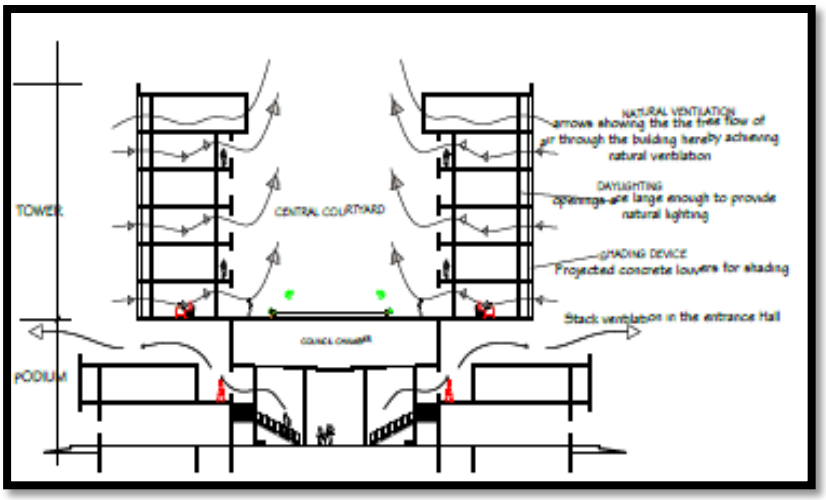


Figure 4.7: A sketch section through the administrative building showing air flow
Source: Researcher's field work, (2014)



Plate 4.17: The central courtyard of the senate building. Source: Researcher's field work 2014

4.6.3.2 Lighting

Natural lighting is achieved using the central courtyard and exterior openings which can be seen on all façade of the building. There is adequate lighting in the offices even without the use of artificial means only for the stair lobby in the first floor and other circulation spaces that are nearly dark even during the daytime. See figure below

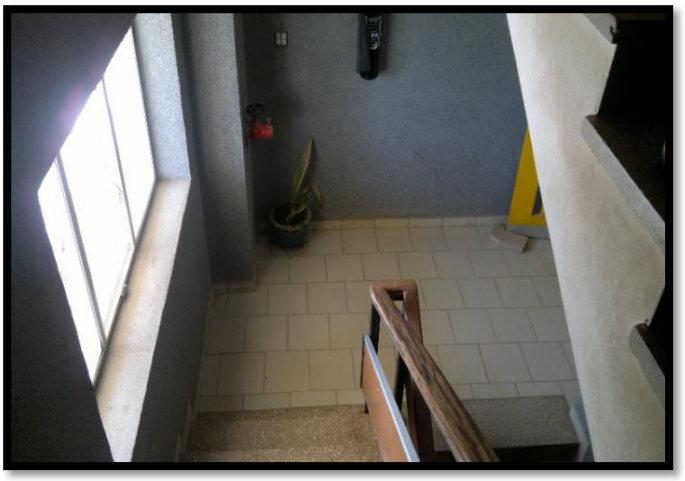


Plate 4.18: Natural lighting in the stair hall Source: researcher's field work 2014

4.6.3.3 Landscaping

The building is surrounded by **s**oft landscape elements. Trees and shrubs were planted to control movement and modify the micro climate by providing fresh air and good vista. However, hard landscape elements such as pavements were used which contributes to urban heat island effect. This can be seen in the plate below



Plate 4.19: View of landscape around the senate building. Source: Researcher's field work 2014

4.6.3.4 Building form

The building is square having a Podium and Tower. The podium constitutes the ground and the first floor. The tower is raised above the podium using structural columns and beams. It is in form of reinforced concrete frames with concrete floors and roof having a central courtyard to provide adequate ventilation and lighting.

4.6.4 Building materials

The structural system is chiefly concrete with the sand Crete block partitions and external walls. The finishes include: painted sand/cement render to vertical and horizontal louvers and Sandtex to walls, grand terrazzo and PVC tile floor finishes and Aluminum horizontal pivoting glass windows.

4.7 CASE STUDY 4: PALM SPRING CONVENTION CENTER

Architect: Originally designed by Arc. William Pereira, expansion design by Fentress Architects using principles of Critical Regionalism

Location: Palm Spring, California-U.S.A

Building Type: Institutional **(**Standard Convention Center)

Construction System: Masonry/Concrete Structures

Climate: Hot-Dry

Style: Critical Regionalism

4.7.1 Background

The Palm Springs Convention Center is a 22,800 sqm facility located in downtown Palm Springs, California, USA. It was originally designed in 1974 by Architect William Pereira. The Palm Springs Convention Center recently completed a massive expansion, adding over 9,300 sqm. It can now accommodate groups from 12 to 12,000 people, depending on the configuration. The new design, by Fentress Architects, pulls colors and design elements from the surrounding desert; a design approach known as Critical Regionalism. Of great importance is the site features from which design influences were generated. Critical Regionalism emphasizes reflecting environment in design. This makes the trend suitable for design in Palm Spring.

Palm Springs is a desert city in Riverside County, California, within the Coachella Valley. Its topography is sheltered by the San Bernardino Mountains to the north, the Santa Rosa Mountains to the south, by the San Jacinto Mountains to the west and by the Little San Bernardino Mountains to the east. This geography gives Palm Springs its hot, dry climate, with 354 days of sunshine and only 122.7 mm of rain annually. The winter months are warm, with daytime highs often between 23 and 30 °C and corresponding nighttime lows of 10 to 16 °C while the coolest days tend to average from 17 and 22 °C), and corresponding nights falling to the mid 7 to 9°C. This approach is what makes it suitable as a case of study in this research having similar climatic characteristics as that of the location of this study. The geographical features of the area, resident colors and elements are what Fentress Architects utilized in the application of Critical Regionalism for the design.



Plate 4.20: Entrance Porch to Palm Spring Convention Center, Palm Spring, California, U.S.A, showing regional vernacular elements. (Source: http://www.palmspringscc.com)

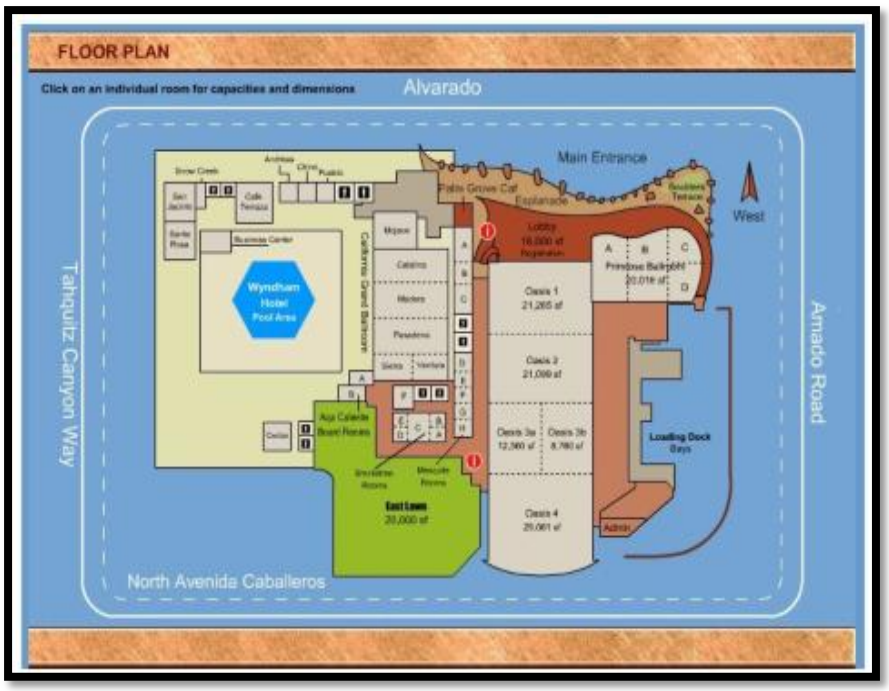


Figure 4.8: Floor plan of palm spring convention Center, USA
(Source: http://www.palmspringscc.com)

Here the emphasis is not on the critical regionalism, rather it is placed on the facilities to see how they can be explored in the design. This canbeusedtocomeupwithuser spaceneeds, aspirations and requirements. Briefly speaking, Palm Spring Convention Center have the following features:

Up to 10080 squaremeter of exhibit space.

I. 19 total breakout rooms of various sizes.

ii. A 1800 sum ballroom.

iii. A carpeted exhibit hall divisible into five sections

iv. New 1620 square metre state-of-the-moment lobby with panoramic Mountain views

v. 9-bay loading dock

vi. Scenic outdoor function area for memorable dining and receptions

vii. Swimming Pool

4.8 CASE STUDY 5: MENARA MESINIAGA (BIOCLIMATIC SKYSCRAPPER)

i.	**Client:**	IBM Headquarters.
ii.	**Location:**	Selangor, Kualalumpur, Malaysia.
iii.	**Architect:**	Ken Yeang
iv.	**Construction date:**	1992.
v.	**Context:**	Urban.
vi.	**Climate:**	Tropical (Hot dry)
vii.	**Construction materials:**	concrete, glass.

4.8.1 Background

The building visually define the high-tech architecture style, conceptual organic architectural disposition and a bioclimatic skyscraper. It is meant to give a progressive environmentally responsive building that increase the surrounding land value, energy saving, climate consciousness and improved occupancy comfort. It is a sixteen storey office tower, cylindrical in form and a distinct tripartite structure.

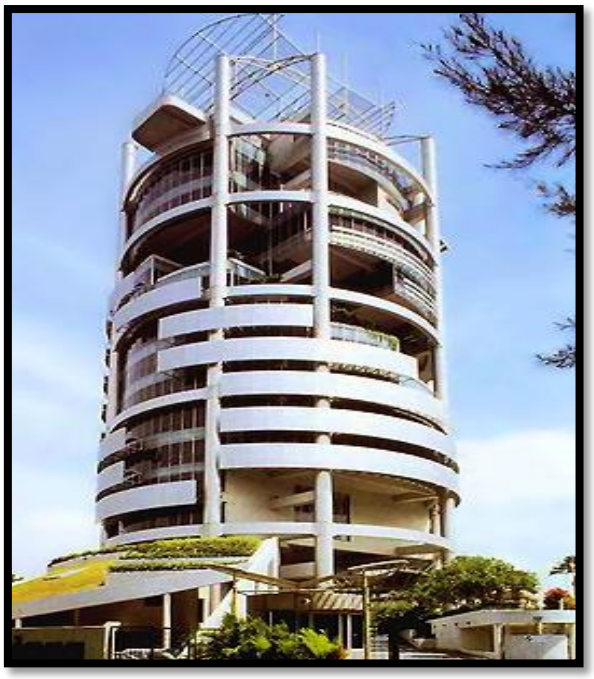


Plate 4.21: Entrance of the Menera Messiniaga showing the architectural features. Source: (http/: www. Menara messiniaga.com)

The body is a series of spiraling floor plates with landscape terraces and external louvers that shades the offices spaces. Steel trellis rotates about a central axis (core) of the building. At the top, the tower is capped with a cantilevered pool terrace and an overhanging gymnasium. It is oriented for maximum environmental efficiency shading against direct overheating and allowing for natural daylight.

The extension of the land that begins at the sloped berm spirals up to the height of the building with planted terraces that culminates the inhabited roof top. These terraces shades the building and also provide vertical garden.

4.8.2 Orientation

The building is circular in form with the service core facing the east there by shading the building and achieving natural lighting in the stairs and toilets. This can be seen on the figure below. The roof top trellis is a steel structure designed to support solar panels to

compliment the energy supply in the building. This is oriented along the north to maximize the sunlight path from east to west as can be seen.

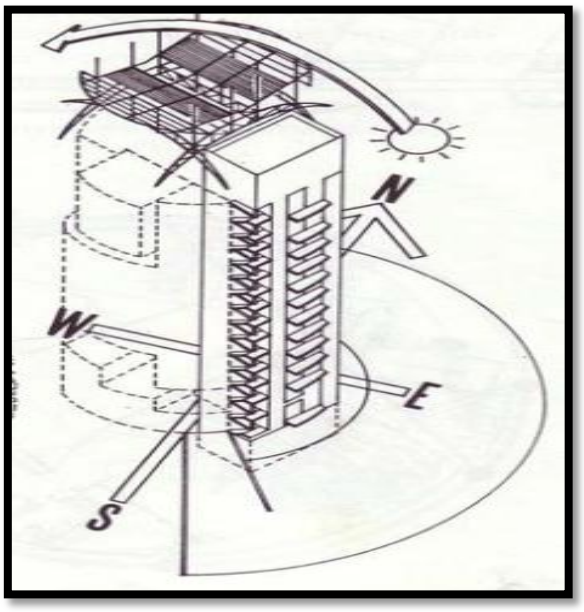


Figure 4.9: solar orientation of the building in relation to the cardinals.
(Source:http://www.menear messiniaga.com)

4.8.3 Shading devices to reduce direct glare from the sun

The building is shaded using the aluminum fins shading device placed approximately 50cm away from the building face to shade against the excessive overheating. The outdoor terraces with green plants shade the windows and increase oxygen production which improves the microclimate of the office space.



Plate 4.22: Shaded outdoor terraces. (Source: http/: www. Menara messiniaga.com)



Plate 4.23: projected aluminum panels for shading the building in all facade.
(Source: http/: www. Menara messiniaga.com)

4.8.4 Use of passive design techniques

4.8.4.1 Ventilation

Natural ventilation is achieved in the office space through the courtyard system. The outdoor terraces that goes up to its roof top and gymnasium allow fresh air into the building. also, the swimming pool at the roof top enhance evaporative cooling as the air

speed is very high at that level, the water will cool all dusty winds passing through the building and improves cooling of the interior space.



Plate 4.24: Outdoor employee swimming pool shaded by steel structure supporting solar panels. (Source: http/: www. Menara messiniaga.com)

4.8.4.2 Lighting

Natural lighting is achieved through the central courtyard. The curtain wall also allow adequate light to pass through the interior office spaces.

4.8.5 Landscaping

The building surrounding is well landscaped to reduce urban heat island effect. Trees were placed in the east and west side to reduce heating. The building also incorporate vertical landscaping of plants to improve the climate at various levels and increase oxygen production. This can be seen in the section below.

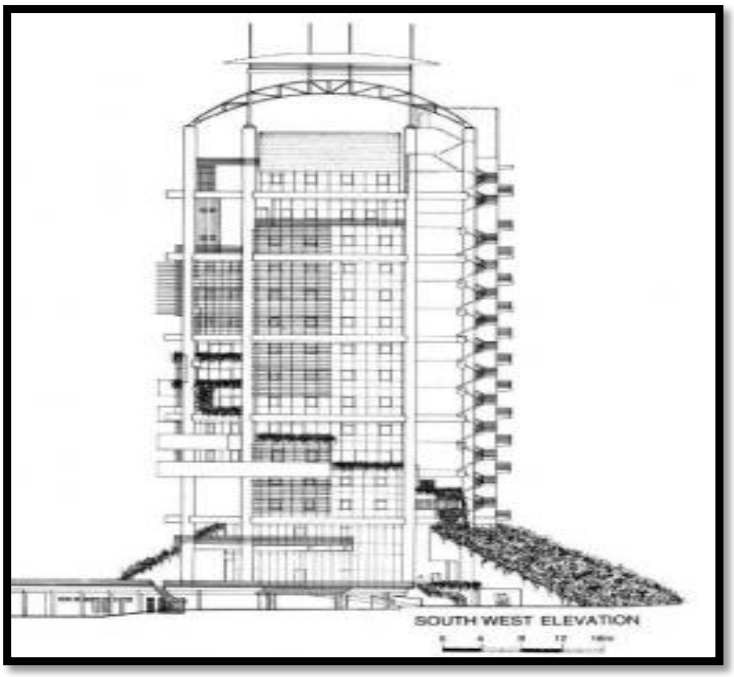


Figure 4.10: Section through the building showing the vertical landscaping at various level. (Source: http/: www. Menara Messiniaga.com)

4.8.6 Building materials

The buildings materials are locally available reducing the embodied energy. The materials are customized to have thermal property of reducing overheating especially the glass used for the curtain wall. The finishes in the walls have good reflecting property which reduce incident ultraviolet rays that may cause overheating in the interior of the building.

4.9 CASE STUDY 6: GANDO PRIMARY SCHOOL

i. **Location:** Gando Village, Burkina Faso
ii. **Architect:** Diebedo Francis Kere
iii. **Building type:** Institutional (School).
iv. **Building Style:** Regionalism and bioclimatic.
v. **Climate:** Tropical (Hot Dry).
vi. **Construction:** Sun dried mud bricks, concrete and steel.

4.9.1 Background:

The concept of the building is to achieve an architectural piece that is adaptive to the economic situation of the village, needs of the people, responsive to the prevalent climatic conditions and achieving sustainability. The architect considered the climate and got the impression of his design to be compatible with the climate. It determines the building form, orientation and materials used in the construction. This is what makes this case study suitable for this study.

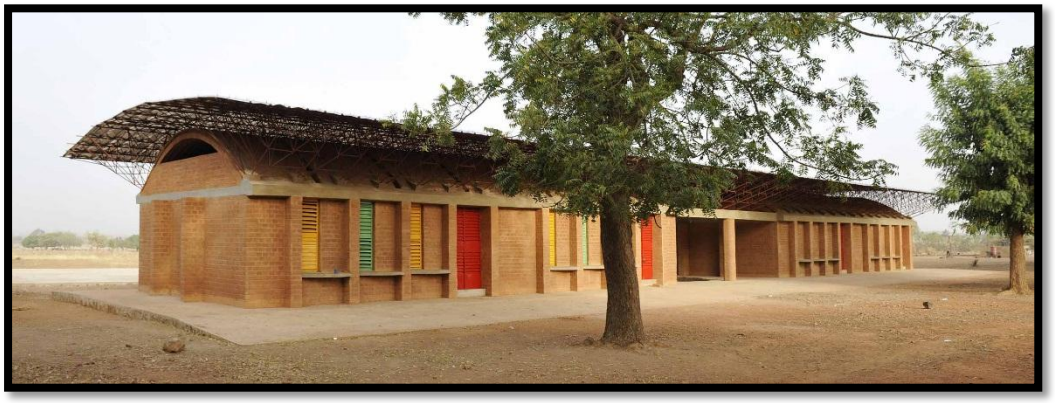


Plate 4.25: View of the Gando School showing the structure.
(Source: http://www.Gandoschool.com)

The site allocated for the school was 30,000sqm including the sport fields and garden. The building occupies 526sqm. It is a rectangular volume, set on a platform raised 50cm from the ground. The walls are built of stabilize earth bricks. These are ribbed with pilasters for further structural soundness and to provide solar protection from the east and west, they also enhance the three dimensional quality of the walls.

4.9.2 Orientation

The building is oriented along N (North) and S (South) of the cardinal having minimal exposure to solar radiation. It is oriented to take advantage of the prevailing winds to achieve natural ventilation. The teacher's houses were oriented to shade one another at

same time taking advantage of the prevailing winds. This can be seen in the figure below:

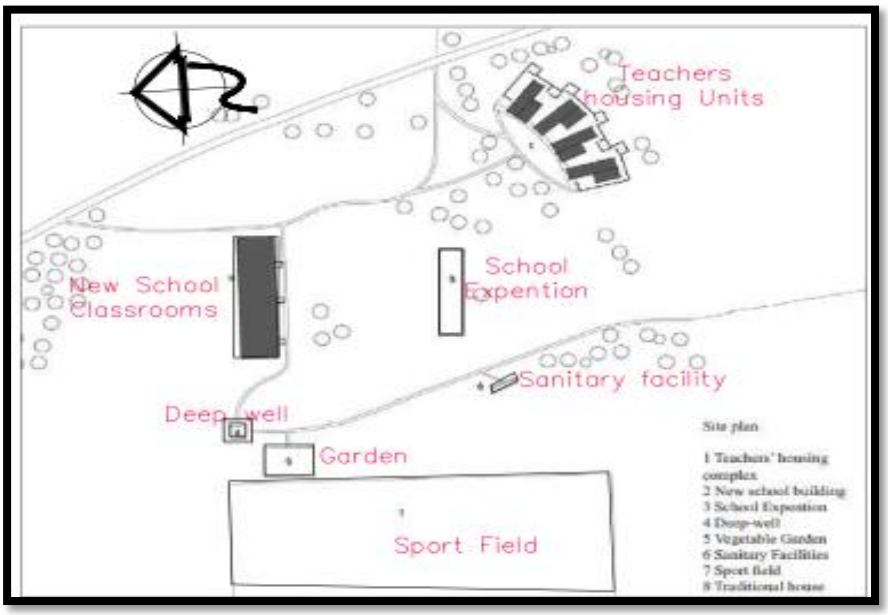


Figure 4.11: site plan of the school showing orientation and spatial organization. (Source: http://www.Gandoschool.com)

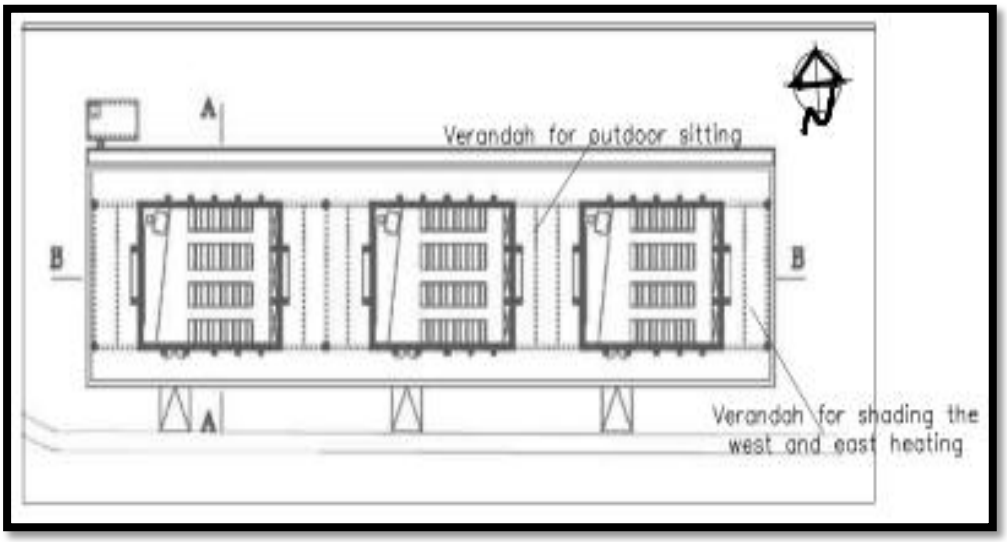


Figure 4.12: floor plan of the classrooms showing the orientation. (Source: http://www.Gandoschool.com)

4.9.3 Shading devices to reduce direct radiation from the sun

The building is shaded by the large roof overhangs supported by the roofing structure. The veranda between the classroomsshades the east and west solar radiation.



Plate 4.26: the large roof overhang shading the walls. The verandah in the west shadesthe exterior walls as well. (Source: http://www.Gandoschool.com)

4.9.4 Use of passive design techniques

4.9.4.1 Ventilation

The ventilation system is natural enhance by the use of abundant shutters on the northern and southern walls. This makes the windows exposed to the prevailing winds and shaded away from the west and east sun. This can be seen on the plan above as well as the section below.

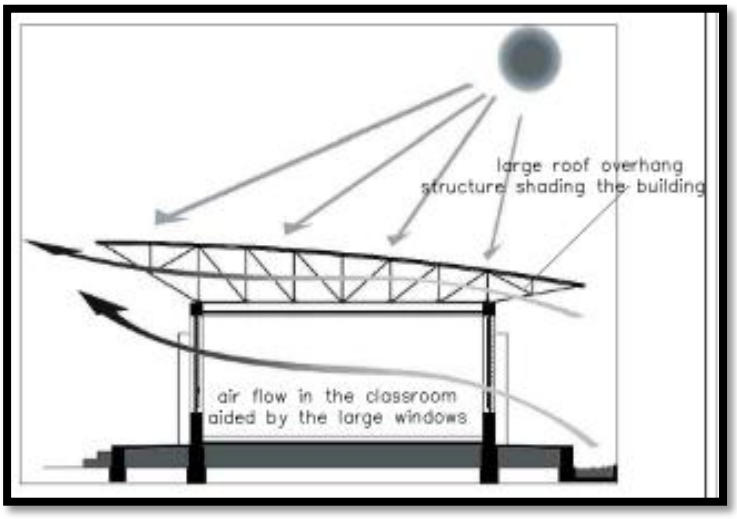


Figure 4.13: A sketch section through the building showing air flow. (Source: http://www.Gandoschool.com)

4.9.4.2 Lighting

Natural lighting is achieved using the big shutters windows on the sun path direction i.e. north. The windows have void screens that allows for uninterrupted light passage into the classrooms for effective academic activity. This is shown in the figure below.

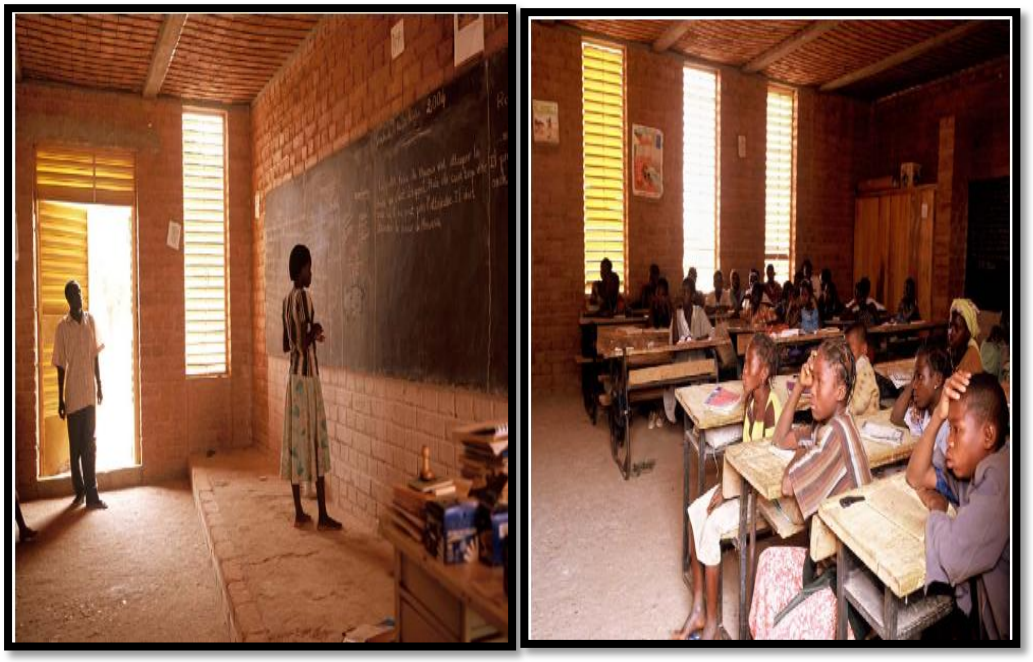


Plate 4.27: Natural lighting in the classrooms. (Source: http://www.Gandoschool.com)

4.9.5 Landscaping

The site is surrounded by sparse soft landscape elements. Trees were planted to control movement and modify the micro climate by providing fresh air and good vista. This is not adequate considering the size of the site relative to the buildings.

4.9.6 Building materials

The main structural system is chiefly concrete with the stabilized earth bricks partitions and external walls. The concrete is used to form the structural columns and beams. The ceiling is a suspended clay brick structure to reduce heating of the classrooms. The roof

structure is a frame work of steel girders welded to reinforcement steel. This can be seen below.



Plate 4.28: a view showing the building materials and construction technology employed. (Source: http://www.Gandoschool.com)

4.10 General Summary of Case Study Results

This presents the summary results found in all the case studies looking at the general facilities provided based on the contemporary design requirements in convention center.

The case studies are successfully carried out for two purposes: One is identifying bioclimatic design features and explore how they could be applied to satisfy the variables. Also, identifying the energy consumption sources as well as energy efficiency measures if provided. The other is the exploration of different types of spaces and facilities a convention center should have, and the different types of public events that require a convention center within Kaduna State in particular and Nigeria at large. The summary of case study results is as follows:

I. **Event Types**

From the cases studied, the findings reveals the following events to be the most frequent:

a) **Ceremonial Events**

i. Receptions

ii. Weddings

iv. Launching

b) **Religious Events**

i. Meetings

ii. Book Launch

iii. Qur'an Commentaries (Tafseer)

iv. Lectures

c) **Official Events**

i. Workshops

ii. Seminars

iii. Conferences

iv. Meetings

d) **Voluntary Associations**

i. Corporate Meetings

ii. Celebrations

iii. Party

The above events are fished from the regional scope. The literature review andsome cases studied revealed that for a convention center to meet internationalcontemporary standards, it must be able to host tradeshows, exhibitions,colloquiums, banquets and festivals.

II. **Facilities/Spaces**

These are drawn from some study cases and literature review. Thefollowing facilities are found to be necessary for a standard conventioncenter:

a) Exhibition hall/Space

b) Lobby/Reception/Waiting

d) Conference hall

e) Executive meeting halls

g) Amphitheatre

i) Banquet hall/Space

j) Administrative Offices

k) Kitchen and Eatery

l) Outdoor courtyard/Garden

m) Lodgment

n) Sports/Games Facility

IV **Energy consumption sources**

Energy consumption in the case studies largely come from areas of cooling using air conditions and chillers. The energy consumed for lighting is minimal even though significant percentage of the buildings studies have minimal energy saving bulbs. Other appliances like computer, refrigerator, office water heaters, fan, and television e.t.c are areas of energy consumption which cannot be effectively measured considering the scope of facilities and lack of accessibility to the appropriate data.

V **Energy efficiency/ Renewable energy measures**

There is virtually no significant level of exploring energy efficiency measures in the various case studies. The research proposal should take this into consideration to optimize energy use. The common renewable energy strategy used is solar panels. This should also be recommended for the design proposal as it will effectively harness the abundant sunlight in the region of Kaduna (Hot dry) with high intensity of solar radiation.

VI **Bioclimatic design principles applied**

This is discussed under the principles outlined in the previous chapter for the analysis of the different case studies. A summary of the common /general features in each case is drafted as thus;

a) Natural ventilation

This was achieved using the large windows along the wind ward side of the cardinals. Courtyards were also applied to aid effective natural ventilation. Stack ventilation is also noticed as in the case of A.B.U senate building and messiniaga in Malaysia. Other design features that will aid ventilation is water body which can aid evaporative cooling and remove dust in the north east wind that normally blows from the Sahara.

b) Orientation

From the study, reasonable percentage of the case studies achieved proper orientation. The recommended as established in the literature review is North-South orientation which gives minimal exposure of the building external walls to excessive solar radiation.

c) Shading

Shading devices inform of projected steel fins covered with aluminum panels were used. Other strategies used for the shading are proper positioning of the building for minimum exposure. Balconies, large roof overhang, verandahs were also incorporated together with effective landscape elements. These are believed to provide significant reduction of the amount of radiation reaching the building envelope. These strategies were also recommended as established earlier in the literature review.

d) Natural daylighting

Glass atriums and courtyards were used to provide adequate lighting. With proper planning and orientation, natural lighting can be enhanced.

e) Building materials

Materials like concrete, steel, glass and sandcrete blocks were largely used. This increase the embodied energy of the building. Other local indigenous materials

with high thermal capacity like bricks, stabilized earth were used to enhance the microclimate of the building. These materials should be recommended for the design proposal giving much emphasis to the high thermal capacity materials with high time lagging property considering the climatic characteristic of the region under study.

Table 4.1: **Summary table for case study results**

CASE STUDY	ORIENTATION	NATURAL DAYLIGHT	NATURAL VENTILATION	BUILDING MATERIALS	EXISTING ENERGY SOURCE	ENERGY EFFICIENCY
INTERNATIONAL CONFERENCE CENTER ABUJA	The building is well oriented to take advantage of prevailing winds and minimize exposure to solar radiation	There is little daylight achieved in the building main entrance banquet facility and the passage along the hall	This is not adequately achieved as some functions are cooled using air condition	The building is chiefly concrete, steel and glass	Energy from the national grid and mechanical generator	No noticeable energy efficiency/renewable system applied
SHEHU MUSA YARADUA CENTER	The building is not properly oriented, it is square in plan and having equal exposure to all the cardinal	Natural daylight was achieved in the central atrium used for exhibition and other banquet activity	Natural ventilation achieved in the central atrium however, other functional spaces are ventilated/cooled using mechanical air condition	The major building materials are concrete, glass, steel and sandcrete blocks	Energy from the national grid and mechanical generator	No noticeable energy efficiency/renewable system applied
AHMADU BELLO UNIVERSITY SENATE BUILDING ZARIA	Square in form, diagonally facing the north and the other diagonals facing east-west respectively	Natural daylight was achieved in the central atrium used for exhibition and other banquet activity	It is achieved using stack ventilation system enabled by the podium and tower, this provide adequate natural cooling in central courtyard and entrance hall, while in the office, it is achieved with the aid of large windows on exterior walls	The major building materials are concrete, glass, steel and sandcrete block	Energy from the national grid and mechanical generator	No noticeable energy efficiency/renewable system applied
MENARA MESSINIAGA (BIOCLIMATIC SKYSCRAPER) MALAYSIA	The building is circular oriented with the service core shading the east sunlight and the north-east is glassed to receive little sunlight. In this type of orientation, there is equal exposure to solar radiation on all sides	Natural daylight was achieved with the use of large windows openings oriented along the north	Natural ventilated service core and offices which is enhanced by the central courtyard and windows	50% of the building materials are manufactured locally, this reduce the embodied energy of the materials and makes it energy efficient	Energy from the national grid, mechanical generator and renewable energy	Renewable energy of solar panels where used to generate which is about 20% of the anticipated total energy used by the building

GANDO PRIMARY SCHOOL, GANDO VILLAGE, BURKINNA FASO	The building are well oriented to take advantage of the prevailing winds and reduce solar radiation	Achieved through the windows oriented along the sun path (ie north) on the perimeter walls	Natural ventilation achieved with the use of proper orientation and large fenestration on all external walls.	Local indigenous brick (banco) having high thermal mass and time lagging which reduce the adverse indoor temperature and improve comfort	Considering the nature of the facility (local school), it does not use energy from either national grid or generator	No renewable energy efficiency system applied

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS

5.1 ASSESSEMENT TABLES FOR THE LEVEL OF APPLICATION OF BIOCLIMATIC DESIGN PRINCIPLES INTHE CASES STUDIED

Table 5.1: **Summary on International Conference Center, Abuja (ICCA)**

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.

VARIABLES	**FEATURES**	**METHOD OF APPLICATION**	**WEIGHT FACTOR**	**REMARKS**
Orientation	Positioning of building in relation to climate	The building is oriented towards the north and south taking advantage of the prevailing winds and reducing radiation.	4	Positive
Shading devices	Use of shading devices to direct sun glare.	Parabolic roof overhang provides adequate shading to the exterior walls and the interior entrance lobby which is completely glazed	4	Positive

Passive design	Less use of mechanical cooling means	The cooling system is largely mechanical which perhaps increase the energy consumption of the center.	2	Negative
	Sufficient day lighting requirement.	Artificial lighting is virtually the lighting source only for the entrance lobby that is glazed.	3	Positive
Building materials	Materials that can be recycled which are locally available should be used to reduce impact.	Materials used are concrete for panels, granite and ceramic tiles, padded paper walls, aluminum and steel.	3	Positive
Landscaping	Trees shading around and within the environments.	Soft landscape elements to reduce urban heat island effect. Other hard landscape elements are used to pave the pedestrian and vehicular circulation spaces.	3	Positive
Renewable energy	solar panels to generate electrical energy or any of geothermal, wind energy sources	nil	1	Negative
Scope of facilities	The functional spaces provided and other ancillary facilities	The facilities include outdoor arcade, conference hall, gallery, committee/ meeting rooms, communications studio, press centre.	3	Positive
Construction technology	The structural system and architectural style used	Concrete walls together with metal grills.Parabolic shaped roof of aluminum sheets and glazed glass supported by concrete	3	Positive

		columns.		

Table 5.2: **Summary on Shehu Musa Yar'adua Centre, Abuja**

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.			
VARIABLES	**FEATURES**	**METHOD OF APPLICATION**	**WEIGHT FACTOR**	**REMARKS**
Orientation	Positioning of building in relation to climate	The building is oriented towards the north- south direction to take advantage of prevailing winds. However there is equal exposure to sun due to the building square form.	3	positive
Building form	Rectangular/vertical or circular in relation to its positioning on site.	Simple square geometric form with central atrium and other facilities surrounding it.	3	Positive
Shading devices	Use of shading devices to direct sun glare.	Double walling system with recessed walls were used. The dome also shade against solar penetration	4	Positive
Passive design	Sufficient day lighting requirement.	Glass dome was used in the central atrium and exterior windows for the offices	4	Positive
	Effective cross ventilation.	Use of vents in the atrium and wide openings. And for auditorium, mechanical cooling is used	3	Positive
Building materials	Materials that can be recycled which are locally available should be used to	Concrete, masonry block work and acrylic skylight glass dome. Other material is	3	Positive

	reduce impact.	aluminum and steel.		
Landscaping	Trees shading around and within the environments.	Soft landscape elements with paving for pedestrian and vehicular circulation.	3	Positive
Renewable energy	solar panels, geothermal, or any other source to generate electrical energy	Nil	1	Negative
Scope of facilities	The functional spaces provided and other ancillary facilities	Exhibition hall, research library, central atrium for meetings and other banquet services, auditorium, meeting rooms, adequate parking spaces.	4	Positive
Construction technology	The structural system and architectural style used	The building used simple modern architectural style with a square form achieved using concrete. the facilities are accessed from a central atrium roofed with acrylic glass	4	positive

Table 5.3 Summary on Ahmadu Bello University Senate Building

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.			
VARIABLES	**FEATURES**	**METHOD OF APPLICATION**	**WEIGHT FACTOR**	**REMARKS**
Orientation	Positioning of building in relation to climate	The building is oriented to take advantage of the prevailing winds. However, it has equal exposure to solar radiation which is affected by the	3	positive

		building square form.		
Building form	Rectangular/vertical or circular in relation to its positioning on site.	the square form was adopted which provides equal exposure to solar radiation	2	negative
Shading devices	Use of shading devices to direct sun glare.	Vertical and horizontal projecting concrete louvers in all façade.	4	Positive
Passive design features	Sufficient day lighting requirement.	Large exterior openings provide adequate fenestration. The central courtyard also provides reasonable amount of lighting in the functional spaces.	4	Positive
	Effect cross ventilation.	Air flow is achieved through the windows and central courtyard for effective natural ventilation as can be seen in the previous figure…..	4	Positive
Building materials	Materials that can be recycled which are locally available should be used to reduce impact.	Concrete, sandcrete block, aluminum framed window with glass, grand terrazzo and pvc tiles.	3	positive
Landscaping	Trees shading around and within the environments.	The building is surrounded by trees and shrubs well landscaped with other elements.	3	positive
Renewable energy	solar panels to generate electrical energy	Nil	1	Negative
Scope of facilities	The functional spaces provided and other ancillary facilities	Offices, lifts and meeting rooms	4	Positive
Construction technology	The structural system and architectural style	Concrete columns and structural beams to support	3	positive

	used	the building. The partitions are basically sandcrete blocks.		

Table 5.4 Summary **on Menara Mesiniaga, Malaysia**

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.			
VARIABLES	**FEATURES**	**METHOD OF APPLICATION**	**WEIGHT FACTOR**	**REMARKS**
Orientation	Positioning of building in relation to climate		2	negative
Shading devices	Use of shading devices to direct sun glare.	Vertical and horizontal projecting aluminum panels on the west.	4	Positive
Passive design features	Sufficient day lighting requirement.	Large exterior openings provide adequate fenestration. The central courtyard also provides reasonable amount of lighting in the offices.	4	Positive
	Effect cross ventilation.	Air flow is achieved through the windows. The swimming pool also aids evaporative cooling	3	Positive
Building materials	Materials that can be recycled which are locally available should be used to reduce impact.	Concrete, aluminum framed panels, glass and steel	3	positive
Landscaping	Trees shading around and within the environments.	The building is surrounded by trees and shrubs well landscaped with other elements. There is also vertical landscaping at various levels to improve the microclimate.	5	positive

Grey/Rain water collection	waste water collected from kitchen and toilet basins to be treated and recycled and use in the building	The rain water collected at the landscaped sky garden is retained and gradually returned back into the ground. It reduces consumption for irrigation by 50%.	4	positive
Renewable energy	solar panels to generate electrical energy	Photo voltaic panels used to generate about 20% of the energy used in the building	4	positive
Construction technology	The structural system and architectural style used	Concrete columns and structural beams to support the building.	3	positive

Table 5.5 **Summary on Gando Primary School**

	Scale Factor: Excellent = 5, Very Good = 4, Strong = 3, Weak = 2, and Very Weak = 1.			
VARIABLES	**FEATURES**	**METHOD OF APPLICATION**	**WEIGHT FACTOR**	**REMARKS**
Orientation	Positioning of building in relation to climate	The building is oriented to take advantage of the prevailing winds. The building is oriented to the north-south with shorter sides to the west and east	4	positive
Shading devices	Use of shading devices to direct sun glare and heating.	Long roof overhang and exterior wide verandas to shade direct radiation on the external walls.	4	Positive
Passive design features	Sufficient day lighting requirement.	Large exterior openings provide adequate fenestration.	4	Positive

	Effect cross ventilation.	Air flow is achieved through the large shutter windows properly positioned along the wind direction.	4	Positive
Building materials	Materials that can be recycled which are locally available should be used to reduce impact.	Clay and stabilized earth were used to reduce overheating due to their high thermal mass and time lag property.	4	positive
Landscaping	Trees shading around and within the environments.	The building is surrounded by sparse trees and shrubs landscaped within the school site.	2	negative
Renewable energy	Solar panels and other source of energy to generate electrical energy.	Nil	1	Negative
Construction technology	The structural system and architectural style used	Concrete columns and structural beams to support the building. The partitions are basically stabilized earth bricks and clay.	3	positive

5.2 BIOCLIMATIC DESIGN PRINCIPLES ANALYSIS

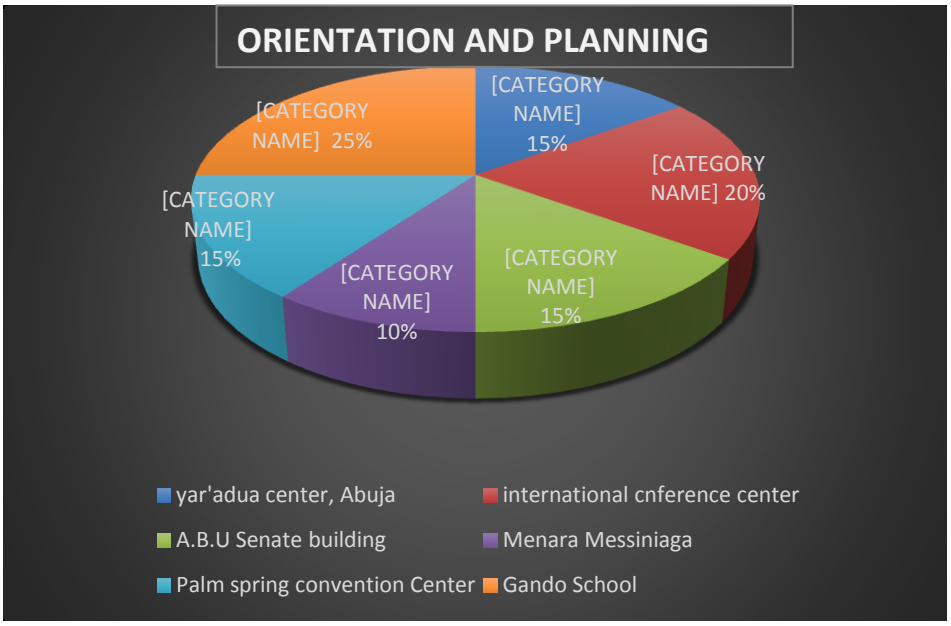


Figure 5.1: Bioclimatic design principle analysis: Orientation and Planning.

Source: Researcher, 2013

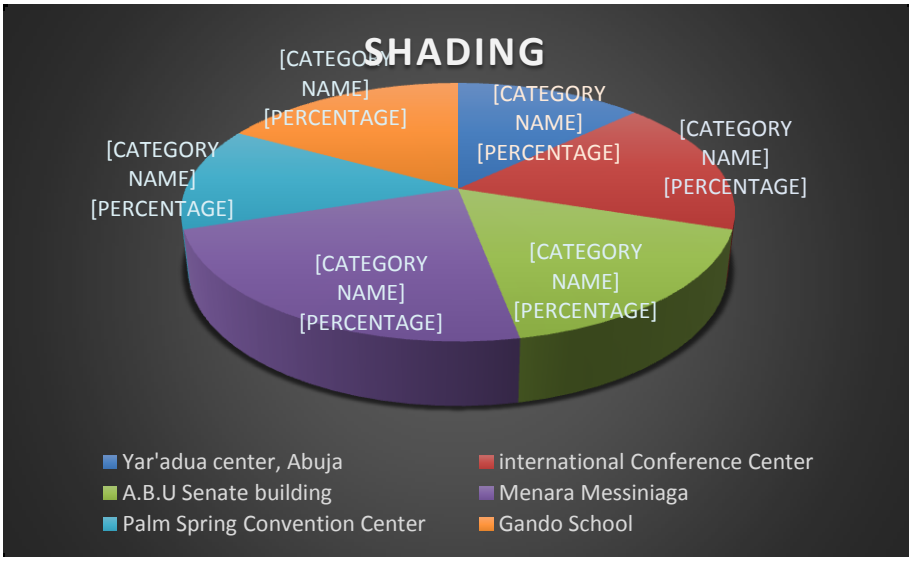


Figure 5.2: Bioclimatic design principle analysis: Shading.

Source: Researcher, 2013

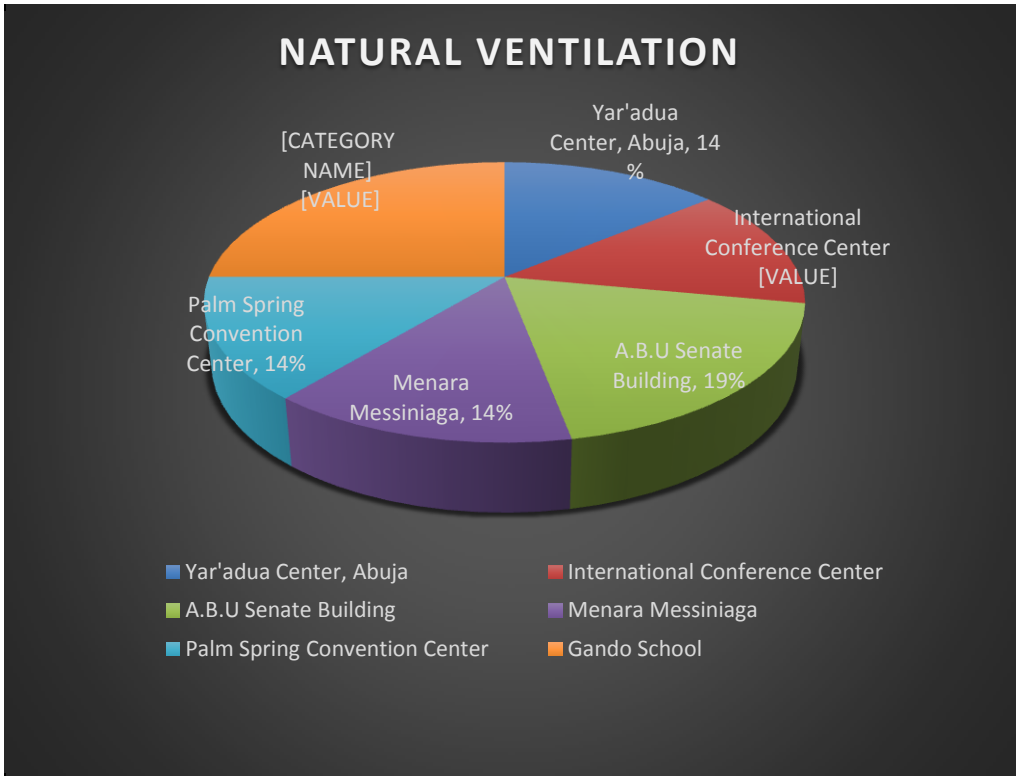


Figure 5.3 Bioclimatic design principle analysis: Natural Ventilation.

Source: Researcher, 2013

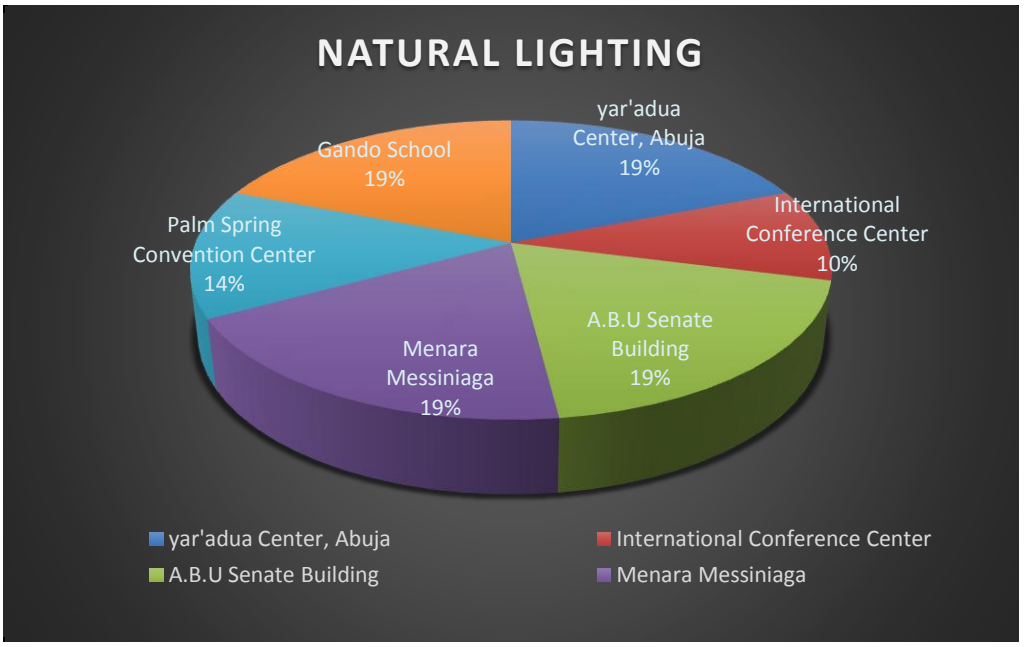


Figure 5.4 Bioclimatic design principle analysis: Natural Lighting.

Source: Researcher, 2013

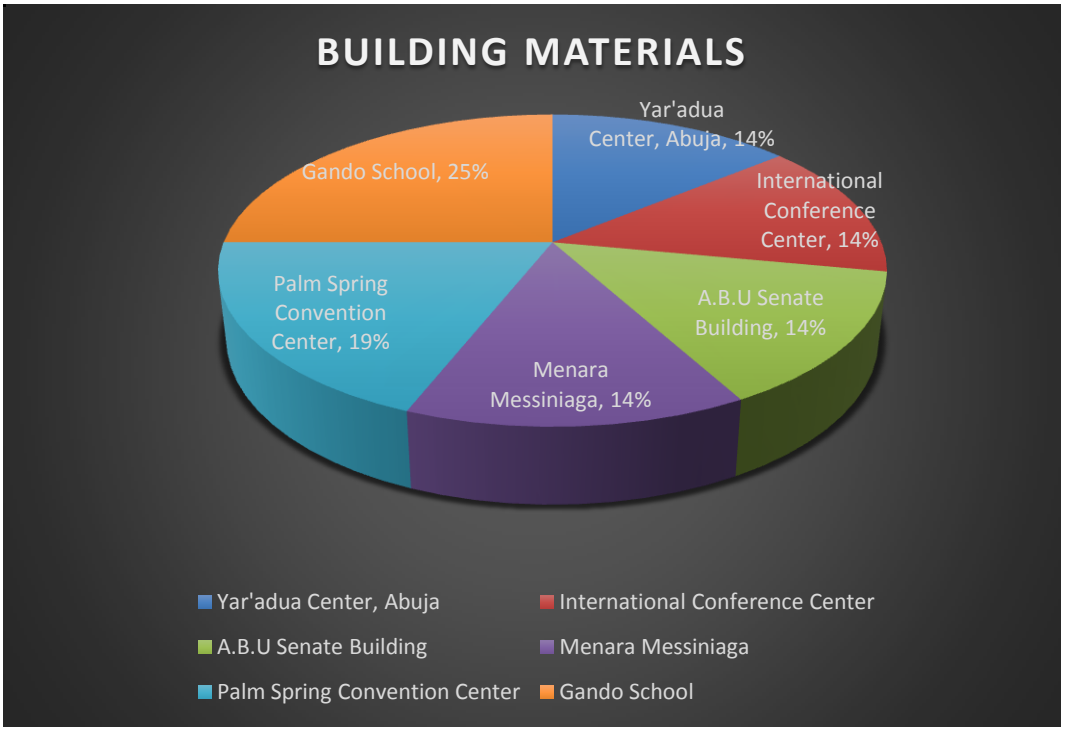


Figure 5.5 Bioclimatic design principle analysis: Building Materials.

Source: Researcher, 2013

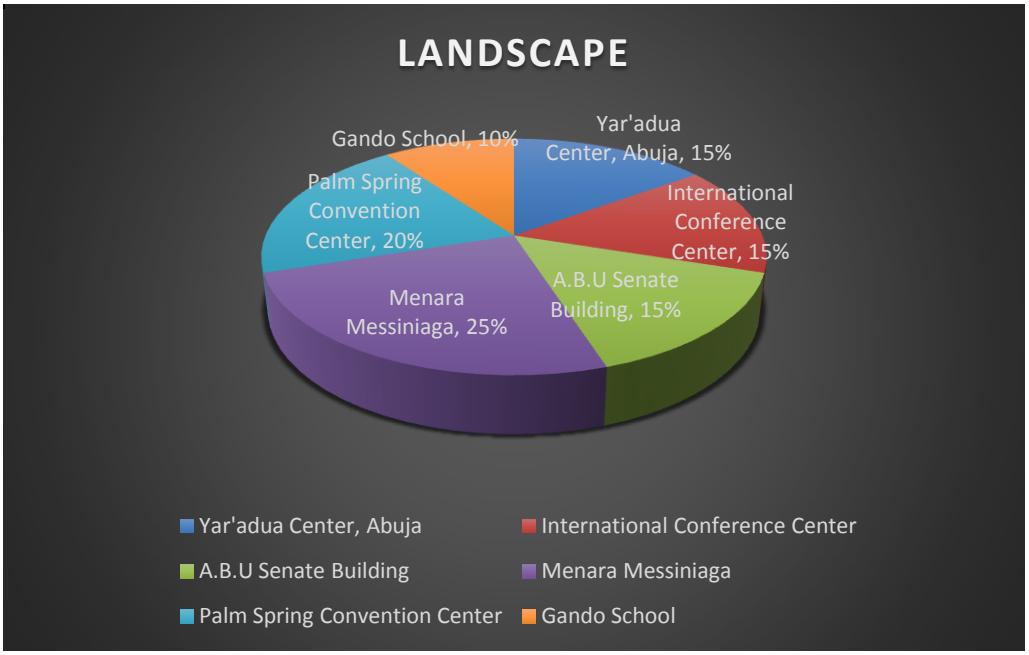


Figure 5.6 Bioclimatic design principle analysis: Landscape.

Source: Researcher, 2013

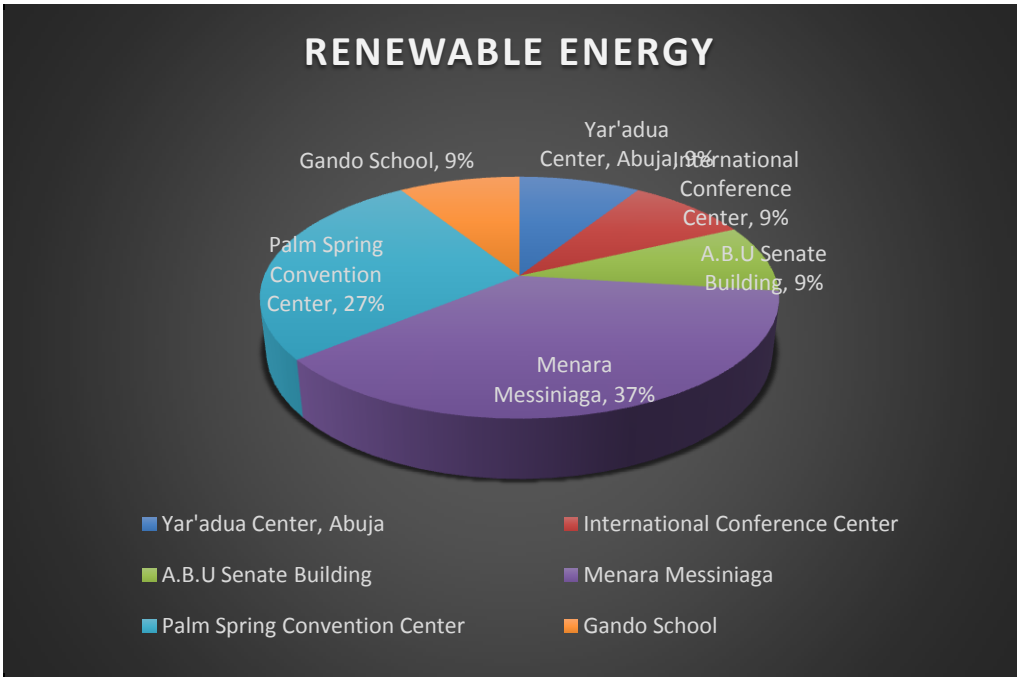


Figure 5.7 Bioclimatic design principle analysis: Renewable Energy.

Source: Researcher, 2013.

5.3 DISCUSSION OF FINDINGS

This section presents the overall research findings from relevant literatures and the preliminary case studies. This is to establish a theoretical frame work for the proposed design to bridge the gap between what is missing in the existing case studies and to improve and implement the findings for effective energy efficient architectural design proposal.

Research has shown that the building envelope which has to do with the materials, HVAC and lighting systems are the integral factors that greatly consumes energy of any building and hence affects its efficiency. However, as established in the literature review, fundamental bioclimatic design principles like orientation, natural daylighting, shading, natural ventilation, materials and existing energy source when effectively considered can help to achieve energy efficiency. These are the variables used to analyze the case studies and need to be properly addressed to optimize the energy of the proposed facility. Every

material used in the assembly of building envelope has fundamental physical properties that determines its energy performance, affects the building energy consumption which in turn affects its efficiency. It controls the amount of light and heat that gets into the building. The thermal properties of the building material determines how a building conducts, transfers and absorb heat. However, studies show that the lower the conductivity value of a material the better the material for insulation and reduction of heat transfer and the cooler the building becomes which positively affects the HVAC and lighting systems hence the energy efficiency. For the climatic region in question (hot dry), study by olotuah (2011) recommends materials like mud and bricks as indigenous materials for walls with time lag of eight hours. Looking at the thermal conductivity of bricks with 0.65w/mk as compared to concrete with 0.8w/mk. Also bricks has a U- value of 0.37w/m²k and that of concrete is 0.67w/m²k (Arthur, 2007). The thermal conductivity refers to the property of the building material to conduct heat. That is to say, materials of low conductivity are best for thermal insulation and gives greater energy efficiency. On the other hand, the U-value is a measure of the rate of heat gain or loss through a material, the lower the U-value, the greater the materials resistance to heat flow and the better the insulation and energy efficiency. It can be said that based on this thermal and energy performance, bricks offer the best thermal property and anticipated energy efficiency than sandcrete block and concrete which makes it recommended for the research design proposal. Another material for building envelope is glazing and window materials. The double pane glass window is best insulating than the conventional single pane glass window used. This is to have the most effective thermal regulation by the envelope material. Study by combustion research cooperation reveals that, the double pane is having a U-value of 0.70w/m²k as compared to the single pane with a U-value of

1.22w/m²k which makes the double pane recommended as it will have the best thermal property and insulation needed for optimum energy efficiency.

Secondly, the HVAC and lighting system will be considered based on the climatic elements. According to the Atkinson system of climatic classification, hot dry region has the following characteristics:

Table 5.6. Climatic characteristics of hot dry climate

Air Temperature	Maximum: 24- 30 Minimum: 47-49
Solar Radiation	Direct and intense
Wind condition	Local, hot and dusty
Humidity (%)	20-55

Source: koeingsberger etal (1974).

Relating to the basic principles outlined earlier, studies have shown that the recommended design solutions for hot dry climate are; for the orientation, north to south orientation is the best which reduce the exposure to intense solar radiation and favors prevailing winds (Givoni, 1994). Study by Reardon (2008) established that this can reduce the cooling loads and energy bills. This is further buttressed by simulation analysis conducted by Marija (2013) on building forms. On the other hand, Opoko (2011) opined that insulating the building will greatly reduce the intensity of radiation as this has to do with the material choice and has been addressed earlier.

The ventilation variable can be effectively achieved using courtyard and adequate orientation to take advantage of the prevailing winds. Study by Komolafe (1983) states that, since the wind in this climatic zone is dusty from the North-East, water body and

pools should be placed along that direction to reduce inflow of dusty and hot air. Olotuah (2011) opined that cross ventilation is paramount along the south –west direction.

The shading device type depends on the exact sun path. Therefore, shading device should be based on the solar orientation of windows. The table below shows the recommended type of shading device depending on the orientation of the building windows

Table 5.7. Shading strategies for different orientation

ORIENTATION	EFFECTIVE SHADING
Equator- facing	Fixed horizontal
East	Vertical device / louvers
West	Vertical device / louvers

Source: Reardon (2008).

Study by Suzer (2010) show that effective shading can be achieved using deep recessd verandahs and balconies and have the potential of reducing energy consumption by about 40% for both cooling and heating loads in a building. Other energy simulation study by Marija (2013) affirm that it can reduce energy by about 45%.Shading strategies include use of aluminum fins supported by steel structure, green roof also reduce the intense solar radiation (Mohammad, 2012). These findings can effectively optimize the energy of a building if properly applied.

This section also presents the results of a preliminary study of some buildings in selected climatic regions. The case studies were surveyed as presented in the previous chapter based on the principles of bioclimatic design giving much emphasis on six important variables; Orientation, natural ventilation, shading, natural day lightning, landscaping, building materials and renewable energy. These variables will be analyzed relative to the

findings established earlier from the relevant literatures as thus; Based on the result found, Gando School has the highest percentage of up to 25% of reflection regarding the orientation. It has the North- south solar orientation and is in conformity with findings by Givoni (1994). The building is assumed to have minimal energy load as studies reviewed by Marija and Reardon stated that it has the potential of saving significant percentage of the energy for cooling the building. It is followed by International Conference Center, Yar'adua Center, A.B.U senate building, Palm spring convention centers and Menera Messiniaga with scores 20%, 15%, 18% and 40% respectively. This shows that the building is adequately oriented taking all climatic factors into consideration this enable the building to be placed so as to take advantage of the prevailing wind and reduce exposure to solar radiation. This is in line with the finding established by Hernandez (2011).

More so, in the next variable of shading, Menera Mesiniaga (bioclimatic skyscraper in the highest score of 23% followed by Gando school (17%), International Conference Center (17%), Senate Building A.B.U (17%), Yar'dua Center (13%) and Palm Spring Convention Center (13%). This is considered based on the building with minimal exposure of external walls to the west or east of the cardinal. In Menera mesiniaga, the orientation placed the service core of the building to the east and west there by shading the main functional spaces and providing adequate lighting. It is also having landscaped balconies to shade the external walls of the office. This is believed to save about 40% of the cooling loads of the building Suzer (2010). It also have aluminum fins projected from the walls and is in line with findings by Muhammad (2012) as recommended for climate of the region studied. The rooftop is covered with a steel structure that will support photovoltaic panel and will also shade the outdoor swimming pool and gymnasium at the rooftop. Other elements used for shading in other case studies are large overhang as in

international conference center and Gando school, and landscape trees position along the west side of building.

Under variables of natural ventilation, Gando School have the highest scores of 25% followed by ABU Senate Building with 19% and the others having 14% each. Considering the scope of facilities provided and the complexity of the buildings. The school is having a single unit which makes it easier to orient and achieve maximum ventilation. This is enhance by the large screen windows that allows for 100% uninterrupted airflow. On the other hand, the senate building, it's a large office building which also relatively achieve natural cross ventilation through the use of courtyards and large fenestration. The building form also helped using the podium and tower that aids stack ventilation in the large central lobby.

Furthermore, looking at the building material as one of the variable that have so much impact on the comfort of the interior spaces and energy efficiency. The Gando also recorded the highest score of 25% in the ranking. This means, the materials used for the construction are more climatically friendly to the environment and can effectively enhance the micro climate and achieve comfortable interior environment, since its design to annul the adverse climatic element effects. The materials is chiefly stressed earth brick which is the abundant materials in the area this reduce the cost of transportation and production of other building materials, thereby reducing the embodied energy. It also have a high time lagging property of absorbing heat storing it during the day when the indoor temperature is high outside, the stored heat will reach the interior during the night when the temperature cool. The material also have low thermal conductivity, low U-value which makes it have high resistance to heat flow and high thermal insulation and hence energy efficient as established earlier. The next in the ranking is the palm spring convention center with a score of 19% followed by the others with 12% only. Other

materials used like concrete, steel and excessive glazing will affect the energy efficiency negatively.

Looking at the natural day lighting principle as a variable for the analysis, the building with the highest score are Yaradua Center, ABU Senate Building, Menara Messianaga and Gando school which having 19% each. They are followed by Palm Spring Convention Center with 14% and lately the international Conference Center Abuja with 10% score. The Yaradua Center achieved natural lighting using the glass dome covering the central atrium which is used for large exhibition and banquet activities. This reduces the cost of lighting the mighty space. Other offices within the building are lighted naturally with the large exterior fenestration. In the senate building, lighting is achieved using the central courtyard serving as access to five upper floors. It is also enhanced by the windows in all façade of the building.

Considering the landscape principle, Menera Messiniaga is ranked the highest with 25% followed by Palm Spring Convention Center Abuja, ABU Senate Building each having 15% and lastly the Gando school with 10%. The menara building is having adequate landscape around it, vertical landscape elements were also used to shade and improve the microclimate at all levels of the building.

Lastly, the variable of renewable energy or energy efficiency strategies employed in the various case studies, the only noticeable building with renewable energy is the menara messiniaga skyscraper. The renewable energy is employed to harness the abundant intense sunlight in the Malaysian climate to generate electricity using the photovoltaic panels installed at the apex of the building. This is to avoid any barrier that may shade the panels from exposure to the sunlight. The energy generated is estimated to take care of about 20% of the total energy used in the building. From the study established when the

building project was completed , there was about 26% decrease in energy consumption in the building compared to a similar building design and constructed without employing these principles. This should be employed in the design proposal of this research considering the climate characteristics of Kaduna (hot dry) with abundant natural daylight.

CHAPTERSIX

6.1. SITE SELECTION CRITERIA

Atonetime,conventioncenterswerebuiltinblightedoroutlying locationsinhopesthatthey wouldencourageotherdevelopments.Nowconventioncentersarebeing builtinprimeareas andonprimesitesnearhotelsandattractions.They are partofanoveralldowntownpackage thatmakesthedestination competitive (Lenhart,2007).conventioncentershave topackage themselves with nearby hotels, restaurants and retail to create the "under one roof" conventionexperience.Proximity toallofthecityamenitiesiskey toacenter'ssuccess. Hence, the following factors are consideredin makingthe selection:

i. **GoodOrientationandEase ofAccessibility**

Thesiteboundary shouldgiveroomforfutureexpansionandproperbuilding orientation for thermal comfortandwaste discharge. It shouldalsobe easily accessible fromthemainroadsotoenhance safe ingressand egressinthe eventof crowd orloading and uploading.

ii. **Proximity to Airport**

According tofiftheditionofprofessionalmeeting managementmagazine(2007),itis highly desirabletolocateconventioncentersnotmorethan3kmawayfromairports. Thisaidcrowdandtrafficcontrolinthehostcity,asvisitorsdonotnecessarilyhave to pass through thecitybeforetheyreach events'venue.

iii. **Proximity to LodgmentFacilities**

Someconventioncentersdonothaveaccommodationforvisitorsandthusthey are locatednearbyhotelsandmotelswhichserveassupplementary totheconvention centers. Modern conventioncentershavelodgmentfacilities. However,specialeventsmaygeneratecrowdtoolargetobeaccommodatedby the availablelodgmentfacilities.Hencetheneedforproximity ofconventioncentersto hotels and motels is paramount.

iv. **Proximity to Security Points**

Crowdissomething that attractscrime.Conventioncentersareplacesofcrowdand hence require proper crowd controlandsurveillance. For this reason, conventioncenterslocatednearsecurity centersprovidemoreconvenientvenuesforevent planningandcrowdcontrol.

v. **Proximity to Attractions**

Conventioncentersunlikebefore,arenowbeing sitedalongsideattractionssoto createthemostpleasantvistaand welcoming environmentforguest.Thisistoattract customers'attentionandmakeeventslivelier.They arenowlocatednearwater bodies, mountains, valleys andplantations.

vi. **Possibility ofExpansion**

Conventionsare crowdgenerating events.Therefore,theremaybeneedforexpansion insizeofeventvenuesatany pointintime.Thustheneedforabundantlandthatwill guarantee futureexpansion.

vii. LandUseCompliance

Siting aconventioncenterinresidentialareasmay causenuisancetothe residents. Locatingitinhighlyindustrialareamaybeasourceofharmtocustomers,work andtheeventplanners.Thereforerespectinglanduseinthesitingissosignificantto the patronageof convention center

viii. Utility service: utilities-availability and cost of electrical service, sanitary service.

SITE 1

i. 

Plate 6.1: Ariel view of Site 1 showing site at Rigachukun kawo. Source; Google maps 2013.

SITE 2



Plate 6.2: Ariel view of Site showing site alternative at Kaduna millennium city.

Source; Google maps 2013

Table 6.1: **Summary table for Site selection criteria**

CRITERIA	**SITE 1** **Rigachikun Kawo**	**SITE 2** **Millennium city**	**REMARKS**
Location/Accessibility	3	4	Both Sites are close to the Kaduna city, walkable also in general, a focal point from which visitors can experience the new city. However site two is closer to central city
Proximity to residential areas	3	4	Site two is more centralized, proximity to future entertainment, shopping, and other attractions
Proximity to national landmarks	2	5	Site two is closer to Kaduna river. Which will also aid evaporative cooling.
Proximity to lodgment facilities	3	2	Site two is close to residential facilities and hotel.
Appropriate size, including adequate space for buildings, grounds, convenient, plentiful parking and expansion.	3	4	Site two is larger in size than site one.
Possibility of expansion	3	5	Site two is bigger giving room for adequate expansion.
Land use compliance	2	4	Site two is more compliant
Security and safety	3	2	Site one is safer with proximity to Kaduna central town
Utility service: utilities-availability and cost of electrical service, sanitary service	4	3	Site one has more services than site two.
Total	27	29	

Weighing scale: Excellent 5, Very good 4, good 3, fair 2, and poor 1. **Source**: Researcher, 2014

6.2 SITE LOCATION

Inreference tothe tableabove site 2whichislocatedat the new Kaduna millennium city popularly known as Makarfi city hasbeenselected.The site is located close to the bridge linking the new city and the old Kaduna city. Approximately a 30minutes drive from the central city. The site is tagged C02 based on the legal city percelation and planning in accordance with the master plan. It is located in the zone allocated for civic buildings which makes it suitable for the proposed facility and conforming with the land use compliance criteria for selection of the site as outlined above (see plot summary table below). The site is about 3.66 Hectares equivalent to 36,600square meter. The site coordinates are Latitude: 10°23'07.26"N and Longitude: 7°23'50"E. it is having an altitude of 594 above sea level.

Table 6.2: **plot Summary table for the proposed Site**

Plot Summary - Makarfi District, Kaduna New City

Central Area

Parcel C02	Parcel size	3.66	hectares

Plot area by land use summary	No. of Plots	Area (m^2)	% of plots	% of parcel area
Residential				
Low density	0	0.00	0%	0%
Medium density - Townhouses	0	0.00	0%	0%
Medium density - Flats	0	0.00	0%	0%
High density flats / Mixed Use	0	0.00	0%	0%
Sub-total residential plots	*0*	*0.00*	*0%*	*0%*
Non-residential mixed use	0	0.00	0%	0%
Commercial	5	24,181.12	100%	66%
Industrial	0	0.00	0%	0%
Institutional	0	0.00	0%	0%
Open Space	0	0.00	0%	0%
Sub-total non-residential plots	*5*	*24,181.12*	*100%*	*66%*
Sub-total all plots	5	24,181.12	100%	66%
Roads and non-assigned		12,418.88		34%
Total - square metres		**36,600.00**		**100%**

Parcel	Sub-parcel	Plot No.	Plot Area	Land Use	Type
C02	-	1	5463.71	Commercial	Commercial
C02	-	2	5435.55	Commercial	Commercial
C02	-	3	4448.64	Commercial	Commercial
C02	-	4	4809.68	Commercial	Commercial
C02	-	5	4023.54	Commercial	Commercial

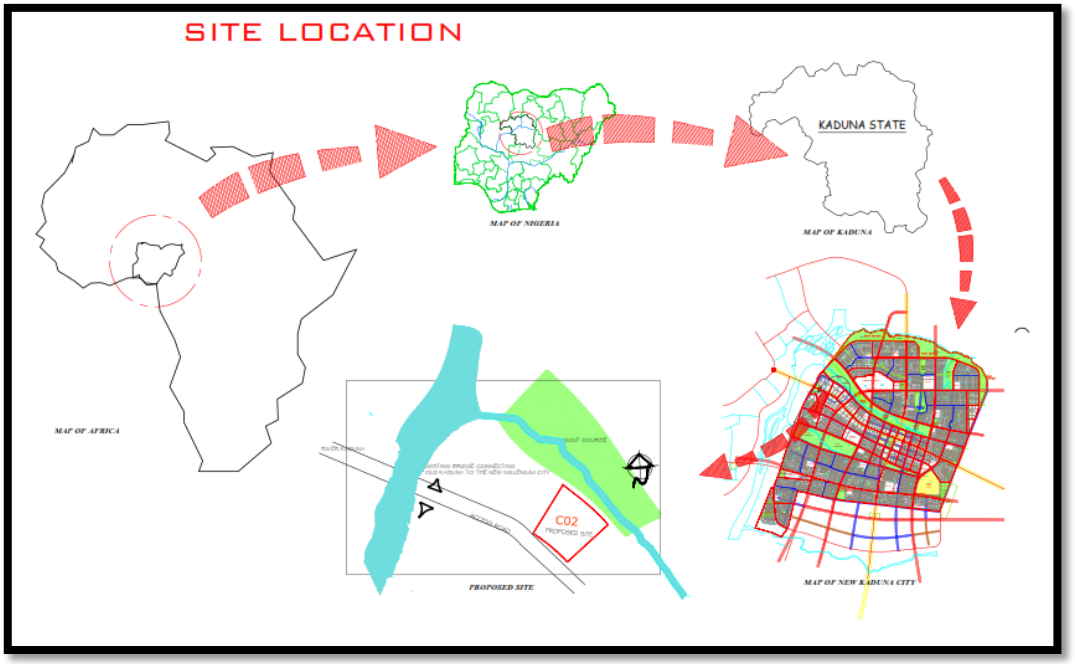


Plate 6.3: Location ofSite2: (Source: Researcher, 2014)

1. Basic Information on Kaduna State

i. Latitude: +10.52(10°31'12"N)

ii. Longitude: +7.44(7°26'24"E)

iii. Time zone: GMT+1hours

iv. Country: Nigeria

v. Continent: Africa

vi. Sub-region: Western Africa

vii. Altitude: ~600 m.

2. Population Density of Kaduna State

Kaduna state has the third largest population in the country. According to the just concluded census figures of 2006, Kaduna state has a population of over six million people.

6.3SITE ANALYSIS (CLIMATE)

For the purpose of this study, it is paramount to make a general study of the climatic factors and surrounding environment thus outlining the climatological influence that affect the design within the locality of the site. TheclimateofKadunaisSemi-aridcontinental.Rainfallfiguresrangefrom600-700mmperannum.Climatevariesconsiderably withmonthandseason. DecembertoFebruarywitnessacooldry(Seldomdustyhammatan)season; whilefromMarchtoMay witnessahotdry seasonwithtemperaturesranging from32^{0}Cto40^{0}C.Theseasonisfollowedbyawarmwetonewhichflowsfrom Juneto September.Anotherseasoncomesbetweenthemonthof Octoberand November.Itischaracterized by decreasingrainfallandgraduallowering of temperature.

6.3.1 TRADE WINDS

The prevailing winds in Kaduna state are the southwestern and northeastern trade wind patterns. The former originates from the Atlantic Ocean and it brings moist cool breeze and rainfall; and the latter originates from the Sahara desert and it brings dusty breeze and harmattan. The wind speed ranges from 2.96 to 4.31 meters per second, varying from month to month as shown in table to this effect barriers should be used and also the building shall be oriented so as to achieve the south western wind and wind breakers shall be introduced to reduce the effect of the harmattan wind or using water bodied or trees.

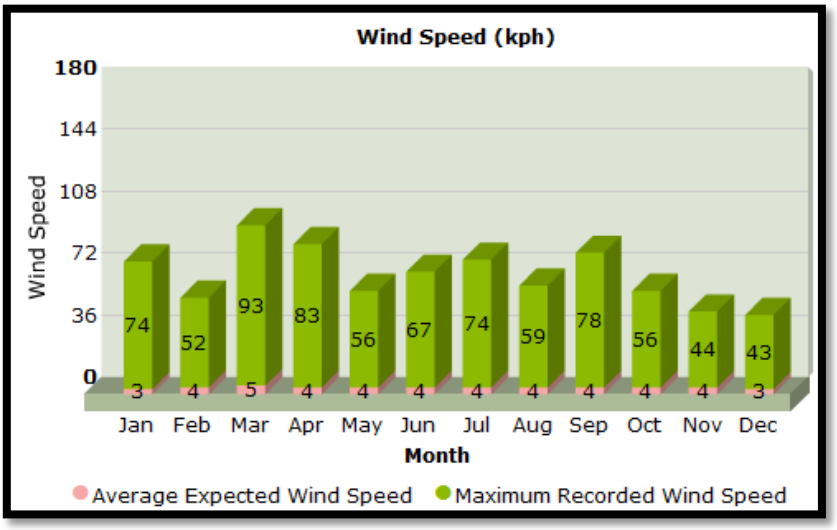


Plate 6.4: Wind Speed: Awka.Source: Myweather2.co.uk.

6.3.2 RAINFALL

There exists two seasons in Kaduna state - the rainy and the dry season. The rainy season lasts for about six months from April to October see **(**Figure 6.5). There is heavy rainfall in the southern and the northern parts of the state. The rainfall ranges from 0 to 825 millimeters per month.

The design proposal has to adopt a proper system of surface drainage to take away this amount of rain away from the site. Thunder strikes are also prevalent during the rainy seasons therefore thunder deflectors are also a necessary consideration.

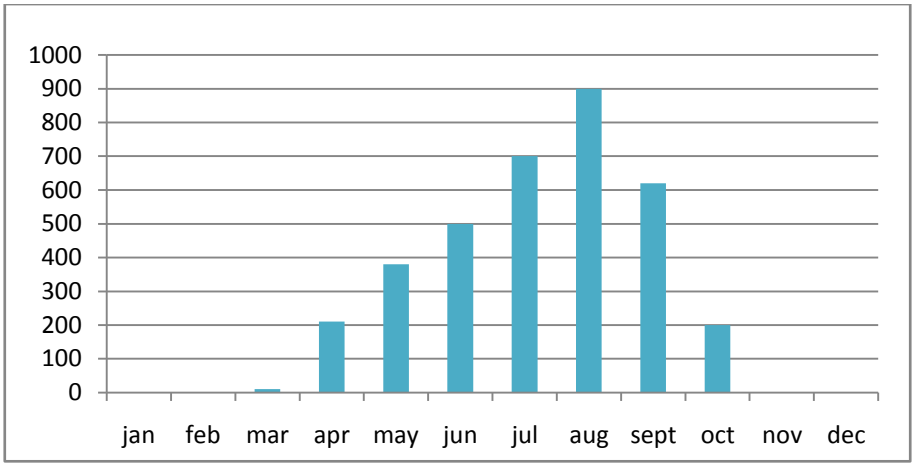


Plate 6.5: Annual Rainfall data in Kaduna state. **Source:** NASA Langley Research Center Atmospheric Science Data Center; New et al. 2014.

6.3.3 TEMPERATURE AND HUMIDITY

Temperature in Kaduna state ranges between15.9 to 30.35 Celsius. At the start of the dry season, relative humidity falls from 68% in October to 36% in November with the stabilization of the easterly winds. It further falls to 35% in January and 20% in February. Mean relative humidity reaches its maximum value of 80% in the month of August. Consideration has to be made to minimize the amount of solar radiation that gets into the building.

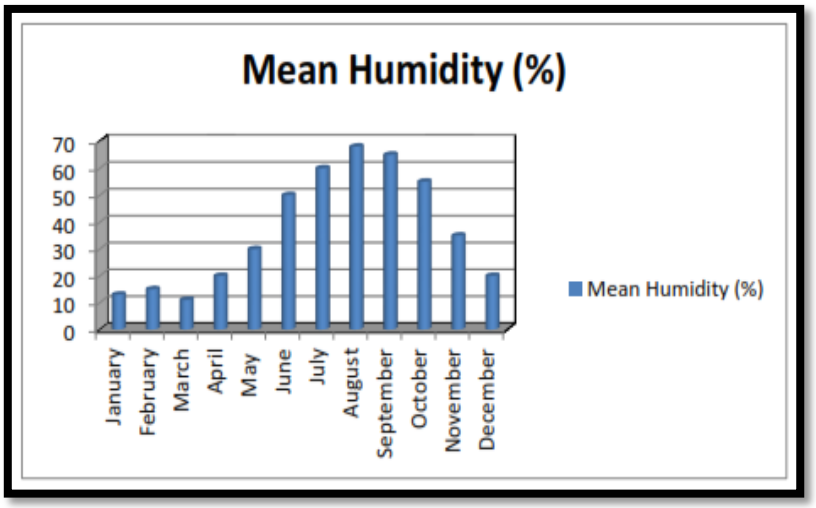


Plate 6.6: MonthlyRelativeHumidityChart forKadunaState.

(Source:www.gaisma.com, retrieved on 10th June,2014)

6.3.4SUNSHINEANDRADIATION

Thehoursofsunshinevaryconsiderablywithtimeoftheyear. Theaverage rangesbetween6.5hoursperday inAugustand10hoursperday inNovember. Thediagram below explain the dailysunshine:

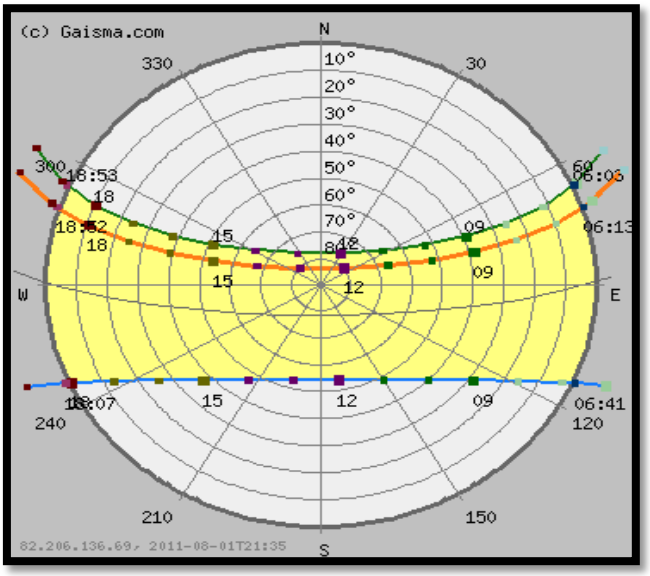


Plate 6.7: Sun path diagram forKaduna.(Source: www.gaisma.com, retrieved 2013).

The yellow section shows when the sun is up, and how this changes over the year. The time-of-day scales, on the left and right, and the month scale on the top and bottom, shows approximately when sunrise and sunset occur.

SITE ANALYSIS-(Climate)

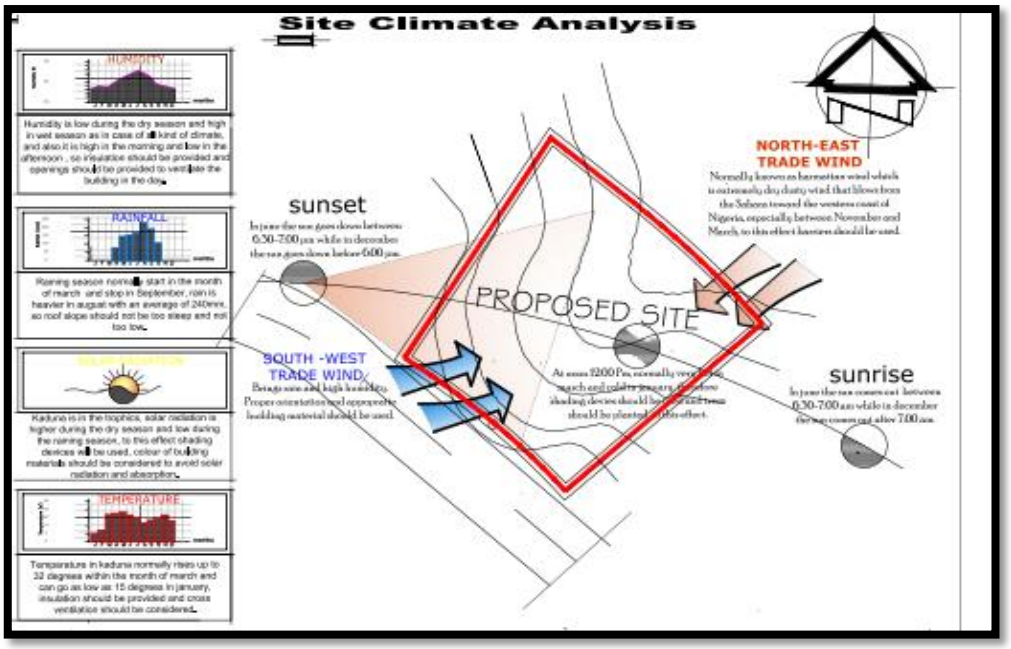


Plate 6.8: site analysis (climate). Source: (Student's Fieldwork Observations).

6.4 SITE ANALYSIS (SORROUNDING ENVIRONMENT)

6.4.1 Vegetation

The vegetationofKaduna StateisSahel-Savannahinnature.Therefore,thearea ischaracterizedby sparsebushes,opengrasslandandfewnaturalforests.Thetreescanserveaswindbrakersandshieldfrom noise fromneighboringsources. Togetherwiththe abundantgrasscover, the trees formapleasant micro-climateto thesite.



Plate 6.9: A part ofsite's vegetation Source: (Student's Fieldwork Observations).

ii. **T o p o g r a p h y**

ThenorthandeasternpartofKadunaStateisgently undulating plainwith occasional outcrops. However,the southwesternpart is hilly,rockyand wooded. Thesitespecifictopography hasagentleslopenorthwards.Services suchas sewage,refuse,drainageandplumbing take theslopedirectionsotoutilize naturalgravity.

iii. **S o i l s**

ThesoilofKadunaStateisgenerallyalluvial fertile lossplain.Areaswithlowestslopeinthesitehavearelatively sandy soilwhile eastwardsthesitehasabrownlateritecoveredby grasses.Thesite'ssoil superficially exhibitsomephysicalsignsofloadbearingcapacity.However,the actualloadbearingcapacity issubjecttohydrologicalandgeologicalsurveys whicharebeyondtheresponsibility ofarchitects,hencetheneedtorefertosoil engineers for appropriateadvice.For the purpose of the research, we are considering what the physical observationsof the soilconditionshow andassume oursite tohave the bearing capacitythat canwithstand the proposed development.

i. **S o u r c e ofNoise**

Thesiteisrelativelyattheoutskirt,located in the new city layout. Therefore thereislittlenuisancebesidethat createdbythehigh-waybymovingvehicles.Theneighboringstructuresare for future in accordance with the master plan of the city. As such there isnegligiblenoisethathasvery littleimpactonthesite zoning.

Access to site

The site is located along the eastern bye pass which brings in the flow of traffic from Kaduna city as well as the immediate environment of the proposed city.

The main access into the site is directly from the dual carriage roads which divide the new city into two equal halve running from the east to the western part of the city see **(**Plate below).



Plate 6.10 Access road to the site. Source: researcher's field work 2014

ii. **Services**

The site will be accessed through a proposed road which is connected to the main road leading into the layout via the new completed bridge which connects old Kaduna city and the new city (Makarfi Layout). Power can easily be supplied to the site from the 33KV/11KV PHCN sub-station which is less than a kilometer away. Also, water supply to the proposed site can be connected directly from the existing main-water supply line. There is good GSM coverage and telephone lines could easily be connected from the proposed layout telephone line.

iii. **Neighboring Developments**



Plate 6.11: developed HousingUnitsalmost adjacent to thesite. Source: (Student's Fieldwork Observations.

iv. **Vista andAttractions**

The site has eye-catchingvista northandwestwardsdue tothevirginforest landsthatprovideanuninterruptedviewof thehorizon,andgreenvegetation. However,thereisnoanymajorattractionnearb ythesitewhichissofarthe mostapparent short comingof thesite. Also, there is water body to the north of the site which can also provide

good vista and can serve as a recreational facility which will enhance the outdoor activities and attract customers.



Plate 6.12: Water body flowing adjacent to thesite. Source: (Student's Fieldwork Observations)

SITE ANALYSIS–SurroundingEnvironment

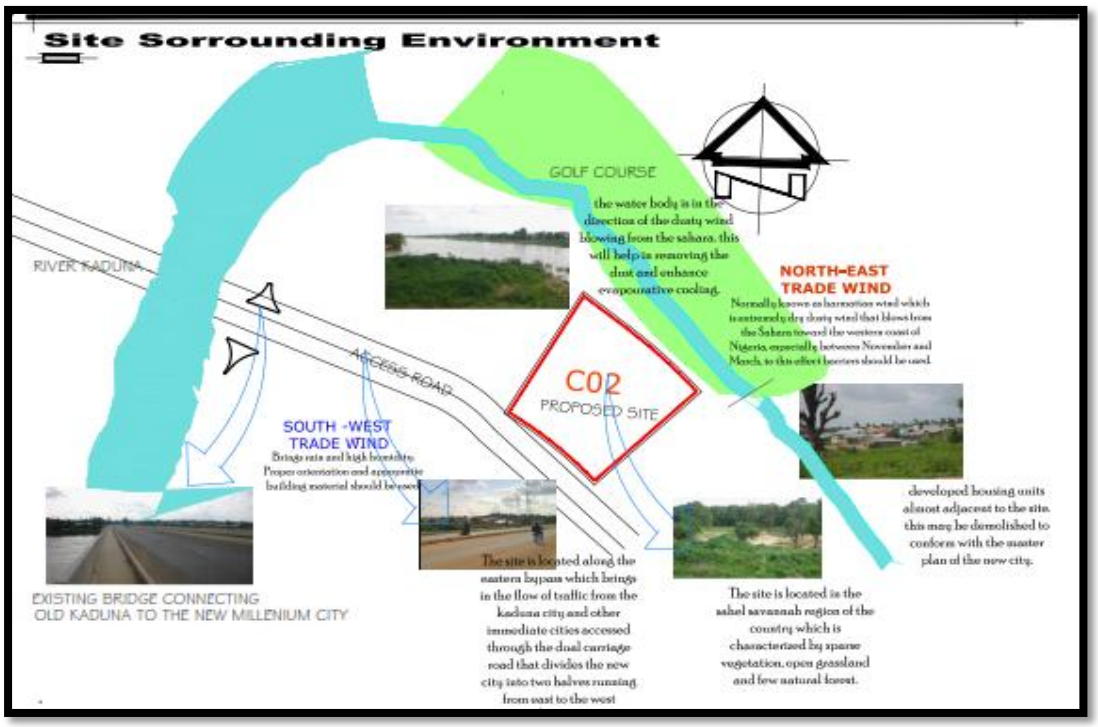


Plate 6.13: Site andIts surroundings (Source: Student's Fieldwork Observations).

6.5 SUMMARY OF SITE AND SORROUNDING ANALYSIS

The followingobservation aremade from theanalysis:

i. Thesiteslopes gentlynorthwards.

Ii .Watersupplypipesandpowerlinesarelocatedatthehighestpointof the slope.

Iii. Thesitehas a vegetativecover andaveryconducivemicro-climate.

iv. KadunaState is hot-drySahel Savannah Region.

v. Thesoil bearingcondition is favorableforthe development.

vi. Current and futureland useplan favors of theproposeddevelopment.

viii. Access to the siteis viathehigh way.

ix. Thereis adequate securityandadditional lodgment in the area.

x. Thesiteisnearb yanInternationalAirportasdemandedbythesite selection criteria.

xi. Sizeof theland is enough to guaranteefutureexpansion.

xii. Sitehas no attraction.

6.6 RECOMMENDED EFFECTIVE DESIGN SOLUTION TO THESE CLIMATIC FACTORS

Natural climatic factors such as climate, geology and vegetation influence the lifestyle of the occupants and the design of a building landscape. For example, the two prominent trade winds influence orientation and design of buildings. The long span of buildings is oriented in a north and south direction. This is to reduce the effect of intense solar radiation from the east and west directions where sun rises and sets respectively. The cropping season begins in May at the commencement of the rains. The porous nature of the soil condition dictates special consideration for foundation design and landscape design that considers conservation of natural features on site. To achieve an effective bioclimatic design considerations on;

- **Temperature**

Design should be such that;

- Shading devices or mechanism should be employ- canopies, covered walkways, wide veranda and balcony, and pergolas.
- Water bodies like pool and fountain around and within the building should be provided for evaporative cooling and landscaping.
- Healing, shading and absorption of radiation.
- Shaded windows and openings to encourage good natural ventilation.
- Minimum use of dark colored materials outside and inside building to reduces absorption of heat and radiation.
- Materials should have good reflective capacity, low thermal conductivity and high U-value.
- Good orientation of building to take advantage of prevailing condition.
- Courtyards should be provided foe effective daylighting and natural ventilation.

- **Humidity**
  - Due to the presence of water body close to the design site, there will be a relatively high humidity in the area; there is need for effective ventilation to help the body lose heat. For close up and huge walls, air conditioning is inevitable.
  - The ground floor slab of the building should be damp proofed.

- **Rainfall**
  - Roof form should encourage effective discharge of rain water.
  - Provision should be made for adequate drainage channel to avoid flooding.
  - Planting and paving should be used to discourage erosion on site.

- Canopies, eaves, window hoods and veranda should be employed to prevent driving rain from entering into the building through external windows and openings.
- Building materials used should withstand moist and wet environment.

- **Wind Pressure**
  - Proper bracing and rigidity of the building structure to withstand strong wind is necessary.
  - Trees should be planted in the site to reduce devastating effects of wind on the building.
  - Good orientation of the building in relation to wind flow is necessary.
  - Windows and openings should be of appropriate sizes, operable and should not be placed directly to the wind direction.
- **Solar Radiation**
  - Good landscaping is necessary to reduce radiation of sun at the outdoor environment
  - The use of sun shades and sun breakers is necessary in the building design.
  - Good orientation of the building on site and spaces in the building is important to take advantages of the sun radiation.
  - Building materials should be poor conductors of heat having high time lag effect to minimize heat transfer into the building interior.

CHAPTER SEVEN

DesignReport

7.1 DESIGNPROBLEMS

Accordingto Uji (2002),what constitutes design problems to abuildingarethemajor influencesthatmayimpingeontheorganizationofspace, givecharacterto,andhence determinethephysicalformofthedesign. Designproblemsare largely generatedfrom the designbrief.Designproblemsaregeneratedbasedonthekindofapproachwarrantedby the nature of thedesign.In thisproposalhowever,designthoughts areintendedtobe shapedby problemsthatincludethoserelatedtothefacility suchasuserandclientrequirementsand thoserelatedtocontextsuchassitespecificfactors(climate), zoningand planningregulations as well as energy efficiency.

7.2 DESIGN BRIEF

AFDIN Ventures in conjunction with DangoteGroup ofCompanies desire to exploit architecture toexpandtheirbusinessfrontierthroughinvestmentintoconventionandmeeting industry.Toachievetheaboveobjective,they requestedaproposalofanational standardconventioncenter, in KadunaState, thatwillreflectitsenvironmentandidentity of thepeopleandatthesametimeserveinternationalcontemporary conventionandmeeting needs.Thefacilityshouldpresentanarchitecturethatwill attractcustomers/visitorsfrom withinandbeyondandgenerateincome.It mustalsobeabletohost, atleast,conventions,conferences,corporatemeetings,tradeshows, parties,festivalsandbanquets.However,morepriority shouldbegiventolocalevents.The structureis to havethreecategories of facilities forthe abovefunctions:

i. Administrative Facilities

ii. Events Facilities

ii. LodgmentFacilities

Iv. AuxiliaryFacilities.

Adequateandappropriateconsiderationmust be giventosite specificfactorsespecially regional architecture, climate and topography.

7.2.1ADMINISTRATIVEFACILITIES

The administrative sectionoftheconventioncenter isspreadedwithinthefirsttwofloor to enhanceeasyaccesstostaffandeasy co-ordinationofadministrativeactivities.Theoffices provides include:

i. **General Manager's Office**

Itincludesthe secretary'sofficeandattachedstaff conference for inhousemeetingsandthen thehead's(GeneralManager's) self-containoffice whose accessisviathereceptionist (Secretary's office). It should also be attached to additional office for the assistant manager accessed through the secretary's office.

ii. **OtherOffices**

Theseinclude;

1 no. Personnel Managers/ PublicRelations Office

ii. Cashier's Office.

iii. Event Planner's Office

iv. StoreKeeper's

v. MaintenanceOffice

vi. GeneralReception Counter.

vii. Visitor's Waitingand Circulation Hall.

7.2.2 EVENTSFACILITIES

The research find out the nature of facilities to accommodate the different event.Themostfrequenteventsgather peoplein hundreds. Thereforethis fact is taken into consideration in allocating events' spaces.

i. **Event Halls**

ConventionCentersusually havedistinct typesofeventspacesofdifferentsizes depending onthenatureofeventsandexpectedsizeofaudience.Forthe purpose ofthisproposal,iintendedtoignorespaceswhosefunctionmay notserveany purposeasregardsthenatureofeventsinKaduna.Summarily speaking, I chose spacestoinclude orexcludeinthedesignbasedontheirrelevanceand compatibility tothenatureofeventsandrespectivesizeofaudiencewithin Kaduna and its immediateneibouring states.

a. **ConferenceHall**

Therearetwonumberconferencehallamong whichonehave60people capacity and the other can serve as a seminar room with 80-90 capacity. The small seminar room is intended to be forsmallcorporate andgovernmental meetings.

b. **SpecialExhibit Hall**

Exhibitionspacesaretheonly facilitiesthatmakeamajordifferencebetween conventioncentersandother relatedsimilarstructuressuchasexpoand conference centers.Thereis a big specialexhibithallsattachedinoneway toconferencetheatres and banquet

hallandinanothertothevisitors'circulationandwaitinghall.Thisistoenhanceproperdisplay

ofproductsbothfromtheconvention theatres andthewaiting hall. It is located at the nucleus of the center were the central atrium is located.

c. **BanquetteHall**

Banquettegatheringstake place during weddings,festivalsandotherrelated ceremonies.Thereforea700peoplecapacitybanquette/restaurantspace,with akitchenattachedisprovidedfor tocaterfor thosedemands.Therearealsoopenbanquettespaceslandscapedtoprovide thesite witha conducive outdoorpartyandbanquettevenue.Thisisduetothefactthat in traditional architecture of Kadunapeople, they are used to having communal ceremonies in open courtyards within their houses or even outside. This also favor the main target which the design is anticipating to address.

d. **Executive Meeting Room**

ThesearespecialV.I.Pmeeting rooms that areusuallyprovided in Convention Centersforvery confidentialconferencesandgovernmentalandnon-governmental meetings. They are mergedwithbreakoutrooms. There functioninthisdesignistakenbytheprovidedbreakoutrooms,hencethey arenot provided.

e. **Auditorium**

Thereis 1no.1000people double volume capacity Conventionauditoriumwithan exhibitionspaceattachedtoeaseproductdisplay intheeventoftradeshowsor workshops.

f. **Theatre/Amphitheatre**

A multi-purpose900no. Seats outdoor amphitheaterfortradeshows,business presentations and seminars is providedto accommodate smallergatherings.

g. **Multi-purpose Courtyard**

Thereare twomajorcourtyardsprovidedinadditiontoopenbanquette spaces. Thesecourtyardsare landscapedtoserveassitoutsandprovideventilationto indoor spaces.

Courtyards areimportant features of northernarchitecture, therefore it is incorporated to showcase these important social space.

7.2.3 LODGEMENTS

Therearefewcategoriesoflodgmentsprovidedduetothefactthatmosteventsin Kaduna are briefandhencedonotrequireparticipants topasstheirnightsinthecenter.Inevents wherelodgmentsareneededmorethecenter canprovide,thereareneighboring hotelsand motels that can serveas supplement.

TABLE FOR SCHEDULE OFLODGEMENTS

Types ofAccommodation	Quantities
3. Executive suites	1
5. Standard Suits	4
Total	5

Table 7.1: Schedule ofDistinct types of lodgment. (Source: Student's Proposal based on casestudiescarried out)

Presidential,RoyalandExecutive suitshave thesamefloor area.Theywillbe differentiated by finishesandfacilitiestobe providedtherein.Samething isappliedtobusinessand standardsuits.Mosteventsareasingleday events;thereforeaccommodationsarenotgiven muchpriorityduetotheiroccasionalneed forefficientconductofmostevents.Theyare zonedaroundthe less noisyand less publicpartofthe site.

7.2.4 AUXILLIARY

i. **Easements**

These includebothstaffandpublic toiletsprovidedinthecirculation/waiting hall, in convention theatres, banquettehalland most senior offices.

ii. **FitnessFacilities**

There is a big gymnasium; partitioned into two halls,one for womenandtheother for mento ensureabsolutesegregationasdemanded by thecultureofthe people ofKaduna.

iii. **Study roomandInternet Cafe**

Study roomsareprovidedforquickreferencestopreviouspresentations. Seminarsandtradeshowsmade.Internetcafe isprovidedtokeepvisitorsin touchandenhance efficientcommunicationanddatabase management within the center.

iv. **GroceryShop**

3no,groceryshopareprovides withinthe vicinity of the ground floor of the administrative block forguestsand visitorsimmediateneeds andcomfort. It is located close to the entrance reception for effective use by all visiotors.

v. **SwimmingPool**

1no.outdoorswimmingpoolisprovidedattached to a gymnasium and outdoor relaxation and banquet area. The pool is to provide good outdoor vista and relaxation space. It is also to improve the microclimate of the site.

vi. **GamesFacilities**

Facilitiesforoutdoorgamesareprovided.TheyincludeaBasketBallcourtand tennis. They are located in the private zone of the site for maximum comfort of the users.

vii. **Parking Spaces**

Atruckparking foroffloading andloading isprovidedclosetoexhibition spacesandstore.Thereare more than300no.Parking spacesforbothstaffand visitors. A largeareais reservedfor future expansion of parkingspaces.

viii. **Garden,Fountain andLandscape**

KadunaState'sclimateishotdryinnature.Thereforthereisaninevitable needfortheprovisionofgreenareasandplantationstoenhanceindoorand outdoorairquality forthermalcomfort.Thisisachievedthroughprovision garden, fountain and water pools.

ix. **LettableShops**

Additionalofficesare providedfor lease tocorporateorganizations. So also, lettable shopswillbe builtfacingtheaccessroadsotogenerateincome from lease and makethe areamore active.

7.3 DESIGN CONSIDERATIONS

i. **Capacity**

Theproposalshouldbeabletocarry aminimumcapacity of500peoplewith parkingandpedestrianspacesanda maximumof 5000peoplewiththesame requirements.

ii. **U s e r s**

Anticipated users aregovernment,royalties, business and corporatebodies, religiousbodies,familiesandcommunities.Ontheother handusersmay be children, abledand disabled people e.t.c.

iii.**Uses**

Anticipated usesincludeconferences,meetings,wedding ceremonies, conventions,religiousgatherings,seminars, tradeshows,lectures,parties, banquettes andworkshops.

iv.**Spaces**

Minimum

spacesizestoconformtominimumindustrystandardsizes.

2250sqmistheminimumspacerequirementforexhibithalls.

Convention/conferenceandexhibitionspacesshouldflow intoone another as dictated byindustrystandards.

v. **Variables**

They areconsideredsotocreatean energy efficient environmentasdictatedbythe contemporaryconventioncenterdesigntrends.They are climatic elements, regional architecture, and topography and energy efficiency.

vi.**Circulation**

The designconsidersablebodiedanddisabled pedestriansandalltype of carsand trucks forvehicular circulation.

Vii. **Contemporary DesignTrends**

Thedesign willtakeinto consideration the contemporaryconventioncenter design trends that are relevant to architectureas follows:

1. Location: Proximityto all of the cityamenities especiallyto prime areasand primesites near hotels andattractions.
2. Sense of Environment through incorporating architectural setting of the environment which it is located.
3. New Forms and New Functions: Atriums, windows,grand entries andotherdesign elements areincorporatedinto the latest architectureofconvention centers.
4. Green: Recycling, environmentallyconscious landscaping,energy-saving, lighting and ventilation.

7.4 DESIGN REQUIREMENTS

Thedesignrequiresdaylighting,functionalcirculationflow,sustainableheatingandcooling, outdoor spaces, energy efficiency strategies etc.

7.5 CLIENTS' REQUIREMENTS

Theclient's requirementsas generated from the design briefarebriefly as follows:

1. Possible CostEffectiveness (Low maintenance cost)
2. Aesthetics andidentity/ Sense of environment soto attract customers/visitors.
3. User friendliness so to attract event planners.
4. Possible energyefficiency.
5. Privacyand Security.

7.6 USER REQUIREMENTS

The userrequirementsare generatedfromthedesignbrief,literaturereviewandcasestudies carriedout.They includeuserneedssuchasspaceandservicesanduseraspirationssuchas comfort, efficiencyand identity.

7.7 USER SPACE NEED. (TANTATIVE SCHEDULE OFACCOMMODATION)

Thetentativescheduleofaccommodationforthisconventioncentercanbesummarizedin the table below:

ADMINISTRATIVE AND OFFICES SECTION

FACILITY	NO. REQUIRED	AREA (SQM)	TOTAL
Reception Counter	1	90	90
Coffee room	1	30	30
Research library	1	200	200

Manager's Office	2	35	70
Secretary's Office	1	25	25
Personnel Manager's	1	15	15
Cashier's Office	1	20	20
Event Planners Office	1	20	20
MaintenanceOffice	2	20	40
I.Tand Record Office	1	35	35
Internet Cafe	1	50	50
Toilets			
General store	2	30	60
GroceryShop	4	25	100
Staff restroom	2	30	60
VIP Lounge	1	30	30
Gallery / Museum	1	300	300
Conference room	1	200	200
Seminar room	1	250	250

GYMNASIUM AND OUTDOOR SWIIMING POOL

FACILITY	NO. REQUIRED	AREA (SQM)	TOTAL
Outdoor Swimmingpool	1	200	200
Swimmingpool changing	2	30	60
Toilets	8	3	24

Gymnasium Hall	1	300	300
Tennis court	2	120	240
Electric Control Room	1	12	12
Laundry	1	24	24
Office en suit	1	13	13
Shops	4	6	24

CONVENTION THEARTERS AND GENERAL EXHIBITION

FACILITY	Standard	Adopted	Capacity	Total
Open Amphitheatre	0.5/person	0.5/pers	2000	1000
Auditorium	0.5/person	0.6/pers	830	500
Atrium & exhibition	1.2/person	1.3/pers	2000	1500
Banquet hall/ restaurant	0.5/person	0.6/pers	1200	750
Outdoor banquet space	0.5/person	0.6/pers	300	180

Table 7.2: TentativeSchedule ofuserspace requirement (Accommodation)

(Source: Student's Proposal based on casestudiesand data books.)

7.8. CONCEPTSDEVELOPMENT

7.8.1 SiteLandUseConcept

The site landuse conceptisgeneratedfromfunctionalfloor relationshipbetweenthe various componentspacesintendedfor thestructureandsomeelementsofsiteanalysissuchasnoise zoning,topography andsite'sco-ordinatesorientation(Locationofaccess,sunriseandsun setandwinddirection). The land use conceptshowshow differentcomponentsof the site mergeintooneanotherandhowthey relatewithoneanotherandthelinkingroadsand pathways.

The building is oriented relative to the site to take advantage of the prevailing winds and reduce radiation on the external walls. The water body also can help in evaporative cooling along the north east wind which is usually dusty and hot. The functional flow concept is shown in the plate below.

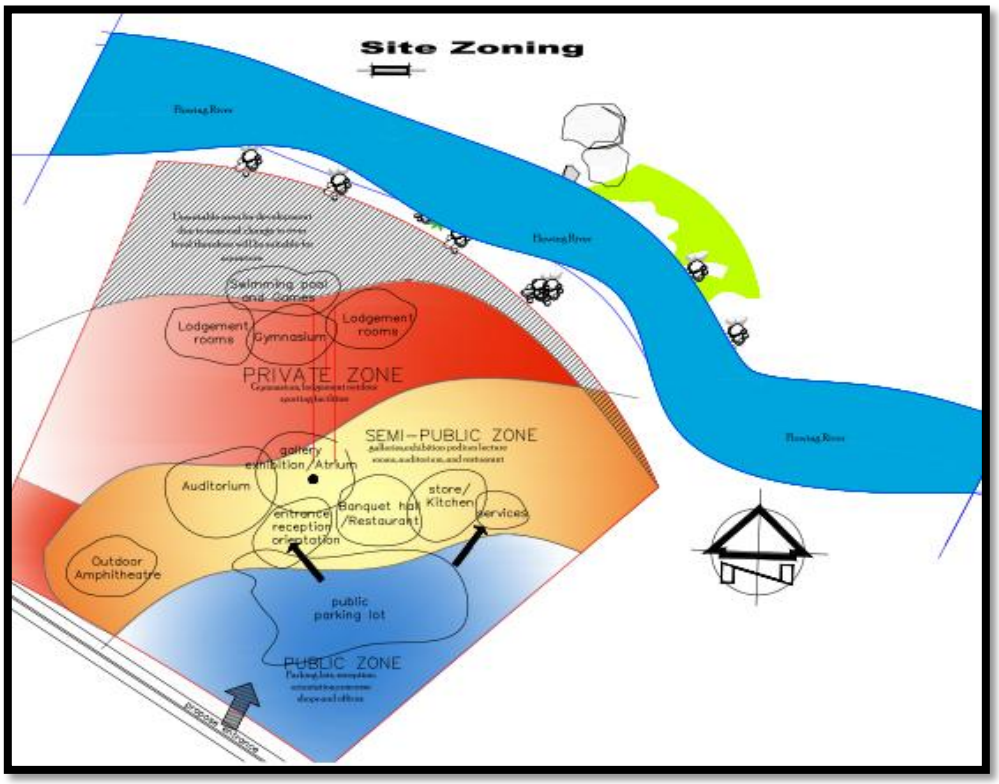


Plate 7.1: Site Concept development and spatial Organization. (Source: Students proposal)

7.8.2. Building Concept

Bioclimatic design has to do with creation of an architectural piece through proper consideration of the climatic elements for comfort of the users. This means the building form and concept has to consider the climatic elements and reduce their impact on the building. The common forces utilized to evoke bioclimatic distinctive and energy efficient building include; climate, history and culture, materials and renewable energy. These forces are merged together to develop the plan and elevational concept for the design proposal.

From the historical point of view, Kaduna state got its name from river Kaduna. This river is an iconic tributary in the state. It got its name because it was crocodile infested. Kaduna being the plural of crocodile in Hausa (Kadduna). The building form emerges from the crocodile form on plan with the functions extended and positioned along the north – south of the cardinals for maximum daylighting and ventilation. Also, the "Dagi" symbol of Area (Northern Nigeria). It epitomizes royalty and depict peculiar identity of traditional architecture of northern Nigeria. Kaduna was the capital of northern Nigeria in the first republic. This in integrated in the design in the central atrium which serves as the modern courtyard for social and physiological feature of northern architecture.

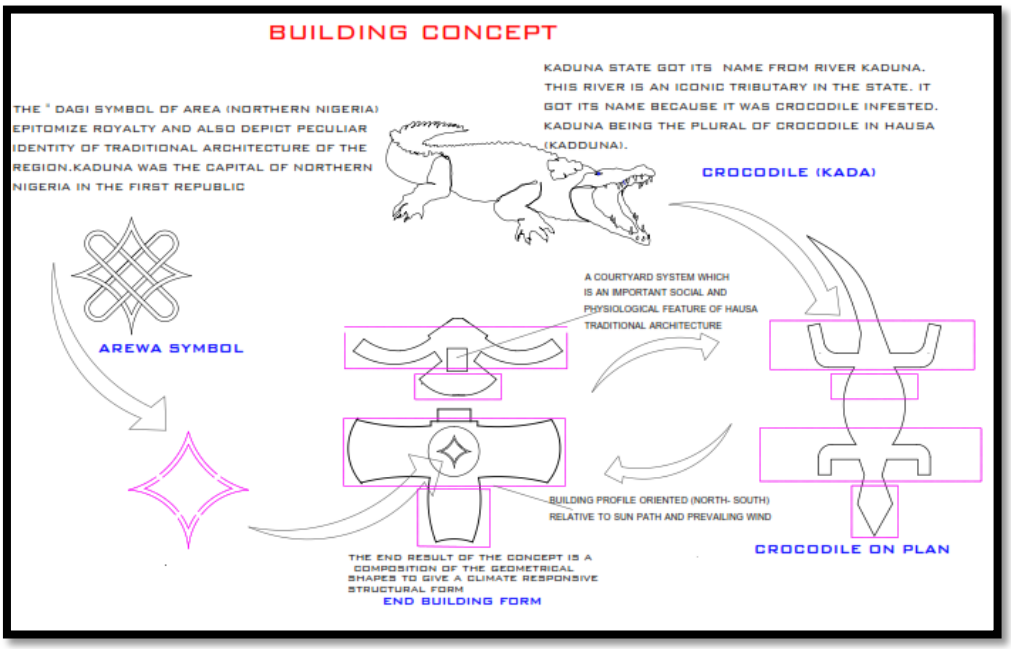


Plate 7.2: Floor Plan Concept from composition of historical elements and climate consideration. (Source: student's proposal)

7.9 ASSESSINGTHEDESIGNPRINCIPLESOF BIOCLIMATIC FOR ENERGY EFFICIENCY.

Thefollowing principlesareadoptedforcreatingan energy efficient convention centerusing bioclimatic design principles in theproposeddesign. Theyare as follows:

i. Orientation

ii. Shading

iii. Natural daylighting

iv. Natural ventilation

v. building materials

vi. Landscape

vii. Renewable energy

Natural Ventilation:

The first determining factor to achieve effective natural ventilation for energy efficiency is the orientation of the building as established earlier in the discussion of findings. This is achieved in the design proposal with the North- south orientation, minimizing exposure to excessive solar radiation and optimizing prevailing winds. Other elements such as the courtyard system was incorporated to enhance airflow with large windows on the wind ward side of the building. The water pool at the main entrance of the building and courtyards help in evaporative cooling of the interior and circulation spaces.

Natural daylighting:

The design proposal adopted atrium and courtyards for effective natural daylight. The atrium is covered with a translucent glass dome from acrylic glass which has thermal conductivity of 0.2w/mk having high thermal insulation to minimize heat gain and achieve adequate lighting. Other strategies include use of large windows along the north-south especially in the major functions (auditorium and banquet halls, general exhibition and atrium, lodgments and gymnasium hall).

Shading:

The building developed a form that provides adequate shading relative to the sun path. It is rectangular like form positioned with the shorter sides along the west and east axis of the cardinals making the exposure to solar radiation minimal. The main functional space

are shaded by the service core to the west and east hence providing adequate lighting in the toilets and kitchen spaces. Other elements like projected walls and balconies were used. Trees positioned along the west help reduce the intense heating. Also, shading devices in form of vertical steel structure covered with aluminum panels were used in the main administrative block to the east and west as recommended in table 5.7 above. Projected large roof overhang were incorporated as can be seen in the elevation and 3D. Other shading strategy is green roof in the lodgment and gymnasium units to shade the building from intense heating and improve the microclimate. There by improving the HVAC system which also improves the energy efficiency.

Landscape:

This is an important principle that reduce the energy load required to remove the heat in a building there by making it energy efficient. The proposal incorporate soft landscape in various transitional space so as to improve the microclimate of the building surrounding. This will be noticed in the courtyards and gardens within the site. Also, vertical landscaping in all the balconies is used to improve the climate and increase the oxygen level thereby enhancing user's comfort. The soft landscape elements covers at least 60-70% of thetotal land area, this reduce urban heat island effect that depletes the ozone and cause global warming. Conclusively, it is obvious that the building has the potential of reducing significant amount of intense heating reaching it from the sun making it environmentally friendly and energy efficient.

Renewable energy:

This principle has to do with employing sustainable energy strategies in the building considering the readily available natural resources on site. Kaduna state being in the hot dry climate region is characterized by intense sunlight and radiation this makes it suitable to employ solar photovoltaic cells as a renewable energy to be used for the design. Since

the design proposal is principally addressing bioclimatic design in relation to energy efficiency in convention center. It will be prudent to harness the naturally abundant sunlight in the climatic zone to generate energy to take care of certain percentage of the overall cooling and lighting energy demand of the building which are the major challenge for the designer in the region. Other renewable energy like wind, geothermal and hydro may not be effective since the resources to harness them are rarely available there by making it difficult and expensive.

Building materials:

Material is one of the critical determining factor that establish the effectiveness of Bioclimatic design principles applied in any building depending on the nature of environment it find itself. It's also one of the major elements that affects the building energy performance and efficiency.Thereforeforany materialtobe chosen,ithastohave the qualitiesthatwillgivedesiredeffect. Materials like brick was used, Concrete and glass are used to defeat the aim of the study. The thermal mass, low thermal conductivity and U-value inherent to brick lends itself to energy efficiency and reduce heating and cooling load often necessitating less mechanical cooling systems. The window and glazing is from double pane tinted glass material in aluminum frame with low emmittance as well as high resistance to heat flow which also makes it energy efficient.

Model and simulation.

One of the aim of this study is to find out the extent to which bioclimatic design principles can be applied in convention center design and their effect on the energy efficiency. Consideration was placed on the building envelope which comprised of the materials. As established earlier in the literature review and findings, materialis one of the critical bioclimatic design principle that significantly affects the cooling and lighting energy use and its efficiency. Hence from the case studied and findings, the recommended

building envelope was carried out on a rectangular model to determine its percentage reduction in cooling and load using ECOTECT software. The rectangular form model was chosen because it's the best form when oriented to North-South gives the best solar orientation for maximum energy efficiency. Other principles like daylighting, shading and ventilation were not given emphasis at this stage because they depend on the orientation. Table 7.3 below shows the result of the analysis.

	Model 1 DEFAULT	Model 2 Wall	Model 3 window	Model 4 Roof	Model 5 RECOMENDED
WALL	Concrete, sandcrete block and plaster	Brick, concrete wall and plaster			Brick wall and plaster
FLOOR	Concrete slab on ground				Concrete slab, tile on ground
WINDOW	Single glazed Alum frame		Double glazed low energy Alum frame		Double glazed low energy Alum frame
ROOF	Corrugated metal roof			Corrugated metal roof	Corrugated metal roof
COOLING LOAD(WH)	7211436	6108087	5325502	5733092	3858118
DIFFERENCE (WH)		1103349	1975934	1478344	3353318
PERCENTAGE		15.3	27.4	20.5	46.5

Source: Simulation result done by researcher with the software ECOTECT for rectangular shaped model using climatic data of Kaduna, Nigeria.

From the table 7.3 above, the simulation was ran five times, the first one was a default analysis called model 1 which comprised of the conventional materials used as noted in the case studies. In model 2, 3 and 4, all materials were kept constant except the wall in model 2, widow in model 3 and roof in model 4. All the sets have various cooling energy loads. In model 5 all appropriate materials as recommended in the findings were used and a reduction of 46.5% cooling load was recorded.

7.9.1 Site plan

Inplanningthesite,topography andco-ordinateorientationisgivenappropriatepriority. Waterandsewagecollectionpointsare locatedatthelowestpointofthesite'sslopesoto utilize the natural pressure. Privacyis paramount in the social settingofmajority of settlements in the north, therefore thesite iszonedintothreedistincttypesof space hierarchy;namely,private,public and semi-publicspaces.This is doneto enhanceprivacyand segregation adequately.Kaduna Statehasahotdryclimate,thereforethebuildingisorientedtofavorventilationforthermal Comfort;especiallythetheatre and banquet halls whoseusageisanticipated mostlyin thedaytime. The service core of the buildings are oriented to the west and east for adequate natural lighting since daylighting is required for effective circulation and other activities in the kitchen and toilets. The lodgment facilities are also oriented to optimize the prevailing winds for maximum natural ventilation. They are oriented to the north and south cardinals. The existing water body feature along the north-east is also considered; the buildings are positioned so as to effectively receive the cooled air from north east which normally is dusty Sahara wind. The water body removed the dust and improve the

humidity of the air there by enhancing the natural ventilation in the outdoor swimming pool and interior spaces within the lodgment facilities.

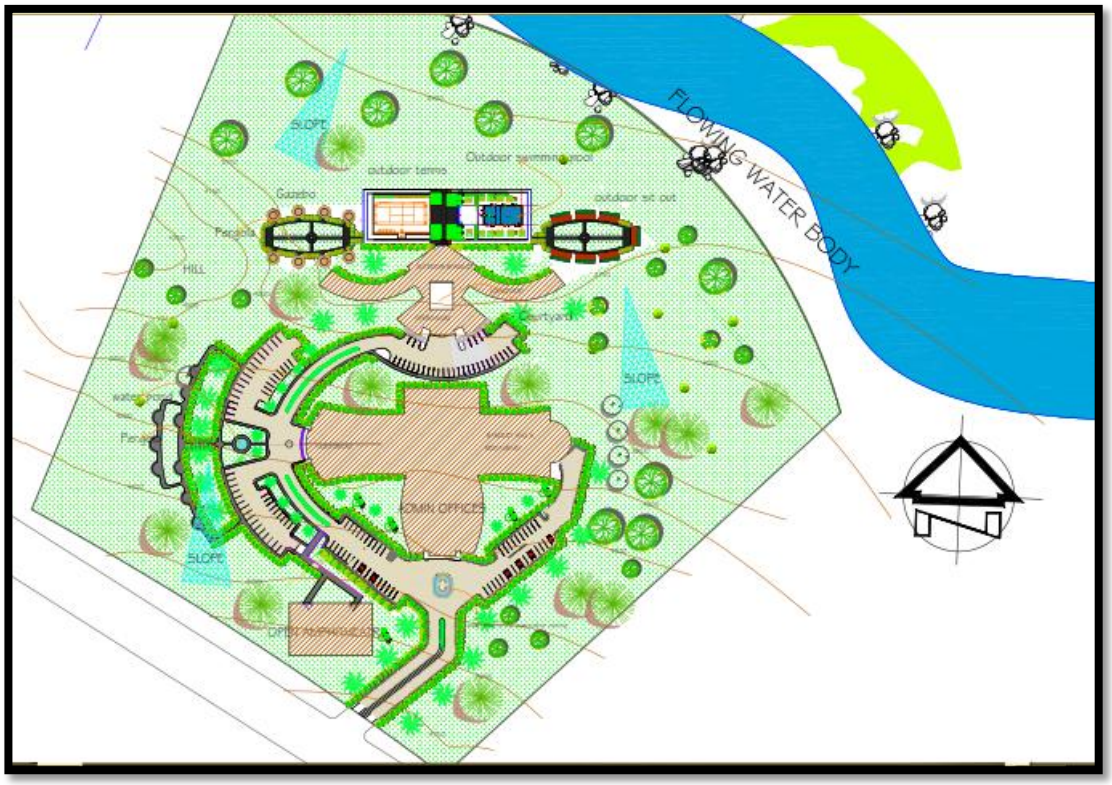


Plate 7.3: Site plan (Source: Student's Proposal)

7.9.2 FloorPlans

Theshapeofthefloorplanisgeneratedfromanabstractcompositionofsomany elements. Courtyardsare a majorpsychologicalcomponentof northern Architecture andhence are providedtoreflectthetraditionalarchitecture,improveventilationforthermalcomfortinthe hot dryclimateand serveas sit outs. This is used in form of atriums and some are open to the Sky for outdoor banquet activities. The respective functions flow into one another making the building functional.

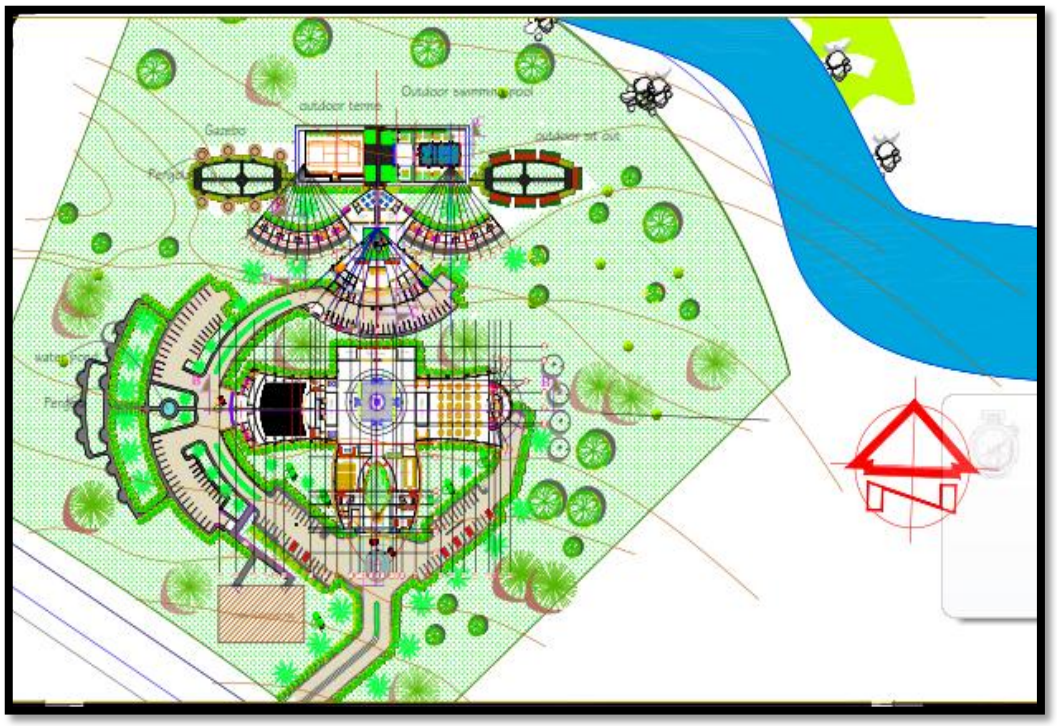


Plate 7.4: Ground floor Plan (Source: Student's Proposal)

7.9.3 Elevations

Theelevationconceptisderivedfromthecompositionofsomeoftheelements peculiar to Kaduna,especially thoseobservedinthecase study and recommended from the findings and literature review. Ranging from the nature of the building facade.Climate responsive elements applicable to enhance the building comfort and historic features. However,theseconceptsdonotpresentthepreciseformofthe proposedbuilding.They areratherатentativeabstractthatgivesaroughideaoftheend results. The conceptual composition of the elevations is as follows:

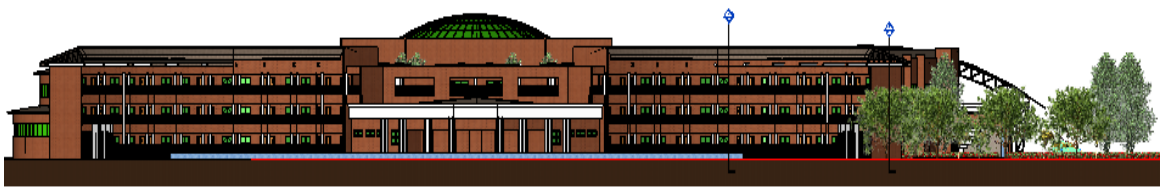


Plate 7.5: Approach Elevation. (Source: Students proposal)

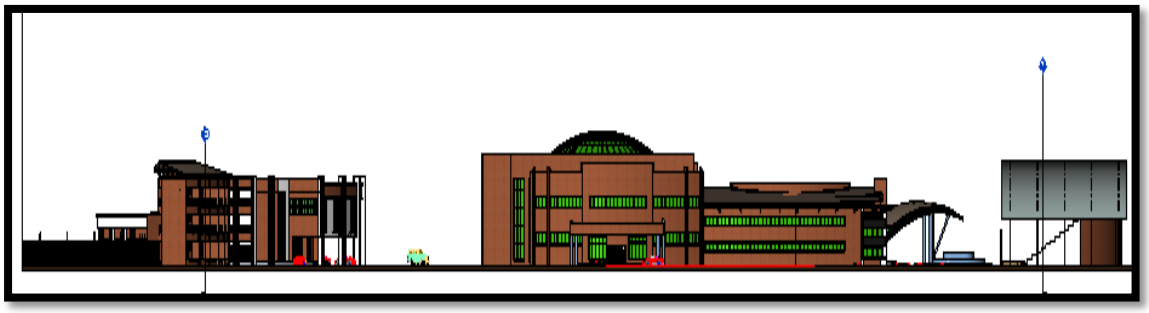


Plate 7.6 Rear Elevation. (Source: Student's Proposal)

The plate above shows a typical side elevation of the building with east to west orientation. It can be noticed that shorter sides are positioned along this elevation with minimal openings to reduce overheating of the interior spaces. Significant percentage of the openings visible in this view are for the service core. Also, recessed walls and balconies with large canopies at the main entrance of the building and the roofing structure of the amphitheater provides adequate shading. While in the lodgment facility, there is no opening in either the west or east of the building which minimize solar heat gain.

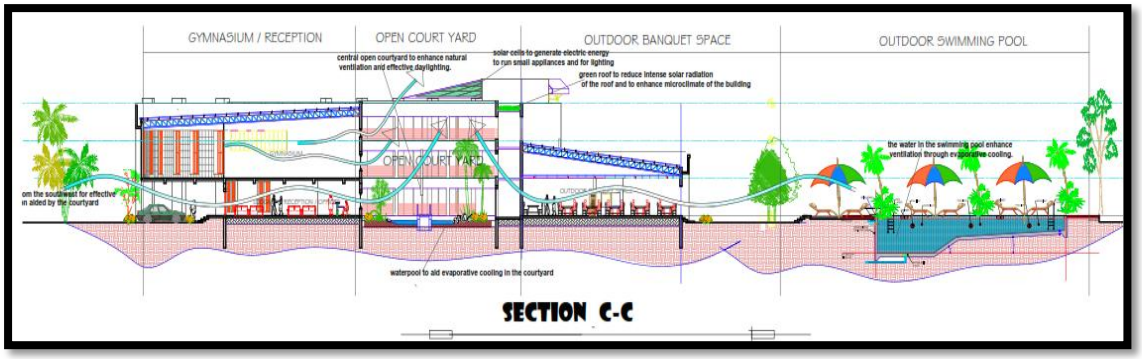


Plate 7.7: Section through the gymnasium and outdoor banquet space (Source: Student's proposal)

The section above shows the air flow in the interior spaces aided by the courtyard system and water body. It also shows how renewable energy solar panels were installed to compliment energy used. Evaporative cooling aided by the swimming pool. It shows the outdoor banquet facility which was enhanced by the outdoor design to take care of

artificial cooling of the space since it accommodates large number of people hence favors the comfort of the users with minimal energy.

7.10 CONSTRUCTION

Constructionmustbe ina manner that will notcompromisethe aimof thedesign. Materials with high thermal capacity, high time lag property and reflectivity are used to reduce the intensity of radiation and heat gain in the building. The construction technique employed the use of concrete to form the main building frame for maximum stability while the other materials serve as the shell cover and partitions. The roofing system is steel covered with appropriate materials. The wall painting have high reflecting property to reduce radiation which will increase heat gain.

7.10.1 FOUNDATION

Determiningtype offoundationisnotanarchitecturalchallengeandthereforearchitect has lesstosay aboutit.Itistheworkofsoilsandstructuralengineerandhenceitsspecifications aredictated byhim.

7.10.2 WALLS

Wallsareconstructedpurelyofmasonry bricks. This is because of their thermal property. The material have a high time lagging quality of conserving the day heat in it to be used to warm the interior during the night when the air temperature in normally cool. Theyarehoweverfacedwithdifferent materialsdepending onthedesiredeffect.Other walls are concrete for structural requirement. Interiorwallsserve aspartition elements withoutnecessarilyhavingto perform anyload bearingfunction. While in the auditorium and spaces like the research library where there is need for acoustic control, fiber and

wooden partitions are used to improve the noise control within the spaces for effective performance.

7.10.3 WINDOWS

Windowsarepurposelymadeandverybigsotoadmitenoughlightandairespeciallyto eventandexhibitionspaces.Glassaluminumtophungpaneledwindowsareintendedfor use almost throughout thebuilding whichprovide almost hundred percent air flow into the interior spaces.

7.10.4 DOORS

Doors willbepurposelymadedependingon sizeand functional requirement.

7.10.5 ROOF

Curvaceousandvaultedroofssupportedby steeltrussmembersareusedasfalsedomes. Spanishroofing sheetsareusedformostoftheroofs.Wheremorelightismostneeded, glazeddomesareintroducedtoperformthefunctionof providinglightandreflectingtraditionalarchitecture.Wherephotovoltaiccellsareused,itistop rovideenergy sufficient forlightingthe spacebelow.

7.10.6 CEILING

Suspendedacousticceilingsare used toprovide conduitfor installationsandreduceeffectof noise and sound reflection during events.

7.10.7 SWIMMING POOLS

Outdoorswimming poolisprovidedwithinapavedarea. This is to servethemenandthe women.Swimming poolis locatedintheinnermostormostprivate partofthesiteandconnectedtothegardentoofferguestsprivacy andcomfort.Theshallow poolisupto600mmdeepwhilethedeepestpartisupto2100mmdeep.The pool is surrounded

toreduce theimpactof evaporationandexcessive heating duringhot-dry season. Users areofferedagoodviewofexteriorlandscape environment.

7.10.8 MECHANICAL ENGINEERINGSERVICESAND EQUIPMENT

The followingmechanical engineeringservices are provided:

a. **WATER SUPPLY**

Thecenterisconnectedtothemainsofwatersupply oftheKadunaStatewaterboardfor supply ofwaterforsuchneedsas,foodpreparation,cleaningandgeneraldomesticpurposes, fire-fighting,coo1ingandsoftening plant,boilers,laundriesandswimming pools.Borehole willserveasalternativesourcesandthey willbelocatedfarfromsewagelinestoavoidany possibilityof contamination.

b. **WATER STORAGE, DISTRIBUTION AND PRESSURE**

Sufficientwaterequaltoatleast100%ofthedailyrequirementisstoredinreservoirs located at the northward highest point of site slope so to utilize natural pressure for continuous flow.

c. **WATER SUPPLIESFOR FIREFIGHTING**

Twoindependentsourcesofwaterathighpressureforfire-fighting are provided.There exists ontheonehand,waterhydrantslinkedwiththe mainssupply andontheotherhand,an underground storage reservoir.Thisundergroundstorage reservoir isconnectedthrougha network of pipingto

i. S p r i n k l e r s withautomaticopeningatasettemperatureatintervalsof4.Auintheatres, meetingrooms, offices,corridors, public rooms and lobbies.

ii.Hose reels and stand pipesareplaced at least 20maparton escaperoutes.

d. **WASTE AND SOILPIPESAND SEWAGE DISPOSAL**

The design,constructionandinstallationof thesepipesare basedoncost savingsandeaseof assembly.Bathroomsandtoiletsare arrangedingroupsorpairstoreducecostofinstallation andmaintenance.Thecollectionpointof thewasteisatthelowestpointofsiteslopesoto utilizenaturalpressureforefficientflowandeasy evacuation.Vehiclescanaccessthe collection pointthrough truck entranceand exit.

7.10.9 ELECTRICAL ENGINEERINGSERVICES

Theelectricalservicesincludetheprimaryandemergencysupplies.Theelectricalmains fromnationalgridsupply a 3-phase AC tothe conventioncenter,withthe mainstransformer locatedexternally(andnotinthebuilding)onafencedoffpartofthesite.Thisisdonesoas toreducetheriskofany accidentalfirefromthetransformerspreadingtothebuilding complex. Theminimumcapacityoftheprimary transformeris160%ofpeakloadrequirementsofthe conventioncenter. Aduplicateof primarysuppliesandotherequipmentisprovidedsoto avoid failurethat mayaffect thewholesystem atatime of emergency.

Renewableenergysourceisminimally employedasasecondarysourcethroughtheuseof photovoltaic panelsmountedontheroof of the lodgment facility and outdoor amphitheatertoprovideenergyforspaces beneath. The generated energy willalsobe provided toexpandthe power optionsand increasetotal energyoutput to cover the followingservices:

i. Lighting:allexitsigns.

ii. T e l e p h o n e , fire alarm and warningdevices.

iii.Fire fightingapparatus(pumps, compressors etc.).

iv.Allsewageandwaterpumpstomainhotandcoldwatersuppliesandpartialheating or cooling.

iv. Sound and projector equipment

vi.Partial services to kitchens

vii.Food refrigerators andcold rooms.

7.10.10 MAINTENANCE SERVICES

Maintenanceservices includebut arenot limited to the following:

i. Roomsandclosetsforlocatingheating,circulationandcontrolequipment(pumps, valves, boiler room equipment and electrical switchgear).

ii. V e r t i c a l ductsbetweenbathrooms(soilwastesandventilatingpipes,hotandcold watersupplies, andelectrical equipment).

iii.Ceilinghousedengineeringservicesandequipment A/Cductwork,lighting fittings, electricalservices,firedetecting,alarmandsprinklers systems,controlandrelay equipment.

iv.Wallmounted equipment,socketoutlets,vacuumconnections, lightswitches, fire alarmsandindicators, recessed hose reels,tableductsandconduitsand roomstatus equipment. Access to ceilingequipment shall bethroughremovablepanels.

7.10.11. COMMUNICATION AND CONTROL EQUIPMENT

Communicationis oneofthemostimportantrequirementsofaconventioncenter.Telephone linesareprovidefor easyco-ordinationofeventsandadministration.Eachtheatre isequipped withsoundandcommunicationdevicesanda language translatorplusaninternetconnection wherenecessary. Thedifferent subscriber lines include:

i. Guest lines

ii. Administrativelines

iii. Service lines

CHAPTER EIGHT

CONCLUSION AND RECOMMENTION

8.1 CONCLUSION

This research work is built on the subject of assessment of bioclimatic design principles in optimizing energy efficiency in convention center. The problem statement established that previous convention center lack this strategy of making the building energy efficient. Convention centers houses large number of people engaged in different activities, this makes thermal comfort difficult without use of artificial means thereby making energy consumption in the center very high and consequently causes dramatic depletion of ozone and contributing to global warming. It was also established that this problem is attribute to the nature of building planning adoption of international styles of architecture devoid of local climatic consideration of the building surrounding. Recent trend in convention center is taking a new dimension of energy efficiency in developed countries and this is minimally noticed in Nigerian architecture. Bioclimatic design principles offers a large approach towards restoring the environment and achieving the current target of efficiency and sustainability. The argument draw its background to the study of relevant literature

Review of recent literature on the writing of prominent bioclimatic architects and theorist aided in the culminating of set of principles on which variables were established to analyze any architectural piece considered having obvious consideration of the local climate. Case studies were carried out and analyzed using general established variables and specific research emphasis on the principles of functioning of the building and the nature of the building energy consumption.

Findings from the case studies and relevant literature review were therefore used to generate design and planning concept for the proposed convention centers. The design provides spaces for the major activities while utilizing bioclimatic design principles. It capitalizes in the nature grandeur of the climatic factors generally affecting the buildings in the zone and provides a functional and comfortable environment to reduce the negative impact of the elements at the same time promoting the energy efficiency of the building by reducing load and employing renewable energy strategies. It is therefore anticipated that, the creation of a better convention facility will foster comfortable and energy efficient building in Kaduna.

8.2 RECOMMENDATION

The universal language of architecture create by international architecture caused catastrophic tendencies of mediocrity and homogeneity, thereby making building so generic devoid of local consideration. The adverse ramification of this is the monotony it create in the built environment. Hence architects should respond to the problems through the following:

1. The essence of bioclimatic architectural identity of a place lies in its materials used and planning setting, this should be optimally considered to create comfortable architectural piece. In view of this, the concept should be derived to suit the climatic factors, rather than mere obstruction and conceptualization from international and unfamiliar forms.
2. Energy efficiency measures should be judiciously incorporated by architects to reduce the consumption and emission of toxic gasses into the atmosphere which is contributing to global warming.

3. Convention centers should be designed using the most contemporary design trends to respond to users' needs and maximize income generation, therefore the recent issue of energy efficiency strategies, sense of environment, spatial organization are paramount and need to be incorporated in the design.
4. Research in the field of regional architecture, energy efficiency and sustainability should come up with framework straighten to solve problems in design, harnessing climatic factors.as this thesis, established the possibilities by taking one of the climatic factors (sunlight) to reduce significant percentage of energy consumption in the building. Other elements like wind and hydro can be explored by researchers in the field of renewable energy and sustainability for further research.

8.3 CONTRIBUTION TO KNOWLEDGE

This study has contributed in the following ways:

i. It provides a platform for effective bioclimatic design expression in architecture by identifying the need for the energy efficiency and sustainability trend which makes buildings fit into its environment without jeopardizing the natural resources or produce greenhouse emissions.
ii. It identified recommended design solutions for Kaduna climatic region (hot dry) and illustrate how they can be applied in the design.
iii. It also identified elements of bioclimatic design principles to be employed to achieve energy efficiency in buildings.
iv. The study has established the strategies to be employed to harness the abundant natural climatic elements as well as devices to enhance the building energy efficiency which can be used by architects and other allied professionals as yardstick for economic and energy efficient projects.

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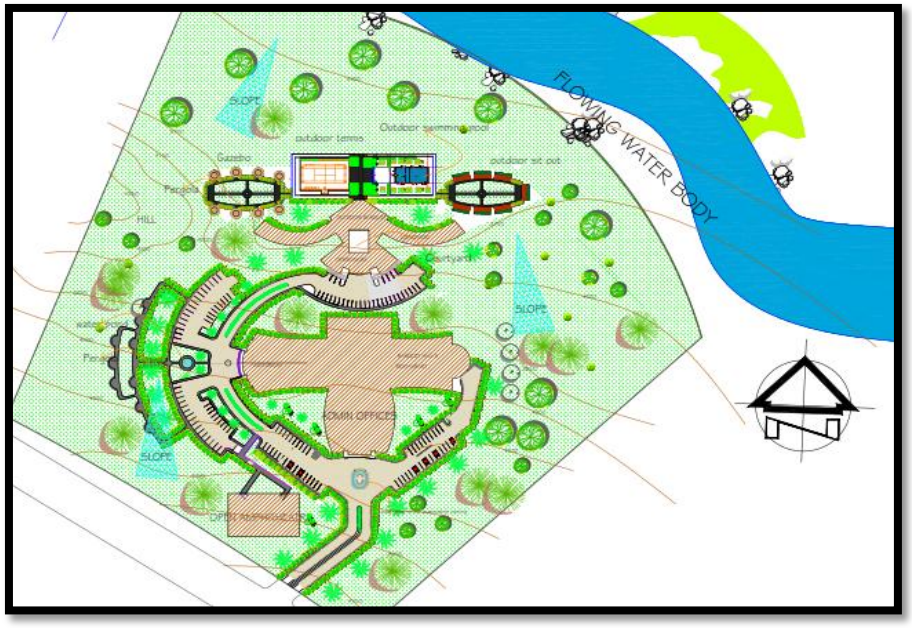
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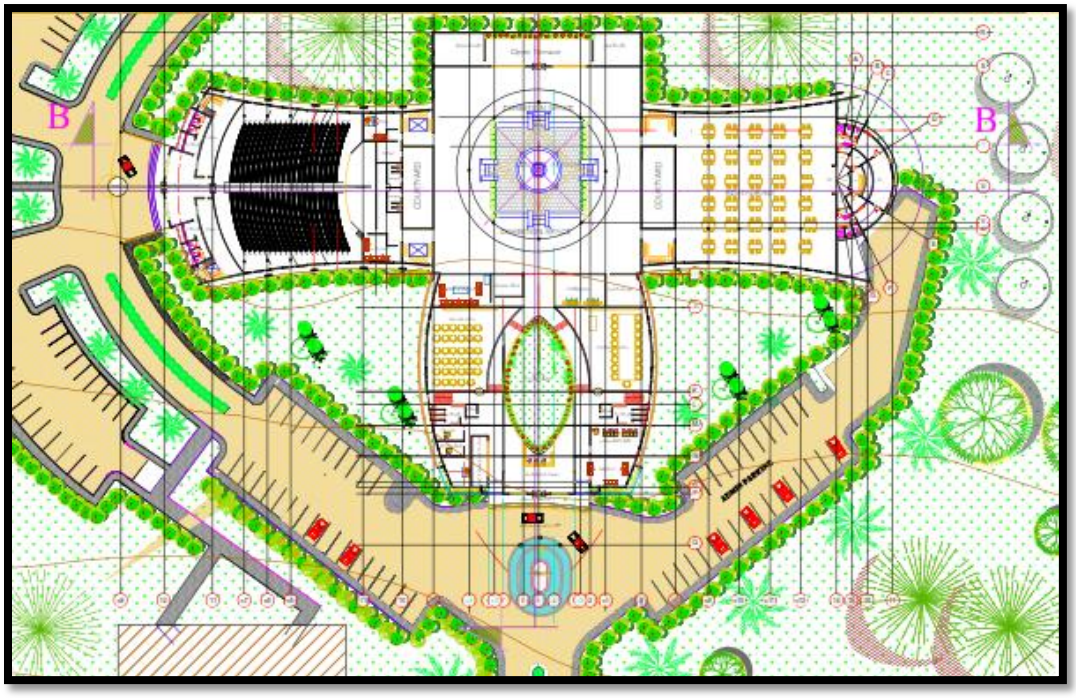
APPENDICES



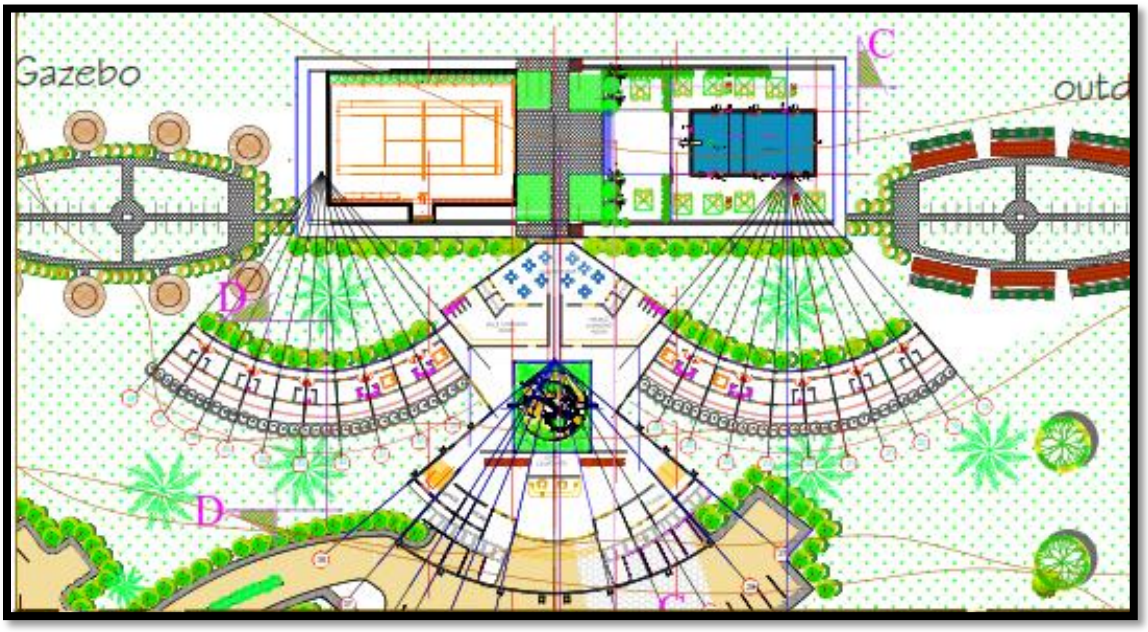
Appendice 1: Site plan



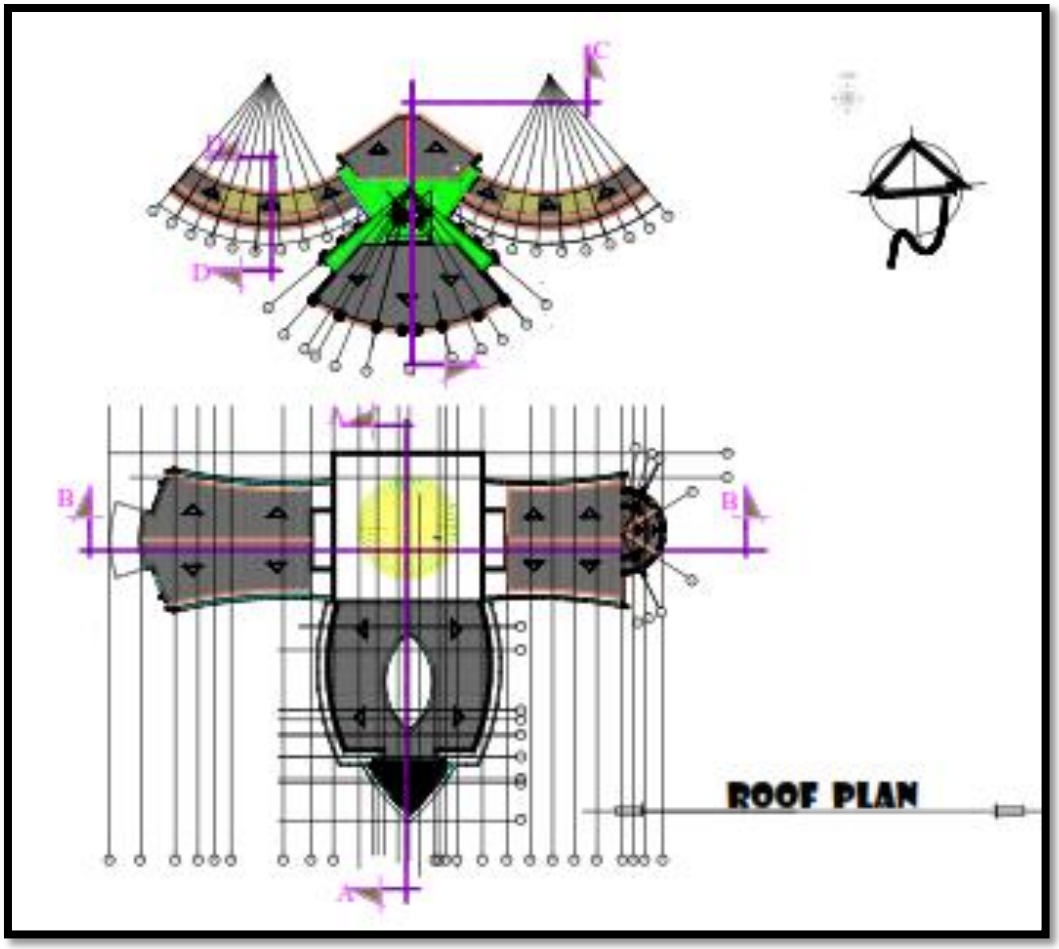
Appendice 2: Ground floor plan



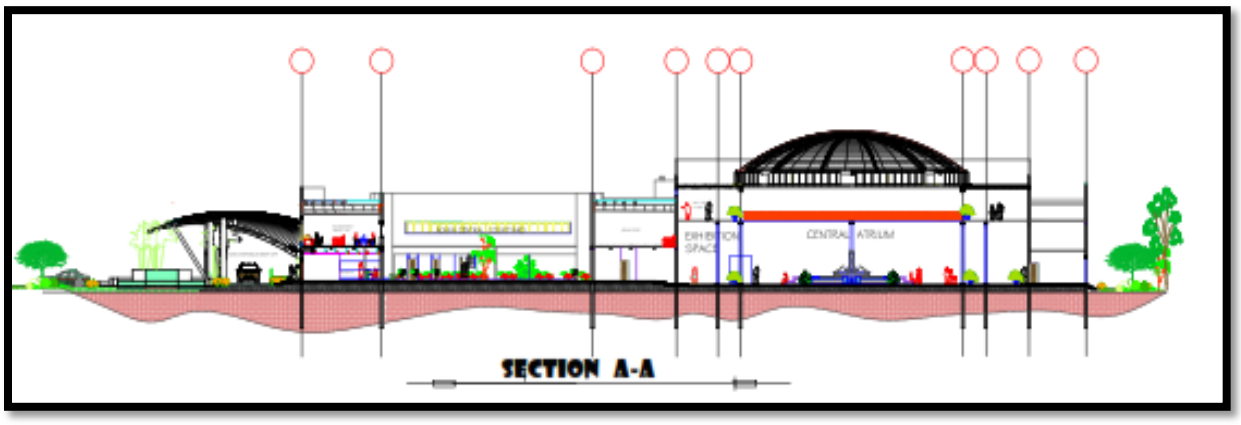
Appendice 3: Floor plan (Main Admin and conference facilities)



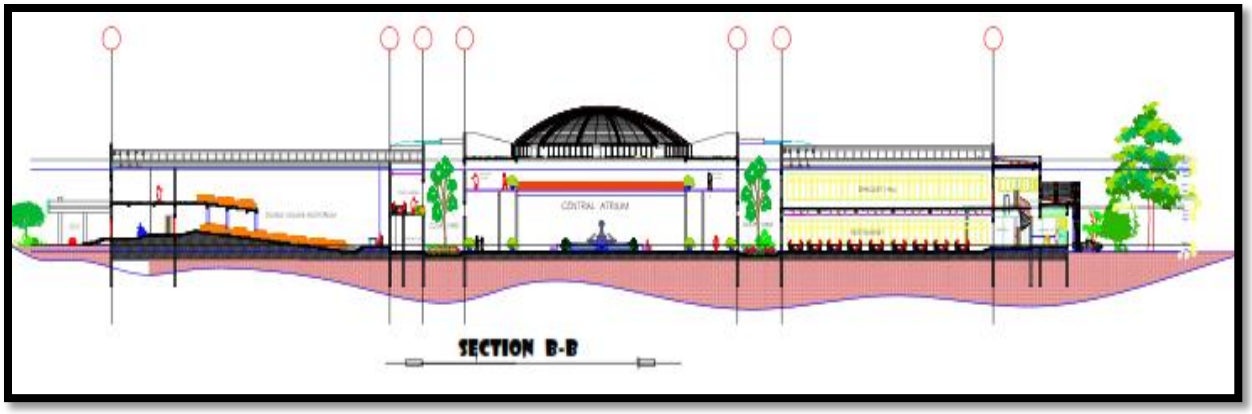
Appendice 4: Floor plan (Gymnasium and Accomodation)



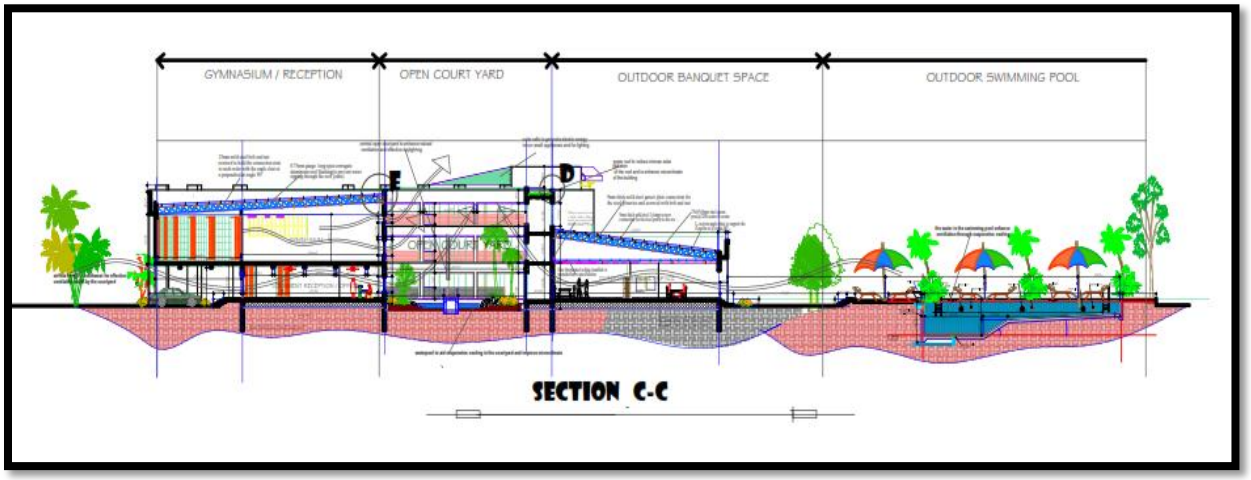
Appendice 7: Roof Plan



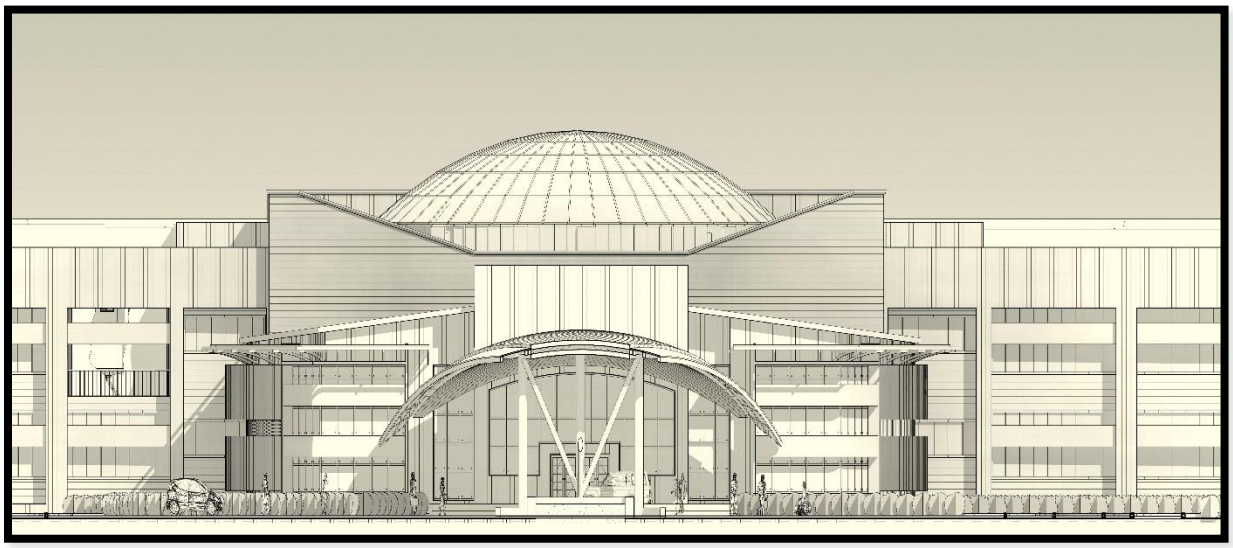
Appendice 12: Section



Appendice13: Section



Appendice14: Section



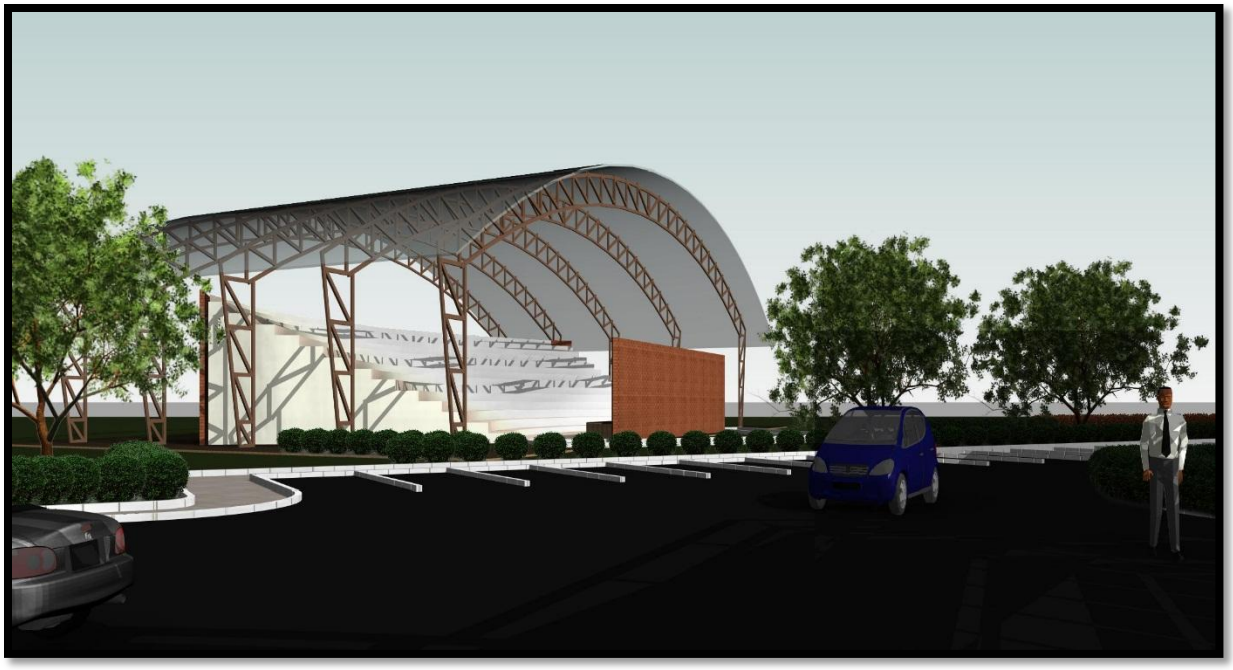
Appendices 15: Admin Approach elevation



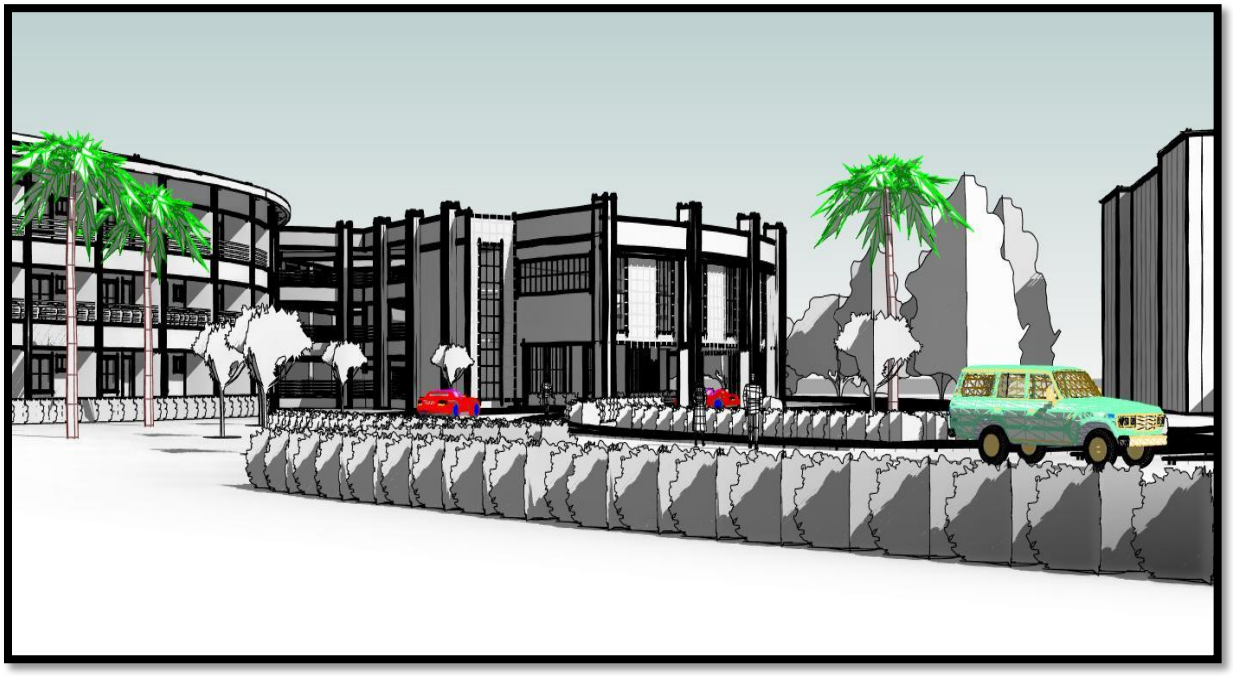
Appendices 25: 3D view of the convention Complex



Appendices 26: Aerial view of the Admin main entrance



Appendices 27: 3D View of the Outdoor Amphitheatre



Appendices 28: 3D View of Gymnasium/ Lodgment facilities