# APPLICATION OF BIOCLIMATIC ARCHITECTURE PRINCIPLES IN THE DESIGN OF HOTEL AT KATSINA NIGERIA

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# APPLICATION OF BIOCLIMATIC ARCHITECTURE PRINCIPLES IN THE DESIGN OF HOTEL AT KATSINA NIGERIA

BY

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## DECLARATION

I declare that the work in the thesis entitled "APPLICATION OF BIOCLIMATIC ARCHITECTURE PRINCIPLES IN THE DESIGN OF HOTEL AT KATSINA NIGERIA" has been carried out by me in the Department of Architecture, A.B.U Zaria under the supervision of Dr. S. N. Oluigbo and Arc. S. S. Tulpule. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this project thesis was previously presented for another degree or diploma at any university.

Abdulmu'Akhir Isah Dalhat

| Name of student | Signature | Date |
|---|---|---|

## CERTIFICATION

This project thesis entitled "APPLICATION OF BIOCLIMATIC ARCHITECTURE PRINCIPLES IN THE DESIGN OF HOTEL AT KATSINA NIGERIA'' by ABDULMU'AKHIR ISAH DALHAT meets the regulations governing the award of the degree of Master of Science of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

| | |
|---|---|
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## ABSTRACT

*This paper presents the application of bioclimatic principles in architectural design whose applicability is modified by region and building type. It highlights the bioclimatic principles necessary to achieve environmentally-friendly indoor environment and energy saving strategies. The aim of the research is therefore to develop a theoretical solutions as well as design solutions for sustainable and energy efficient hotels in hot-dry climate. A qualitative case study of three hotels which indicated the use of bioclimatic principles and which are in the climatic region as the study area was conducted to identify the relationships between variables. Visual survey, interviews and checklist methods were all used in conducting the case study survey of all the selected cases. Therefore, research was carried out on the hot-dry climate, the architectural design requirement of the study area and bioclimatic design requirement of the area in order to achieve the research objectives. The overall thesis studied and incorporated multiple bioclimatic design principles certainly to enhance the quality of the interior spaces and give thermal and bioclimatic comfort to the guest/occupants. The study has shown that conceptually and architecturally nature is incorporated by introducing green vertical gardens and green court yard simultaneously for a region with unstable sources of energy and that there are possibilities that in the near future, bioclimatic designs can be an alternative solution to architectural developments in developing countries like Nigeria. The research concluded that the solutions to high energy demand in architectural design can be achieved by enhancing the use of natural day lighting instead of artificial lightning, enhancing system and passive cooling techniques, micro-climate improvement and by the best use of sun and prevailing winds.*

## TABLE OF CONTENT

**Title page** . . . . . **i**

**Declaration** . . . . . **ii**

**Certification** . . . . . **iii**

**Acknowledgement** . . . . . **iv**

**Abstract** .. . . . . **v**

**Table of Contents** . . . . . **vi**

**List of Figures.** . . . . . **x**

**List of Plates** . . . . . **xii**

**List of Tables** . . . . . **xiv**

**Abbreviations, Definitions, Glossary and Symbols** . . . . . **xv**

**CHAPTER ONE: INTRODUCTION**

**1.1 Background of Study** . . . . . **1**

**1.2 Statement of the Problem** . . . . . **3**

**1.3 Aim and Objectives** . . . . . **3**

**1.4 Research Questions** . . . . . **4**

**1.5 Scope of the Study** . . . . . **4**

**1.6 Justification of Study.** . . . . . **4**

**CHAPTER TWO: LITERATURE REVIEW**

2.1 **Bioclimatic Architecture.** . . . . . **6**

2.1.1 Concept and Evolution of Bioclimatic Architecture . . . . . 6

2.1.2 Importance of Bioclimatic Architecture. . . . . 9

2.1.3 Bioclimatic Architecture Principles . . . . . 9

2.1.4 Bioclimatic Chart and Comfort Zone . . . . . 16

2.1.5 Designing for Bioclimatic Comfort in Hot-dry Climate . . . . . 18

2.2 **Hotels** . . . . . **20**

2.2.1 Types of Hotels. . . . . 20

2.2.2 Hotel Classification Systems. . . . . 23

2.2.3 Hotels and Energy Use. . . . . 27

**CHAPTER THREE: RESEARCH METHODOLOGY**

**3.1 Case Study Approach. . . . . 31**
**3.2 Population of Study. . . . . 31**
**3.3 Sampling. . . . . 32**
**3.4 Instruments of Data Collection. . . . . 32**
**3.5 Procedure for Data Collection. . . . . 33**
**3.6 Variables of Study . . . . . 35**
**3.7 Data Analysis and Presentation. . . . . 37**

**CHAPTER FOUR: RESULTS AND DISCUSSION**

**4.1 Case Study One: NTI Conference Centre, Kaduna . . . . . 40**
4.1.1 Background. . . . . 40
4.1.2 Site Planning and Landscaping . . . . . 40
4.1.3 Spatial Organisation . . . . . 42
4.1.4 Structure and Materials. . . . . 42
4.1.5 Aesthetics. . . . . .43
4.1.6 Application of Bioclimatic Architecture Principles. . . . . .. 44
4.1.7 Summary of the Study. . . . . 49
**4.2 Case Study Two: Katsina Motel, Katsina . . . . . 51**
4.2.1 Background. . . . . 51
4.2.2 Site Planning and Landscaping . . . . . .51
4.2.3 Spatial Organisation.. . . . . 52
4.2.4 Structure and Materials. . . . . 53
4.2.5 Aesthetics. . . . . 53
4.2.6 Application of Bioclimatic Architecture Principles. . . . . 54
4.2.7 Summary of the Study. . . . . 58
**4.3 Case Study Three: National College of Petroleum Studies International Hotel Kaduna. . . . . .60**
4.2.1 Background. . . . . 60
4.3.2 Site Planning and Landscaping . . . . . .61
4.3.3 Spatial Organisation . . . . . 61

4.3.4 Structure and Materials. . . . . 62
4.3.5 Aesthetics . . . . . 63
4.3.6 Application of Bioclimatic Architecture Principles. . . . . 63
4.3.7 Summary of the Study. . . . . 67
**4.4. Comparative Analysis of Results/Findings . . . . . 69**

**CHAPTER FIVE: DESIGN DEVELOPMENT**

**5.1 Site Selection Criteria. . . . . 70**
**5.2 Site Selection. . . . . 71**
**5.3 Site Location. . . . . 75**
**5.4 Site Analysis. . . . . 75**
**5.5 Schedule of Accommodation . . . . . 83**
**5.6 Functional Flow Diagram. . . . . 85**
**5.7 Concept Development. . . . . 87**

**CHAPTER SIX: DESIGN REPORT**

**6.1 Introduction. . . . . 88**
**6.2 Site Planning and Landscaping. . . . . 88**
**6.3 Spatial Organisation. . . . . 90**
**6.4 Structure and Materials. . . . . 91**
**6.5 Aesthetics. . . . . 92**
**6.6 Application of Bioclimatic Architecture Principles. . . . . 93**

**CHAPTER SEVEN: SUMMARY CONCLUSION & RECOMMENDATIONS**

**7.1 Summary. . . . . 99**
**7.2 Recommendations. . . . . 100**
**7.3 Contribution to knowledge. . . . . 100**
**7.4 Conclusion. . . . . 101**

**References . . . . . 102**
**Appendix ... . . . . 107**

## LIST OF FIGURES

Figure 2.1 Olgyay's development of the Vitruvian Tri-partite model. . . . . 7

Figure 2.2 Exploitation of solar energy. . . . . .12

Figure 2.3 The principle of natural day lighting. . . . . 13

Figure 2.4 The principles of summer comfort. . . . . .14

Figure 2.5 The Biomass Cycle. . . . . .15

Figure 2.6 Geothermal Heating . . . . . .15

Figure 2.7 Bioclimatic Chart showing comfort zone. . . . . 18

Figure 2.8 Breakdown of energy consumption in a typical hotel. . . . . 28

Figure 4.1 NTI Conference Centre Site Lay-out. . . . . .41

Figure 4.2 Site Lay-out of NCPS Hotel Kaduna . . . . . .61

Figure 5.1 Site A. . . . . 72

Figure 5.2 Site B Google map. . . . . .73

Figure 5.3 Site C. . . . . 74

Figure 5.4 Site Location. . . . . ..75

Figure 5.5 Climatic analysis the study area. . . . . 76

Figure 5.6 Site analysis, topography and existing features. . . . . 76

Figure 5.7 Temperature chart of Katsina. . . . . 77

Figure 5.8 Relative humidity chart of Katsina. . . . . 78

Figure 5.9 Precipitation chart of Katsina. . . . . .79

Figure 5.10 Sunrise, sunset, dawn and dusk time table. . . . . 79

Figure 5.11 Functional Flow Chart. . . . . .85

Figure 5.12 Concept Development. . . . . .87

Figure 6.1 Hotel Site Planning and Landscaping . . . . . 89

Figure 6.2 2nd floor plan showing the hotel spatial arrangement. . . . . .91

Figure 6.3 View showing the structure and materials of the hotel Building. . . . . 92

Figure 6.4 Hotel Façade. . . . . 93

Figure 6.5 Building shape, orientation and the courtyard. . . . . 94

Figure 6.6 Ground floor plan showing the air circulation in the building . . . . . 95

Figure 6.**7** South Elevation Showing the curtain wall system. . . . . 96

Figure 6.8 Ground floor plan showing the site landscape. . . . . 96

Figure 6.9 The honey comb shading devices on the facade. . . . . 97

## LIST OF PLATES

Plate 4.1 NTI Conference Centre site landscape. . . . . .41

Plate 4.2 Repetitive concrete Façade, NTI Conference Centre. . . . . .42

Plate 4.3 Wooden cladding in the reception , NTI Conference Centre. . . . . .43

Plate 4.4 Concrete floor finishes, NTI Conference Centre. . . . . 43

Plate 4.5 NTI Conference Centre building form and shape . . . . . 44

Plate 4.6 Types of windows used for ventilation, NTI Conference Centre. . . . . .. 45

Plate 4.7 Projection windows for lighting, NTI Conference Centre . . . . . 46

Plate 4.8 Central court yard as a passive technique, NTI Conference Centre. . . . . 47

Plate 4.9 NTI Conference Centre concrete shading devices and deep recesses. . . . . 48

Plate 4.10 Concrete shading devices and balconies, NTI Conference Centre. . . . . 49

Plate 4.11 Katsina motel Reception . . . . . 51

Plate 4.12 Green Court, Katsina Motel. . . . . 52

Plate 4.13 Large trees on site, Katsina Motel. . . . . 52

Plate 4.14 Executive suite Interior, Katsina Motel. . . . . .. 53

Plate 4.15 Presidential suite Interior, Katsina Motel. . . . . 53

Plate 4.16 Interior floor and wall finishes, Katsina Motel. . . . . 54

Plate 4.17 POP ceiling finish, Katsina Motel. . . . . .54

Plate 4.18 Katsina Motel Building form and elongated shape adopted. . . . . .55

Plate 4.19 Windows for natural lighting, Katsina Motel. . . . . .55

Plate 4.20 Green areas and large trees, Katsina Motel. . . . . 56

Plate 4.21 Katsina Motel Chalets vertical garden for shading. . . . . .57

Plate 4.22 Card switch system that reduces energy consumption. . . . . 58

Plate 4.23 NCPS International hotel façade. . . . . .60

Plate 4.24 Curtain wall panels and aluminum cladding, NCPS Hotel Kaduna. . . . . 62

Plate 4.25 NCPS International hotel interior finishes. . . . . 63

Plate 4.26 Large projection windows for ventilation, NCPS Hotel Kaduna. . . . . 64

Plate 4.27 Large transparent glass windows for lighting. NCPS Hotel Kaduna. . . . . 65

Plate 4.28 Court yard for passive cooling, NCPS Hotel Kaduna. . . . . .66

Plate 4.29 Curtain walls and aluminium cladding protecting the external walls. . . . . .66

Plate 5.1 Site soil and topography. . . . . 80

Plate 5.2 Site vegetation. . . . . .81

Plate 5.3 Site Services. . . . . 81

Plate 5.4 FIRS new building. . . . . 82

Plate 5.5 PDP State Secretariat. . . . . .82

## LIST OF TABLES

Table 2.1 Energy efficiency rating of large hotels. . . . . 29

Table 2.2 Energy efficiency rating for medium-sized hotels. . . . . 30

Table 2.3 Energy efficiency rating for small hotels. . . . . 30

Table 3.1 Example of the process of categorisation of the interview. . . . . .38

Table 3.2 Sample of the checklist of the case study variables. . . . . 39

Table 4.1 Assessment of bioclimatic Architecture study variables. . . . . 50

Table 4.2 Assessment of bioclimatic Architecture study variables. . . . . 59

Table 4.3 Assessment of bioclimatic Architecture study variables. . . . . 68

Table 4.4 Comparative analysis of the Cases. . . . . 69

Table 5.1 Assessment of alternative Sites. . . . . 74

Table 5.2 Schedule of Accommodation. . . . . 83

Table 5.3 Staff and Management offices. . . . . .85

## ABBREVIATIONS

| | |
|---|---|
| AA | Automobile Association |
| ADTA | Abu Dhabi Tourism Authority |
| ASHRAE | American Association of Heating, Refrigeration and Air conditioning Engineers |
| CADDET | Centre for the Analysis and Dissemination of Demonstrated Energy Technologies |
| DHW | Domestic Hot Water |
| EDP | Energy design partnership |
| ERG | Energy Research Group |
| EU | European Union |
| IBB | Ibrahim Badamasi Babangida |
| KT | Katsina |
| NCPS | National College of Petroleum Studies |
| NTI | National Teachers Institute |
| RES | Renewable Energy Sources |
| WTO | World Tourism Organization |

## DEFINITIONS

| Terms | Definitions |
|---|---|
| **Air velocity** | Speed of air movement |
| **Average temperature** | Mean of outdoor or indoor temperatures in a specified period. |
| **Bioclimatic architecture** | Building design that offers protection from the unfavourable impact of climate of a specific region by taking advantage of favourable aspects. |
| **Bioclimatic design** | Architecture that deals with specific climate conditions of a specific region that aims to improve human thermal comfort by natural conditioning with bare minimum use of energy. |
| **Bioclimatic design resources** | Unconventional methods of indoor climate modification used in natural conditioning |
| **Bioclimatic strategies** | Ways to achieve favourable human thermal comfort of the indoor environment by modifying the external climate conditions |
| **Bioclimatic zone** | Geographical region defined by meteorological variables related to the interaction between man, architecture and climate to achieve natural conditioning with specific design recommendations. |
| **Climatic factors** | Temperature, humidity, rainfall, wind, cloud cover and other meteorological data. |
| **Comfort zone** | Combination of environmental conditions which a high percentage of subjects consider to be thermally neutral, without sensation of cold or heat. |
| **Environmental impact** | Effect of the physical environment on human health. . |
| **Natural conditioning** | Total or partial control of indoor conditions in buildings as a result of introduction of bioclimatic strategies. |
| **Non-renewable Energy** | Power sources that deplete renewable fuels, specially sun, wind, water and geo-thermal resources. |

| | |
|---|---|
| **Olgyay's Bioclimatic Chart** | Graph proposed by Olgyay showing comfort conditions and zones where different bioclimatic strategies are suggested. |
| **Passive architecture** | Buildings that achieve comfort through design decisions rather than dependence on active mechanical plant with high energy demand. |
| **Passive cooling strategies** | Use of bioclimatic design resources to lower the indoor temperature for human comfort<br>. |
| **Photovoltaic panels** | Used to produce electricity from solar radiation. |
| **Rainfall** | Precipitation on the Earth's surface which include rain, snow and hail. |
| **Relative humidity** | Quantity of water vapour in a given air volume, compared with the maximum possible water vapour content at the same temperature and pressure. |
| **Renewable energy** | Power sources that avoid depletion of fossil or non-renewable fuels, in particular sun, wind, water and geo-thermal resources. |
| **Solar architecture** | Architecture that optimises the use of energy from the sun, both active (requiring additional energy to transfer heat) and passive (using natural heat transfer mechanisms). |
| **Solar energy** | Radiant electromagnetic power emitted by the sun. |
| **Solar radiation** | Electromagnetic radiation from the sun. |
| **Sun path diagram** | Two-dimensional figure that represents a projection of the suns path across the sky, usually for specific latitude. |
| **Sustainability** | Concept used to minimize future environmental, social and economic impacts. |
| **Sustainable architecture** | Architecture aiming to reduce or minimize environmental, social and economic impacts. |
| **Temperature** | Climatic factor that indicates the degree of coldness or heat. |
| **Thermal comfort** | Thermal equilibrium of the human body that creates a sensation of neutrality. |

| | |
|---|---|
| **Visual comfort** | Levels of illumination to favour user satisfaction and productive working conditions. |
| **Wind velocity** | Speed of air movement over the earth's surface. |

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND OF STUDY

In a rapidly changing world where climate change, environmental degradation and the growing concern for over dependence on non-renewable energy is becoming key environmental issues, it is argued that it is necessary to redefine the environmental and architectural attitudes to an environmentally-friendly approach (Evans, 2007). Bioclimatic architecture combines the interests of sustainability, environmental consciousness, green, natural, and organic approaches to evolve a sustainable solution by considering the characteristics of the site, its neighborhood context, the local microclimate and topography (Al-musa'ed, 2011). This approach takes advantage of the climate through the right application of design elements and building technology for energy saving as well as to ensure comfortable conditions within buildings (Goulart and Pitta, 1994). According to Evans (2007), the protection from adverse conditions of the outdoor environment, as well as the conservation of environmental variables favouring comfort, can be achieved through two alternative mechanisms: the use of bioclimatic design resources or the mechanical plant to provide artificial conditioning.

More recently interest has concentrated on human energy in relation to the constantly changing environment. According to data of the Energy Research Group (1999) buildings use at least 50% of all the energy produced in our planet for heating, cooling, lighting and in building construction. Therefore, the biggest part of this consumption is directly related to architectural aspects and the use of the space (Axarli and Teli.,2008). And in this case,

the environmental integration of the building design through bioclimatic strategies present a very good potential of energy saving and comfortable conditions of the indoor environment.

According to Bohdanowicz (2006), hotel buildings consume substantial amount of energy in providing comfort and wide range of services to guest poses a serious environmental threat and this is due to poor environmentally-friendly nature of the architectural concepts used. However, hotel buildings can be designed to meet guests' need for thermal and visual comfort at a reduced level of energy consumption using Bioclimatic solutions as an alternative to the environmental and energy problems (Maciel, 2007). These solutions to high energy demand can be achieved by enhancing the use of natural day lighting instead of artificial lightning, enhancing system and passive cooling techniques, micro-climate improvement or adjustment of environmental conditions by the best use of sun, prevailing wind, the ambient temperature and humidity (Axarli and Teli.,2008). Al-musa'ed (2011) stated that Architecture can be used to harness these natural resources by designing with climate that is through; the use of the appropriate architectural forms, appropriate orientation, good material selection, and efficient use of the site resources.

Furthermore, energy efficiency in the development of new concept in the design of hotel buildings can be affected by adopting bioclimatic approach to the building design (Machaira, *et.el.,* 2012*).* Therefore, the primary goal is to reduce the energy demand for cooling, heating, lighting etc. and at the same time improve the thermal and visual comfort conditions and interior air quality.

## 1.2 STATEMENT OF THE PROBLEM

With increasing environmental awareness, climates such as the hot-dry climate that is characterised with extreme seasons requires a bioclimatic approach to building designs especially to hotel buildings that consume a lot of energy. In order to reduce the energy consumption and increase indoor spaces thermal and visual comfort, there is the need to design for bioclimatic comfort for hotels that are high energy users. The hot-dry nature of the climate of the study area (Katsina) also presents extreme need for bioclimatic approach for thermal comfort.

Despite the effort by many researchers to incorporate bioclimatic Design approaches into building design, there is still minimal consideration of these energy efficient approaches especially during design stages of hotels, in which the main design solutions are identified. Hotel buildings use significant amount of energy in their operations; cooling refrigeration, heating and cooking in order to provide comfort and services to guests.

## 1.3 AIM AND OBJECTIVES

### 1.3.1 Aim

The aim of the research is to study bioclimatic principles and apply the principles in the design of hotel in a hot-dry climate (Katsina).

### 1.3.2 Objectives

The aim of this work would be achieved through the following objectives:

i. To review the concept and principles of bioclimatic architecture.
ii. To identify the bioclimatic architecture principles considered in hotel buildings in the hot-dry climate of Nigeria.

iii. To highlight the bioclimatic architecture principles studied in the selected cases.

iv. To propose a hotel design using bioclimatic architecture principles in order to improve the building occupants' comfort.

## 1.4 RESEARCH QUESTIONS

The main research questions of this research are:

i. What are bioclimatic architecture concepts and principles?

ii. What are the bioclimatic design principles that increase the thermal comfort of internal spaces of hotels in hot-dry climate?

iii. To what extent does bioclimatic design principles increase the thermal comfort of internal spaces of hotels in hot-dry climate?

iv. To what extent can bioclimatic principles be applied in design of hotels in the hot-dry climate?

## 1.5 SCOPE OF THE STUDY

The research is limited to the application of bioclimatic architecture principles in the design of hotel, specifically, in a hot-dry climate. It highlights the theoretical framework necessary to achieve a bioclimatic approach to hotel design through the assessment of existing principles and the consideration of the study area climate. Finally, the research will develop a theoretical solutions as well as design solutions for sustainable and energy efficient hotels in hot-dry climate.

## 1.6 JUSTIFICATION OF THE STUDY

The study area (Katsina) which is located in the Hot-dry climate, characterized by excessive heat and glaring sun coupled with a hotel building that consumes more amount

of energy in providing comfort and services to guests can add the cost of running the building. The application of bioclimatic approach in the design of building in a region with extreme weather conditions and a country coupled with lack of standard energy sources reduces the need for alternative power supply, saves on energy costs and enhances comfort and services provided to the guests.

With the renewed efforts resulting in massive infrastructure, Katsina state is becoming the key target for investments (mostly public-private partnership). The creation of three (3) universities, establishment of several working institutions and many more a hotel promotes the position of Katsina State as the centre of hospitality. According to the Katsina State Ministry of Commerce and Tourism, the state houses a few less than 500 hotel rooms. With three (3) universities (bringing conferences and visiting dignitaries), hosting of events like polo tournament, horse racing, sporting events and competitions, traditional wrestling, social events (wedding) etc are attracting more and more people and businesses from within and outside the country. Consequently, the occupancy ratio of the existing hotels is increasing on the daily basis. Certainly, the existing hotels are not enough to even accommodate the current teeming visitors to the state. Therefore, the need for hotel that is environmental friendly, saves energy and cost of maintenance is beneficial.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 BIOCLIMATIC ARCHITECTURE

### 2.1.1 Concept and Evolution of Bioclimatic Architecture

Many scholars believe that climate has pronounced effects on humans. The protection from climate is one of the initial factors that have remained a constant priority in the long process of the development of the built environment and the history of architecture (Evans, 2007). Therefore, the effort to define the relation between architecture and climate and the influence they both have on humans resulted in Bioclimatic architecture (Maciel, 2007).

According to Machaira *et.al*, (2012), Bioclimatic Architecture existed since prehistoric times when people have been naturally trying to exploit in the best way local microclimate, positioning, winds, humidity, underground streams, tellurian currents, electromagnetic fields and a good choice of materials to create a building cheaper, more pleasant and above all healthier. At the same time, Bioclimatic Architecture may be considered a response to these variables; the approach is also known as Solar Architecture and later Passive Architecture (Evans, 2007). According to Vazquez (2009), it was the two brothers Victor and Aladar Olgyay who in 1951 began to apply the terms Temperate House and Bioclimatic Approach to Architecture until they became an obligatory turn of phrase for architects coming into the field. The Olgyay brothers referred to the bioclimatic approach as a great surface for criteria specific to a project. In 1963, the term bioclimatic was used for the first time by Victor Olgyay and among other achievements in

bioclimatology, he developed a bioclimatic chart, which relates climatic data to thermal comfort limits (Maciel, 2007).

Bioclimatic Architecture relates to the study of the climate applied to architecture to improve the conditions of thermal comfort of the occupants through the use of appropriate project strategies considering the climatic differences of each place (Lamberts, 2006). 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. The bioclimatic approach to architecture 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 (Evans, 2007). Bioclimatic architecture puts the occupant at the centre of its considerations, it re-establishes the architectural link between man (the occupant) and climate (interior and exterior ambiences). It brings together disciplines of human comfort, climatology, building physics (technology and architecture) and the relationship between these elements is according to Olgyay's Vitruvius Tri-partite model (Davies, 1999) as shown in fig. 2.1.

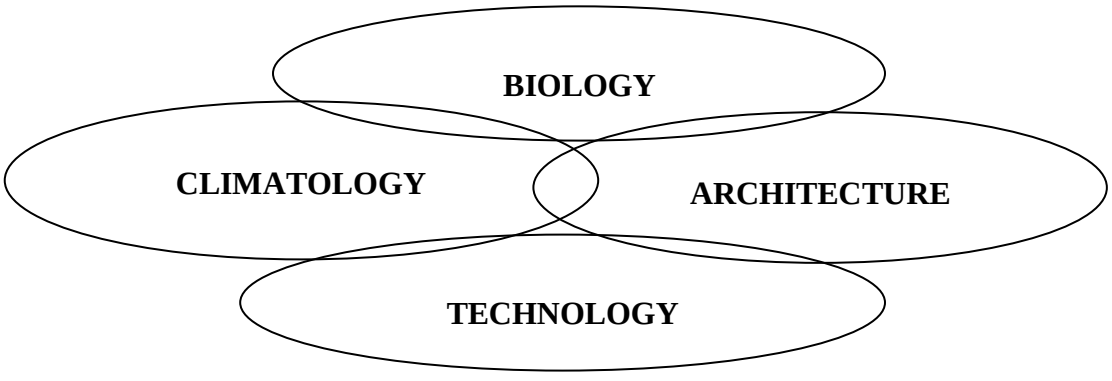



**Figure 2.1** Olgyay's development of the Vitruvian Tri-partite model.

(Source: Davies, 1999)

According to Goulding and Lewis (1997), bioclimatic architecture is a design approach which embraces the principles of sustainability, but which goes further than minimising the environmental impact of buildings; it seeks to create an architecture which is fundamentally more responsive to location, climate and human needs and which gives expression to soundly based design parameters. In 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 (Zachman, 2001). Bioclimatic approach of buildings that takes into account the topography, climate, ground relief, orientation, solar radiation, wind, temperature, humidity, rain etc in order to restrain their consequences to the shell of the building, as well as to exploit them to achieve conditions of thermal ease and healthy living in the inside, aiming to cleaner environment with less emissions and energy saving through restraining the use of conventional power sources (Machaira et al, 2012).

The approach has greater effect over the potential to reduce environmental impacts, the improvement of living conditions as well as lowering the cost and capacity of the conditioning plant (Evans 2007). In 2009, Davies summarised the Olgyay's steps for achieving environmental control by working with climate, and these steps are as follows :

**Step 1.** Survey the climate at the proposed building location. This should include temperature, relative humidity, 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.

### 2.1.2 Importance of Bioclimatic Architecture

Bioclimatic Architecture can be a means of implementing international policy, such as the Kyoto Protocol, through a reduction of energy use and other environmental impacts (Hyde and Rostvik, 2008). Hence, if bioclimatic architecture is the means, then sustainability is the outcome. Bioclimatic Architecture is an approach that takes advantage of the climate through the right application of design elements and building technology to control the heat transfer process and this control promotes energy saving as well as ensures comfortable conditions into buildings (Goulart and Pitta, 1994; ERG, 1999 op cit). It also uses passive low energy techniques to produce buildings which are environmentally interactive, efficient and increase occupant comfort (Yeang, 1996).

### 2.1.3 Bioclimatic Architecture Principles

Bioclimatic Architecture principles represent energy efficient strategies whose applicability is modified by region and building type, and whose contribution varies (Maciel, 2007). It is best achieved using a combination of the principles; slightly increasing construction costs, but managing significant energy saving percentages in the life-cycle of the building (Machaira *et al*, 2012). Different researchers have identified a number of bioclimatic architecture principles. Llisted below are different set of principles

as outlined by previous researchers such as Machaira *et al.* ( 2012), Edpenergy (2011), Axarli & Teli (2008) and Lamberts (2006).

**Set I. Bioclimatic Architecture Principles** (Lamberts, 2006)

i. Building thermal performance
ii. Day lighting
iii. Heating and Passive Solar Cooling
iv. Natural Ventilation
v. Thermal Comfort
vi. Adequate Shading

**Set II. Bioclimatic Architecture Principles (**Axarli & Teli, 2008)

i. Achievement of thermal comfort.
ii. Improvement of visual comfort.
iii. Creation of acoustic comfort.
iv. Improvement of air quality.
v. Improvement of building's energy behaviour.

**Set III. Bioclimatic Architecture Principles (**Edpenergy, 2011)

i. Microclimate Improvement.
ii. Systems and passive cooling techniques.
iii. Exploitation of solar energy.
iv. Thermal protection of buildings and protection through shading.
v. Natural Lighting.
vi. Acoustic Protection.

**Set IV. Bioclimatic Architecture Principles** (Machaira et al, 2012)

i. Energetic Systems

ii. Passive Systems

iii. Renewable Energy Sources (RES) Installations

From the above set of principles, similarities and disparities can be observed. In table 2.1 a new set of principles is proposed comparing the various sources.

**Table 2.1:** Comparison of the new set of proposed bioclimatic principles.

| Sources / Principles | Machaira et al, (2012) | Edpenergy, (2011) | Axarli & Teli, (2008) | Lamberts, (2006) |
|---|---|---|---|---|
| **Exploitation of Solar Energy** | ✓ | ✓ | | ✓ |
| **Natural Lighting** | ✓ | ✓ | ✓ | ✓ |
| **Thermal Protection** | ✓ | ✓ | ✓ | ✓ |
| **System and Passive Cooling Techniques** | ✓ | ✓ | | ✓ |
| **Renewable Energy Sources (RES) Installations** | ✓ | | ✓ | |
| **Acoustic Protection** | | ✓ | ✓ | |

*2.1.3.1 Exploitation of Solar Energy*

According to Bahrami (2008), the exploitation of solar energy is achieved by the proper design of the building envelope (to maximize the absorption of solar energy during winter and minimize it during summer), the proper orientation of spaces and especially of openings (the southern orientation is the most appropriate), the proper sizing of the openings, a layout of the interior spaces based on thermal requirements and the adoption of the appropriate passive system that collect, store and distribute sunlight and can be considered as natural heating systems. Capturing the heat from solar radiation, storing it in the mass of the building, retaining it using insulation, and distributing it around the building, Somfy Group (2009).

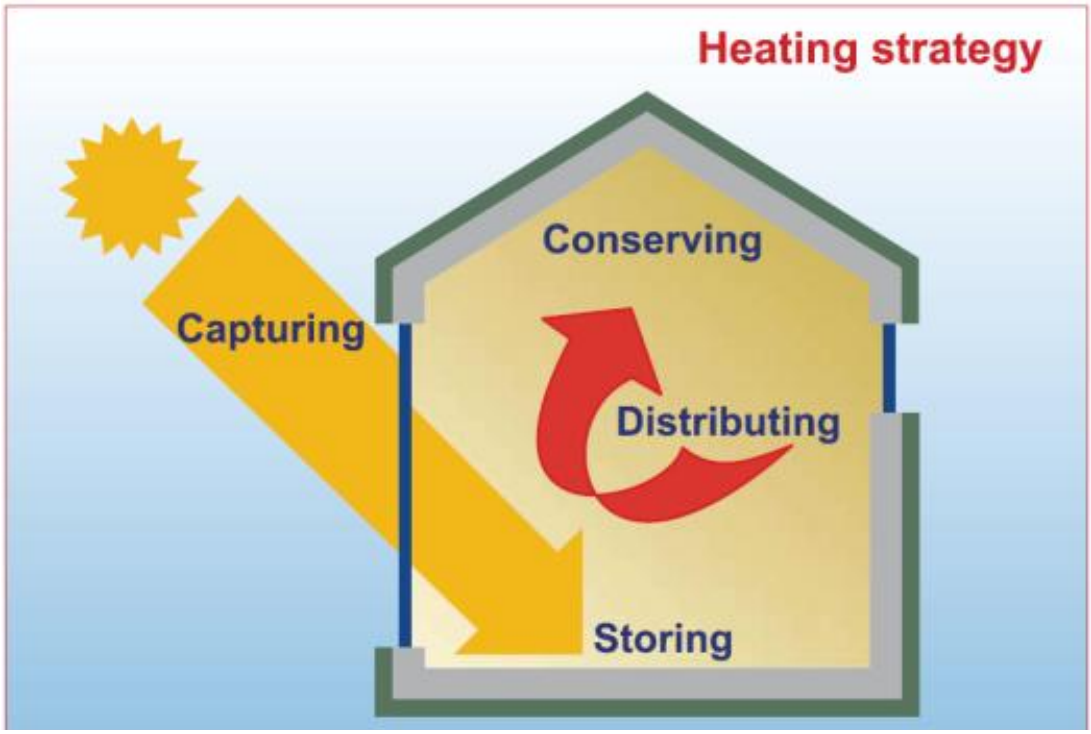



**Figure 2.2** Exploitation of solar energy
(Source: www.somfyarchitecture.com)

*2.1.3.2 Natural Lighting*

Natural lighting refers to the exploitation of direct and indirect light in order to ensure adequate comfort conditions, even light distribution in the interior during all seasons depending on the building type. According to Goulding and Lewis (1997), the optimal use of natural daylight make a significant contribution to energy efficiency, visual comfort and the well-being of occupants. The use of daylight for interior illumination can reduce energy use within buildings and has a positive effect on visual comfort. Therefore, if natural day lighting is 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. According to Altomonte (2008), day lighting depends on the availability of daylight, location, size and orientation of windows. Moreover, strategies like: Roof lights, Atria, Glazing, Transparent Insulation, Light pipes and Light ducts can be used to improve how natural light is captured and allowed to penetrate a building, and to improve how it is then diffused and focused. Controlling light to avoid visual discomfort must also be considered.

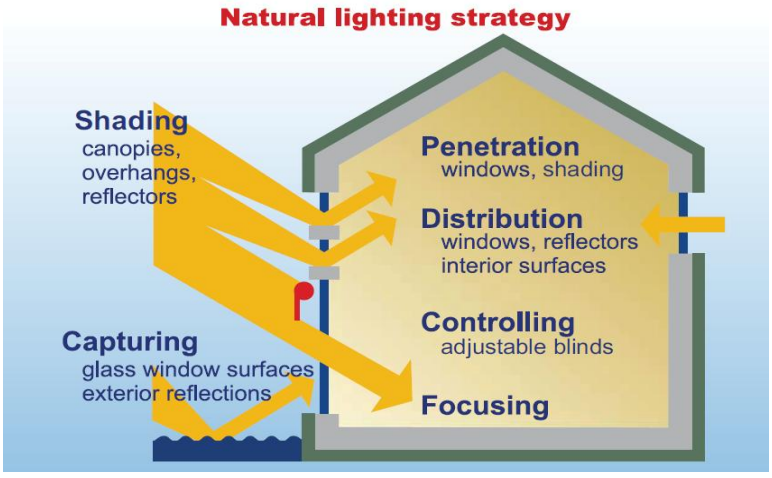



**Figure 2.3** The principle of natural day lighting.
(Source: www.somfyarchitecture.com)

*2.1.3.3 Thermal Protection*

According to Somfy Group (2009), the thermal protection of a building is mainly achieved by the appropriate design of the openings to prevent the escape of heat, the proper insulation of the building envelope and the proper arrangement of internal spaces (rooms used frequently are placed in the south to avoid the cold north). Shading also protect the building from overheating during summer, internal or external, vertical and horizontal blinds can be placed strategically.

*2.1.3.4 System and Passive Cooling Techniques*

It refers to the building's microclimate control, its shading and to the minimisation of thermal loads during the warm summer months through openings, planting of trees around the building, creating ponds, and designing green roofs. According to Somfy Group (2009), cooling strategy is a response to the need for summer comfort: shading from solar radiation and heat gain, minimising internal heat sources, dissipating excess heat and cooling down naturally.

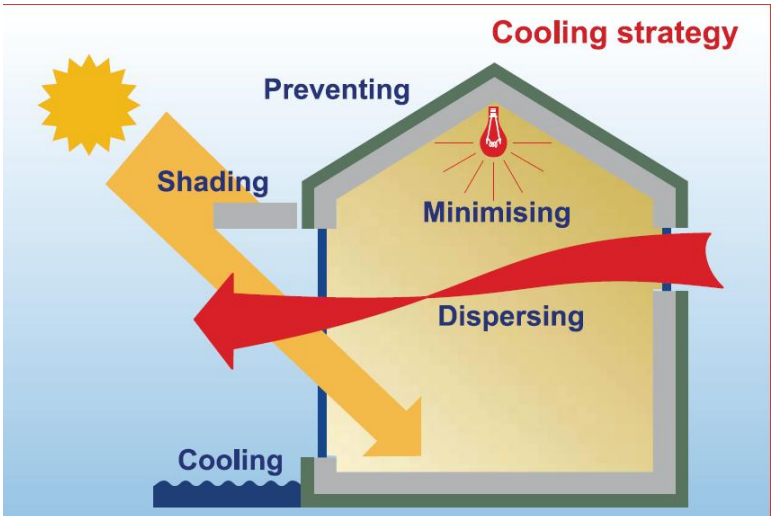



**Figure 2.4** The principles of summer comfort.
(Source: www.somfyarchitecture.com)

*2.1.3.5 Renewable Energy Sources (RES) Installations*

According to Machaira et al, (2012), in order to minimise energy consumption effects to the environment, RES such as photovoltaic systems (on roofs, facades or shades), biomass energy, geothermal energy and solar energy for hot water (for heating and everyday use) should be installed in our buildings.

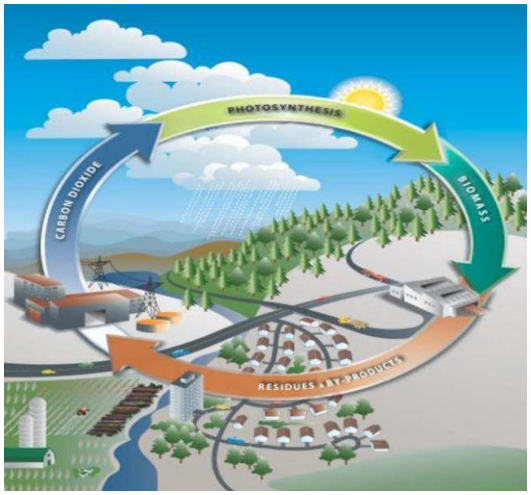



**Figure 2.5** The Biomass Cycle (prosandconsbiomassenergy.org)

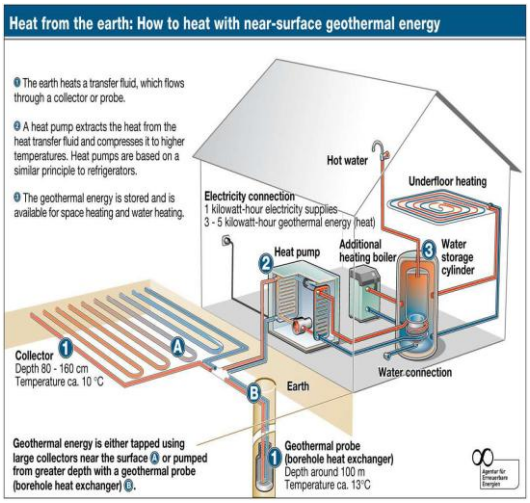



**Figure 2.6** Geothermal Heating (source: www.unendlich-viel-energie.de)

*2.1.3.6 Acoustic Protection*

According to Hyde (2008), controlling noise in the external or internal environment is an important part and is often ignored at the planning stage. Consideration of zoning and distance is paramount to any design, that is proper positioning of the building far away from the possible source of noise. Also, the screening effect of walls, fences, plantation belts, etc. can be used to reduce the noise reaching the building. These should be positioned in such a way as to fit in with any advantageous effects of local topography. As a general rule, it can be established that a given barrier will be most effective when it is as near to the source as possible.

However, When designing for noises generated within the building, he stated that the designer can take the following measures:

i. Reduce at source by enclosing and isolating the source, or use absorbent screens.
ii. Planning: separate noisy spaces from quiet ones, placing indifferent areas in between.
iii. Place noisy equipment in the most massive part of the building (such as in a basement).
iv. Reduce impact noises by covering surfaces with resilient materials.
v. Reduce noise in the space where it is generated by including absorbent surfaces.
vi. Reduce airborne sound transmission through airtight and noise-insulating construction.
vii. Reduce structure-borne sound transmission through discontinuity.

### 2.1.4 Bioclimatic Chart and Comfort Zone

The optimum thermal condition of a situation is that which the least extra effort is required to maintain the human body's thermal balance (Gut & Ackerknecht, 1993). The greater the effort that is required, the less comfortable the climate is felt to be. It is the aim of the designer to build houses that provide an indoor climate close to an optimum, within a certain range in which thermal comfort is experienced. This range is called the comfort zone and it differs with individuals, the clothing worn, the physical activity, age and health condition. Gut & Ackerknecht (1993) further stated that the geographical location plays a role because of the habits and of the acclimatization capacity of individuals. Four main factors besides many other psychological and physiological factors, determine the comfort

zone: air temperature**,** temperature of the surrounding surfaces (radiant heat), relative humidity and air velocity (Bahrami, 2008).

Jitkhajornwanich (2011) stated that the chart shows the comfort zone in the center and the climatic elements around it are shown by means of curves which indicate the nature of remedial measures needed to re-establish the feeling of comfort at any point outside the comfort zone. The bioclimatic chart shown in fig. 2.7 is built up with a dry-bulb temperature and relative humidity and any climatic condition determined by the dry-bulb temperature and relative humidity can be plotted on the chart (McLean et al, 2006). If the plotted points fall into the comfort zone, thermal comfort is achieved; and if the points fall outside the comfort zone, remedial measures are needed. If the point is higher than the upper perimeter of the comfort zone, air movement is needed and if the relative humidity is low and the temperature is high, we feel too dry and hot, air movement is of little help. At the lower perimeter of the comfort zone is the line above which shading is needed. Radiation is also necessary below the line to counteract lower dry-bulb temperatures. However, no remedial measures are necessary for any point of known dry-bulb temperature and humidity which falls within the boundaries of the comfort zone. For any point falling outside this zone, remedial measures needed to restore the feeling of comfort. A simplified version of the bioclimatic chart as presented showing the relationship of various climatic elements to each other is presented in fig. 2.7 by Somfy Group (2009).

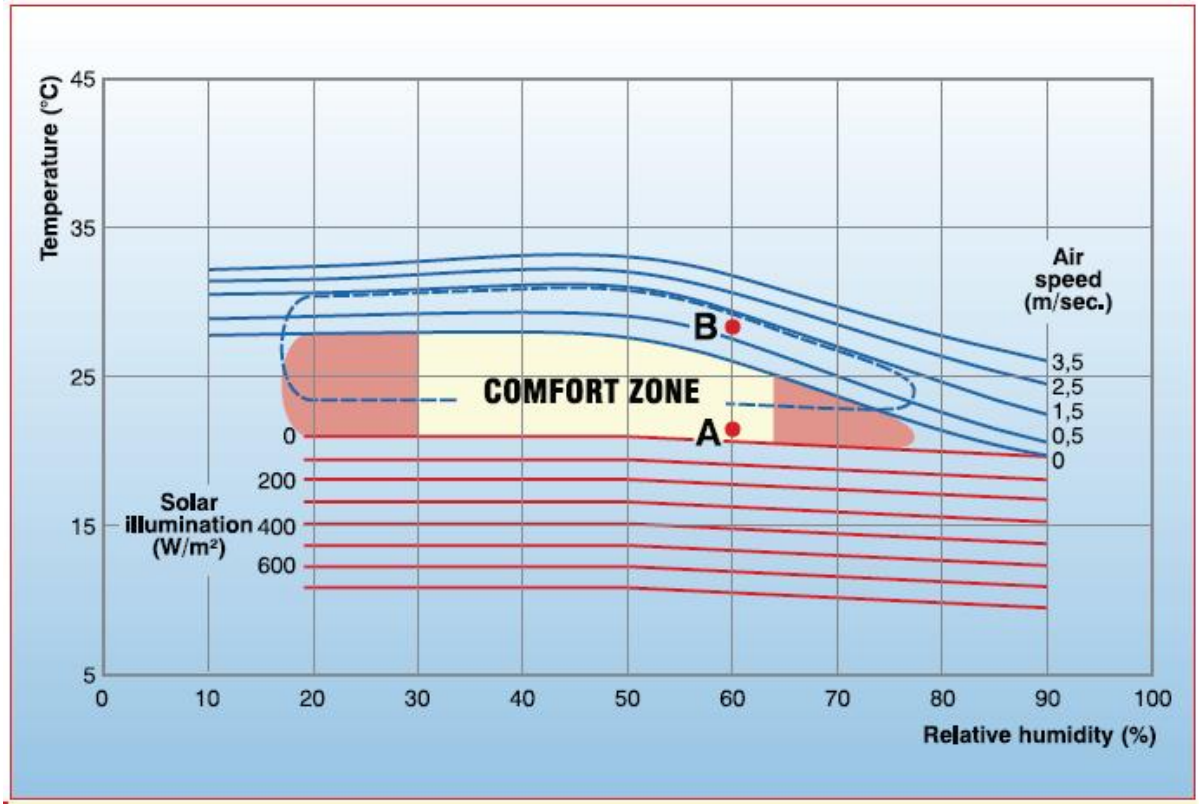



**Figure 2.7** Bioclimatic Chart showing comfort zone
(Source: Somfy Group 2009)

This comfort zone in fig 2.7 indicates that in a dry climate, a higher temperature is acceptable than in a humid one. Evaporation of perspiration from the skin is more effective when relative humidity is lower. By increasing air velocity with certain limits, the comfort zone moves higher up the chart.

### 2.1.5 Designing for Bioclimatic Comfort in Hot-Dry Climate

According to Gut and Ackerknecht (1993), the climates around the globe vary greatly, ranging from the polar extreme to tropical climates. The climate is primarily influenced by the sun heating up the land and water bodies. At the regional level, the climate is influenced by altitude, topography, wind patterns and ocean currents, the relation of land to water bodies, the geomorphology, and by the vegetation pattern.

Hot dry climates, usually found between 15° and 30° north and south of the equator are characterized with large daily and annual temperature swings and marked seasonal variations, predominantly clear skies, intense solar radiation, scarce rainfall and very limited vegetation (Evans, 2007). He further identified typical design recommendations of the region which include: solar protection in summer, construction with substantial thermal inertia, controlled window sizes and protection from hot dry and dusty winds.

Roche (2006) further stated that design in hot-dry climates need to reduce, or at least avoid an increase in the average indoor temperature using selective night ventilation or evaporative cooling, while solar and internal gains should also be controlled. Also, the buildings in the hot dry climate need patios, central courtyard to shade the building in the daytime and allow heat to be released at night.

Somfy Group (2009) state that in hot dry climate, air temperatures vary from 30 to 40°C in the day and from 24 to 30°C at night. In the cold season, air temperatures vary from 27 to 30°C in the day and from 10 to 18°C at night. Day time and night time temperature variation is significant; relative humidity is low (10 to 55 %) and solar radiation is intense ; winds are often hot and localised, carrying sand and dust; rainfall is very low (50 to 155 mm/p.a.). Near the oceans, these climates are influenced by significant seawater evaporation. Humidity goes back up to 50 to 90 %, which reduces daytime/nighttime temperature variation. Winds alternate between a sea breeze during the day and a land breeze at night.

## 2.2 HOTELS

Hotels are establishment held out by the proprietor as offering sleeping accommodation to any person presenting himself who appears able and willing to pay a reasonable sum for the services and facilities provided and who is in a fit state to be received (Mackenzie, 2009).

### 2.2.1 Types Of Hotels

According to Mackenzie (2009), different types of hotels offer different kinds of services to their guests and will be run differently to meet their guests' needs. For example, a luxury hotel may provide more personalised services and facilities that may not appear in a limited-service hotel. Murray Mackenzie further suggested and explained different types of hotels used by travellers (Mackenzie, 2009).

#### *2.2.1.1 Airport Hotels*

These hotels are designed especially to provide travellers with a place to eat and sleep. They offer a mix of facilities and amenities (Mackenzie, 2009). Therefore they are hotels mainly cater for people en-route (traveling) for business or pleasure (Samuel, 2009). The traditional airport hotels were not as multi-dimensional as their modern counterparts and offered fewer facilities and a limited numbers of guests.

#### *2.2.1.2 All-Suite Hotels*

The guest rooms in these hotels are larger than normal hotel rooms, with separate areas for working, sleeping and relaxing (Mackenzie, 2009). A living area or parlour is typically separated from the bedroom, and some properties offer a kitchen set-up in the rooms

(Samuel, 2009).. The amenities and services can vary widely. They can be found in various locations such as urban, suburban, or residential .

*2.2.1.3 Boutique Hotels*

Boutique hotels differentiate themselves from traditional hotels and motels by providing personalized accommodation and services/facilities (Mackenzie, 2009). They are sometimes known as Design Hotels or Lifestyle Hotels. They are more intimate and perhaps more luxurious.

*2.2.1.4 Casino Hotels*

They have gambling operations which are the major revenue centres. They also provide live entertainment. A wide variety of luxury amenities, hotel services including fine and casual dining and shopping centres are typically available on site (Mackenzie, 2009).

*2.2.1.5 City Centre Hotel*

These hotels are located within the heart of a city, the type may vary greatly from business, suites, residential, economy, mid-scale to luxury(Mackenzie, 2009). These are luxury, conventional city hotels characterized by high lot ratio and high rise construction with large functions, accommodation, shops and offices.

*2.2.1.6 Conference/Convention Hotels*

These hotels can have 2000 rooms or more. In addition to accommodation, they provide extensive meeting and function space for holding conventions. There are banquet areas within and around the hotel complex. Most of them provide an in-house laundry, a

business centre, airport shuttle service, and 24-hour room service (Mackenzie, 2009). They are often in close proximity to convention centres and other convention hotels.

*2.2.1.7 Guest Houses*

According to Mackenzie (2009), guest houses are similar to bed and breakfast inns. They range from low-budget rooms to luxury apartments. They tend to be like small hotels in bigger cities. Though the facilities are limited, most rooms are air-conditioned with en-suite shower and toilet.

*2.2.1.8 Highway Hotels/Motels*

They are designed for overnight stays for car travellers with very basic facilities. The rooms usually have direct access to an open parking lot (Mackenzie, 2009). They are often smaller than most hotels. They are located on the outskirts of towns and cities.

*2.2.1.9 Historic Conversion Hotels*

These properties have historic significance which have been converted into lodging establishments with retention of their historic character (Mackenzie, 2009).

*2.2.1.10 Spa Hotels*

They are located in resort-type settings or as part of city spa hotels. They provide accommodations, spa treatments, programs and cuisine. Programs offered vary widely. They may include relaxation/stress management, fitness, weight management, grief/life change and pilates/yoga (Mackenzie, 2009). Spas have professional staff that often include dieticians, therapists, masseurs, exercise physiologists, and in some cases, physicians.

*2.2.1.11 Resort Hotels*

According to Elliot and Johns a resort provides accommodation, as well as leisure facilities desired by the guests with the features of natural beauty or interest (Elliot & Johns, 1993). Also resort hotels and motels usually are located in seaside, lake, or mountain areas, and they cater to tourists and vacationers. Resorts provide all hotel services plus recreational and athletic activities. Ten basic categories of resorts have been defined by Reutes, Penner, & Adams (2001). These hotels are located in picturesque, sometimes remote settings. Guests travel long distance to resorts. Usually, they tend to stay longer (Mackenzie, 2009). Resorts typically provide a comprehensive array of recreational amenities, as well as a variety of food & beverage outlets ranging from informal to fine-dining restaurants. Some of them include Spa Resorts, Ecotourism Resorts, Ski Resorts, and Resort Theme Parks.

### 2.2.2 Hotel Classification Systems

According to Bundhun (2012), hotel classifications are based on star ratings and hotel ratings are often used to classify hotels according to their quality. There are wide variety of rating schemes used by different organisation around the world. Many have a system involving stars, with a greater number of stars indicating greater luxury. Research Department of the Caribbean Tourism Organisation (2002) suggest that the rating system emerged out of efforts by the Automobile and cycling clubs in Europe, who established a rating systems such as the British system, Automobile Association (AA) and its American counterpart the (AAA). According to the AA rating system hotels can be classified based on the star ratings, the lowest rating is one star hotel to five star hotel and recently seven star hotel as the highest rating. Some have claimed a seven star rating for their operation. As no organisation or formal body awards or recognises any rating over five-star

(bundhun, 2012). The Burj Al Arab hotel in Dubai is widely described as a seven star property. However, according to the World Tourism Organization (WTO) hotels are classified based on: .

i. The location.
ii. The purpose functional / on time of stay of guests.
iii. The operating system, the form of exploitation.
iv. The form of ownership, the accommodation capacity.
v. The target market.
vi. The standards of service and facilities offered.

*2.2.2.1 Five Star*

These are larger hotels with even more spacious public areas and bedrooms, luxurious and special surroundings offering the highest quality of accommodation and standards of cleanliness. Abu Dhabi Tourism Authority argued that, the guest accommodation is luxurious and spacious, more formal style of service, professional, attentive and highly trained staff, higher standard of restaurant/eating area open for breakfast, lunch and dinner; room service of all meals and 24 hours availability of drinks & snacks with a higher quality of food & outlets (ADTA, 2007). Research Department of the Caribbean Tourism Organization (2002) also argued that spacious and luxurious accommodation defined five star hotel, matching the best international standards. Interior design should impress with its quality and attention to detail, comfort and elegance. Furnishings should be immaculate. Services should be formal, well supervised and flawless in attention to guests' needs, without being intrusive. The restaurant will demonstrate a high level of technical skill,

producing dishes to the highest international standards. Staff will be knowledgeable, helpful, well versed in all aspects of customer care, combining efficiency with courtesy.

#### *2.2.2.2 Four Stars*

These are mostly large formal hotels with smart reception areas, front desk service and bellhop service, the level of service is well above average, the rooms are well furnished (Karppinen, 2011). Restaurant dining is usually room service and available during most hours, valet parking and/ or garage service is usually available, Concierge services, fitness centers and one or more pools are often provided (Samuel, 2009).

Four star hotels have more spacious public areas and bedrooms, high standard of cleanliness, superior comfort & quality accommodation, en-suite facilities with shower and bathtub, higher quality and standards of services and facilities. They are more formal in style of service, skilled staff anticipating and responding to guests needs, higher standard of restaurant/ eating area open for breakfast and dinner, Room service of all meals, 24 hours availability of drinks & snacks and a higher quality of food (ADTA, 2007). According to Research Department of the Caribbean Tourism Organization (2002) expectations for these hotels include a degree of luxury as well as quality in the furnishings, decor and equipment, in every area of the hotel. Bedrooms will also usually offer more space than at the lower star levels, and well designed, coordinated furnishings and decor. The en-suite bathrooms will have both bath and fixed shower. There will be a high enough ratio of staff to guests to provide services like porter age, 24-hour room service, laundry and dry-cleaning. The restaurant will demonstrate a serious approach to its cuisine.

*2.2.2.3 Three Stars*

Research Department of the Caribbean Tourism Organization (2002) stated that at this level, hotels are usually of a size to support higher staffing levels, and a significantly greater quality and range of facilities than at the lower star classifications. Reception and the other public rooms will be more spacious and the restaurant will normally also cater for non-residents. All bedrooms will have fully en suite bath and shower rooms and offer a good standard of comfort and equipment, such as a hair dryer, direct dial telephone, toiletries in the bathroom. Some room service can be expected, and some provision for business travelers. These hotels higher standard of restaurant/eating area open for breakfast and dinner, room service of continental breakfast for a limited number of hours per day and are often located near major expressways or business areas, convenient to shopping and moderate to high priced attractions (ADTA, 2007).

*2.2.2.4 Two Stars*

This class of hotels have high standard of cleanliness, comfortable and simple accommodation, straightforward range of services with a more personal touch. The staff are also friendly and helpful with a higher standard of restaurant/eating area. The hotel is usually small to medium-sized and conveniently located to moderately priced attractions (ADTA, 2007). Research Department of the Caribbean Tourism Organization (2002) argued that in this classification hotels will typically be small to medium sized and offer more extensive facilities than at the one star level. Some business hotels come into the two star classification and guests can expect comfortable, well equipped, overnight accommodation, usually with an en-suite bath/shower room. Reception and other staff will

aim for a more professional presentation than at the one star level, and offer a wider range of straightforward services, including food and drink.

*2.2.2.5 One Star*

According to ADTA (2007), hotels in this category are basic, yet provide the important comfort. The hotels are clean and well maintained offering a limited range of facilities and services, Staff are friendly and helpful, their restaurant/eating area is open for breakfast and dinner and usually located near affordable attractions, major intersections and convenient to public transportation. Hotels in this classification are likely to be small and independently owned, with a family atmosphere and services may be provided by the owner and family on an informal basis (Research Department of the Caribbean Tourism Organization**,** 2002). There may be a limited range of facilities and meals may be fairly simple. Lunch, for example, may not be served. Some bedrooms may not have en suite bath/shower rooms. Maintenance, cleanliness and comfort should, however, always be of an acceptable standard.

### 2.2.3 Hotels and Energy Use

The hotel industry is one of the leading growth sectors of the economy and constitutes one of the most energy and resources intensive branches of the tourist industry, therefore, has created an increasing amount of stress on the environment according to (Bohdanowicz, 2006). He further claims that services hotel offered rarely incorporate resource efficiency or conservation leading to a significant used of energy and water leading to global warming and climate change (Bohdanowicz, 2006). Furthermore, Ampatzi (2009) also claims that the energy efficiency of most hotel facilities are frequently low, and the

resulting environmental impacts are typically greater than those caused by the excessive consumption of local/imported resources (e.g., water, food, electricity and fuels) as well as by emissions released to air, water and soil.

Heating, air conditioning, ventilation and cooling systems typically account for a major and frequently the largest portion of the energy consumed in a hotel (CADDET, 1997). Other significant end use include domestic hot water production, lighting, electricity for elevators, escalators, catering etc. Figure 2.8 provides a typical breakdown of the energy consumption in hotel showing variations between different types of facilities may be significant.

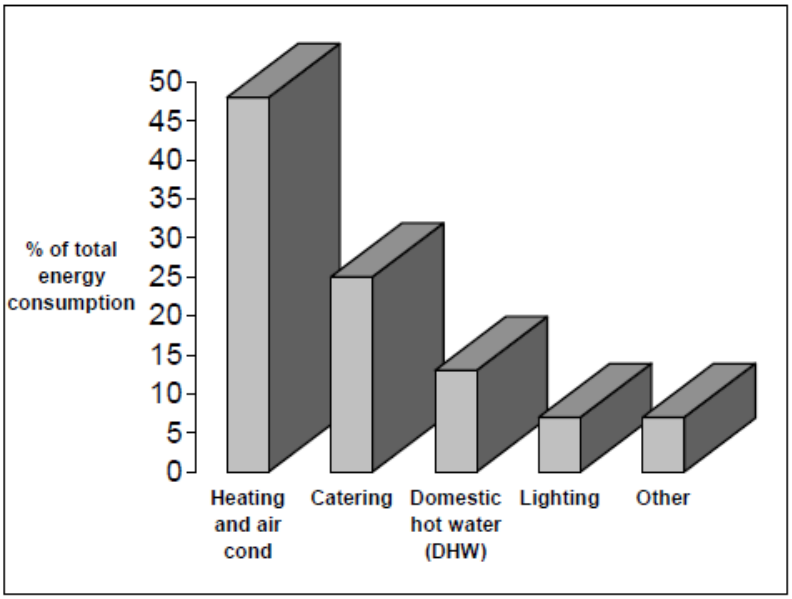



**Figure 2.8** Breakdown of energy consumption in a typical hotel

(Source: CADDET, 1997)

The above data in fig. 2.8 emphasises the claim that the outdoor climate has a significant effect on the overall electricity use. Typically, about half the electrical energy is used for

space conditioning purposes. Depending on the category of the establishment, lighting may amount up to 12-20%, and in some cases up to 40% of the total energy consumption (EU, 1994). The demand for domestic hot water varies appreaciably with hotel category (90-150 litres per guest per day) EU (1994). Supplying DHW typically accounts for up to 15% of the total energy demand. For a medium category hotel with an average annual occupancy rate of 70%, this translates to an average annual consumption of 1500 to 2300kwh/room EU 1994.

According to Shi-Ming & Burnett (2000) most hotel only monitor their overall energy expenditure without detailed attention to the different end uses. Detailed monitoring and documentation of the various energy flows is technically possible but generally regarded as prohibitively complex and expensive (EU, 1994). They further revealed the investigations carried out aimed at obtaining a more detailed understanding of the energy flows in hotels, providing a valuable basis for estimating the energy consumption profiles of similar type of facilities. The summary of the investigation is illustrated in the table 2.1-2.3.

***Table 2.1*** *Energy Efficiency Rating of Large Hotels, (Source: EU, 1994)*

| **Efficiency rating** | **Good** | **Fair** | **Poor** | **Very Poor** |
|---|---|---|---|---|
| **A) Large hotels (more than 150 rooms) with air conditioning, laundry and indoor swimming pool** | | | | |
| **Electricity (kwh/sqm year)** | <165 | 165-200 | 200-250 | >250 |
| **Fuel (kwh/sqm year)** | <200 | 200-240 | 240-300 | >300 |
| **Total (kwh/sqm year)** | <365 | 365-440 | 440-550 | >550 |
| **Hot water (kwh/sqm year)** | <220 | 230-280 | 280-320 | >320 |

***Table 2.2*** *Energy Efficiency Rating for Medium-Sized Hotels (Source: EU, 1994)*

| **Efficiency rating** | **Good** | **Fair** | **Poor** | **Very Poor** |
|---|---|---|---|---|
| **A)Medium sized hotels (50-150 rooms) without laundry and with heating and air conditioning in some areas.** | | | | |
| **Electricity (kwh/sqm year)** | <70 | 70-90 | 90-120 | >120 |
| **Fuel (kwh/sqm year)** | <190 | 190-230 | 230-260 | >260 |
| **Total (kwh/sqm year)** | <260 | 260-320 | 320-380 | >380 |
| **Hot water (kwh/sqm year)** | <160 | 180-185 | 185-220 | >220 |

***Table 2.3*** *Energy Efficiency Rating for Small Hotels, (Source: EU, 1994)*

| **Efficiency rating** | **Good** | **Fair** | **Poor** | **Very Poor** |
|---|---|---|---|---|
| **A)Small hotels (4-50 rooms) without laundry, heating and air conditioning in some areas** | | | | |
| **Electricity (kwh/sqm year)** | <60 | 60-80 | 80-100 | >100 |
| **Fuel (kwh/sqm year)** | <180 | 180-210 | 210-240 | >240 |
| **Total (kwh/sqm year)** | <240 | 240-290 | 290-340 | >340 |
| **Hot water (kwh/sqm year)** | <120 | 120-140 | 140-160 | >160 |

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 CASE STUDY APPROACH

A case study approach is adopted for this research to study the application of bioclimatic architecture principles in the hotel buildings. According to Meyer (2001), the approach enables the researcher to study many different aspects, examine them in relation to each other and view the process within its total environment. Yin (2003) argues that a case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries are not clearly stated. Unlike many other forms of research, the case study approach makes use of multiple methods of data collection such as interviews, document reviews, archival records, direct and participant observations etc. (Yin, 2003). The approach to the cases is qualitative. According to Denzin and Lincoln (2003), qualitative research involves an interpretive, naturalistic approach to its subject matter thereby seeking to understand phenomena within specific contexts. In contrast, qualitative research identifies the relationships between variables, and generalizing those results to the world at large.

## 3.2 POPULATION OF STUDY

Population of study comprises the totality of all subjects that have a set of specifications and characteristics that are of interest to the researcher and to whom the research results can be generalised (Polit and Hungler, 1999). The research population for this study are hotels selected from the hot-dry climate of Nigeria.

## 3.3 SAMPLING

Sampling involves a subset of the research population selected to represent the research population (LoBiondo-Wood and Haber, 2006). For the purpose of this research, non-probability sampling was used and the selection was purposive where three hotels were selected after careful consideration and due to particular interest of the study. The sampling was limited to three hotels; Katsina Motel which is from the same region of the study area (Katsina), NTI Hotel and NCPS Hotel that are from the nearest Kaduna.

## 3.4 INSTRUTMENTS OF DATA COLLECTION

Various sources were selected for this research including: Field survey, checklist, structured interview, photographs, sketches and notes.

### 3.4.1 Field Survey

Field survey was adopted to validate the data that cannot be collected through other means because of the nature of the research. All the three selected hotels were visited. Field visits were supported by comprehensive notes and photographs taken, giving an insight on their physical presence and spatial relativities of each case.

### 3.4.2 Interview

The interview was structured and standardised. In each of the three selected hotels, the same questions were asked on the information of the hotels and were answered by the management. The questions were open, receptive and were decided in advance on what areas to cover. The open ended nature of the interview provided the opportunity for both the researcher and the interviewees to discuss the history and relevant information.

### 3.4.3 Checklist

Checklist was in form of field forms outlining the variables of bioclimatic architecture. It contained the list of variables which were observed and noted during the survey.

### 3.4.4 Photographs

Photographs were taken to support the notes taken during the visit and for record. The photographs also provided a significant source of visual data about the case to outside observers. The photographs of relevant areas were taken in order to show the features of bioclimatic architecture the cases possessed as well as the extent to which they were applied.

### 3.4.5 Sketches

Sketches showing the selected case studies were made during the field survey. These sketches were considered vital to form an opinion on the physical setting and spatial organisation of the case studies in order to explain the research.

### 3.4.6 Notes

This instrument of data collection was adopted to back-up information discussed during the interview and what was observed during the field survey. Comprehensive notes were prepared as an ongoing record of what was happening as the research progressed.

## 3.5 PROCEEDURE FOR DATA COLLECTION

The data is collected through multiple instrument of data collection. All the selected case studies are visited by the researcher for field survey, interviews were conducted, photographs were taken, notes and sketches were collected.

The field survey involved visual survey of both architectural features and bioclimatic principles. The researcher in this case observed the principles of bioclimatic architecture qualitatively using checklist. List of variables in the checklist were checked and assessed sequentially. During the visual survey, careful and direct observation was conducted to obtain spatial organisation and site planning of each case. Sketches were made, photographs and notes were taken. The nature of the building structure, materials used, building aesthetics and the application of bioclimatic principles were documented by the researcher.

During the interview, the researcher adopted a semi-structured interview guide where questions were asked and the answers were taken as notes by the researcher. Data was also recorded on audiotape to enrich the interview. However, permission to use tape recorder was sought before the interview and all the participants agreed to it. The tape recorder was tested before the interview, it was positioned close to both the researcher and the interviewee to record the conversion. While the interview was going on, notes were also being taken to back-up the discussion. Final notes were also prepared after the interview was concluded. All the interviews lasted for less than an hour. After each interviews was concluded, a reflective interview notes were made. The recorded interview was subsequently transcribed into Microsoft Word by the researcher for the purpose of the study.

In cases where were no documentation available for the architectural drawings, the buildings were surveyed and the drawings were prepared by the researcher through sketches, photographs and notes. All photographs were taken either by the author or with

help of relatives and friends. photographs of relevant areas of the case studies were taken in order to highlight the observed features of bioclimatic architecture. Sketches showed the spatial organization of some of the study cases while notes explained the observed bioclimatic principles in each of the selected cases.

## 3.6 VARIABLES OF STUDY

The selected variables for this research are:

i. Building form, shape and orientation
ii. Natural ventilation
iii. Visual comfort conditions (natural lighting)
iv. Thermal protection through shading
v. Passive cooling techniques
vi. Acoustic protection
vii. Renewable energy sources

### 3.6.1 Building form, shape and orientation

The cases are analysed to see if the buildings' orientation suited the hot-dry zone (north or south) orientation and if the longer axis running in an east-west direction. The buildings' shape and form were also anlysed. In hot-arid zone massive shapes are advantageous, cubical forms, or those slightly elongated toward the east-west axis are most adaptable.

### 3.6.2 Natural Ventilation

The effects of air movement in the buildings are analysed to see if windows are sufficient to provide natural ventilation to occupant's life processes and activities. The internal environment is observed to see if it has access to the microclimate and prevailing breezes.

Spatial planning, Position of windows, Ceiling height, Size and types of windows are checked because these stated parameters determine the ventilation of internal spaces.

### 3.6.3 Visual comfort conditions

A survey was carried out to see if the distribution of natural lighting is adequate and uniform in the interior spaces of buildings for visual comfort. Hyde (2008) has argued that, hot-dry zones require consideration of both the need for daylight and the heat gain associated with sunlight. The window designs, shape and depth of internal spaces were studied to see how day lighting was introduced into the interior spaces.

### 3.6.4 Passive Cooling Techniques

The cooling techniques employed in the designs of the buildings were studied. The shading and opening techniques adopted, the trees planted, existing ponds, green roofs (if any), court yard etc are studied. According to Somfy Group (2009), these strategies minimise internal heat gain, aid dissipating of excess heat and natural.

### 3.6.5 Thermal protection through shading

The shading methods used in each case is analysed to see how the internal environment was protected against unwanted heat. Limiting window area in the east and west facades and using shading techniques such as a deep window recess, window overhangs, trees etc can protect and control glare in the hot-dry zone and the main principle is to use diffuse light in interior spaces to avoid the issues of heat gain.

### 3.6.6 Acoustic protection

Unwanted noise protection is crucial to the comfort of the occupant's internal spaces. The planning and zoning of spaces is analysed to see if the designs consideration for noise protection are adequate. Screen, barriers and insulation can be used to control unwanted noise. During the survey, such parameters are checked.

### 3.6.7 Renewable energy sources

The use of energy in all the selected cases is studied to see the extent to which energy consumption is minimised and if any renewable energy sources (RES), such as photovoltaic systems (on roofs, facades or shades), biomass energy, geothermal energy and solar energy for hot water (for heating and everyday use) are installed in the buildings.

## 3.7 DATA PRESENTATION AND ANALYSIS

According to Polit and Hungler (1999), analysis of qualitative data is an active and interactive process and data analysis means to organise, to provide structure and elicit meaning to the data obtained. The theoretical background of the study provides the basis of the method used for analysing the content. For this research, the analysis was first focused on the individual interviews, then the field survey carried out. The data is then analysed and compared the results to identify the application of bioclimatic architecture principles in each selected cases.

The data obtained from interview is first analysed and transcribed to identify and develop the themes in the interviews. The talk is transcribed in full but eliminating unnecessary material, such as repetitions in order to clarify the material. The transcription is analysed to extract essential parts which were highlighted and gathered into themes according to the

purpose of the research. The categorisation and the grouping of the interview into these categories were applied to each interview as shown in table 3.1.

**Table 3.1:** Example of the process of categorisation of the interview.

| | **Category** |
|---|---|
| Introduction<br>In my research, I am trying to identify if bioclimatic principles are considered in the design of this your hotel. Bioclimatic principles are sustainable issues specifically to the climate of this region ( i.e. Natural lighting and ventilation).<br>Firstly, I would like to know the background/history of the hotel…..<br>Responses | 1. Background /history of the hotel.<br>2. Location<br>3.Number of rooms<br>4. Facilities and services offer to guest<br>5. Alternative source energy if any<br>6. Aim of the establishment |

However, the data obtained during the field survey is presented through sketches, notes and photograph translating the study into more themes. The field survey addressed listed variables in section 3.6. The checklist is analysed and the data presented in a simple and tabular form. The checklist of the variables analysed was developed so that the studied data can easily be extracted. The data analysed during the survey was tabulated with each variable presented in column as shown in fig 3.2. The table highlights the principles which were used to define the design concept and the way the bioclimatic concepts were considered in all the cases.

**Table 3.2:** Sample of the checklist of the case study variables.

| **Bioclimatic Architecture Principles**<br><br>**Scale Factor:** Excellent=5, Very Good=4, Good=3, Fair=2, Poor=1 | | | | |
|---|---|---|---|---|
| **Variables** | **Features** | **Method Adopted** | **Scale Factor** | **Remarks** |
| Building form, orientation and shape | | | | |
| Natural Ventilation | | | | |
| Visual comfort conditions | | | | |
| Passive Cooling Techniques | | | | |
| Thermal protection through shading | | | | |
| Acoustic protection | | | | |
| Renewable energy sources | | | | |

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 CASE STUDY ONE: NTI CONFERENCE CENTRE KADUNA

### 4.1.1 Background

NTI conference centre was established to render services to clients from all works of life who desire superior hospitality services. It is located at Rigachikun along the Kaduna-Kano express way, a 30 minutes driving distance from Kaduna Airport with a smooth flow of traffic and not far from the popular Kaduna International Trade Fair Complex. According to the management group (Arewa Hotels Development Limited), the hotel was built in the 1970s to offer accommodation and conference services to guest with peace, tranquility and nature's serenity.

### 4.1.2 Site Planning and Landscaping

The orderly arrangement of structures and other supporting facilities on site makes the place a piece of architecture. The main building is accessed from the parking area, while the restaurant, chalets, laundry and sporting facilities are connected to the main building by well pedestrian walkways as shown in figure 4.1. The hotel has large site area well landscaped with the green areas and hedges ( see plates 4.1), unpaved parking area and a number of large tress which improve the microclimate within the building. The orientation of the hotel is according to the climatic consideration of the region with the longer axis running in east-west direction as shown in figure 4.1.

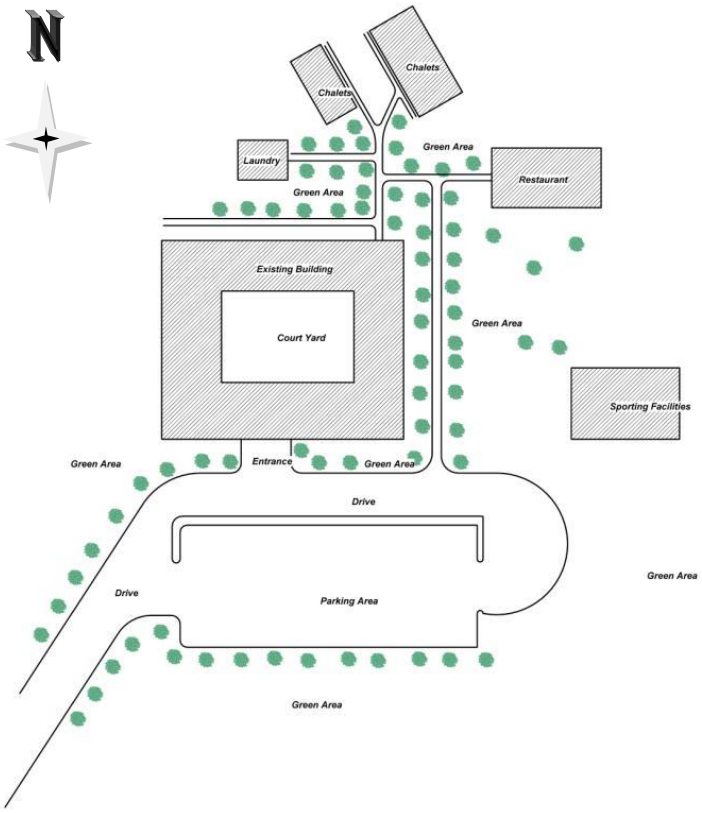



**Figure 4.1** NTI Conference Centre site Lay-out



**Plate 4.1** NTI Conference Centre site landscape

### 4.1.3 Spatial organisation

The hotel has accommodation facilities comprising of 82 rooms, a conference hall, standard seminar rooms, restaurant, bar and other supporting facilities. The spatial arrangement of the hotel is double banking system comprising of 43 single rooms, 15 standards, 4 luxury double, 10 business suites, 8 and 2 executive and presidential suites respectively. A regular approach to planning was adopted with the guest rooms opening into the central courtyards and surrounding environment.

### 4.1.4 Structure and Materials

The hotel design is a typical modern design with adoption of concrete works in repetitive way to shade the building from element of weather as shown in (plate 4.2). The form is simple with a grid framework construction. The building has a structural grid framework of columns and beams, demarcating spaces and floor. Also, services are integrated with the building massing.



**Plate 4.2** Repetitive concrete façade, NTI Conference Centre.

### 4.1.5 Aesthetics

The concrete façade has glass windows with horizontal concrete shading elements. Wooden cladding were introduced on some of the walls and columns in the reception (plate 4.3), the floors were made up terrazzo except that of rooms and conference hall which were tiled and the court yard that has concrete floor (plate 4.4). The paint used was light coloured paint in both the exterior and interior walls.



**Plate 4.3** Wooden cladding in the reception, NTI Conference Centre.



**Plate 4.4** Concrete floor finishes, NTI Conference Centre.

### 4.1.6 Application of Bioclimatic Architecture Principles

*4.1.6.1 Building form, shape and orientation*

According to study carried out by the researcher, the NTI conference hotel was designed and planned to make the best use of the sun, the prevailing winds and other environmental condition to achieve comfort in the internal environment without necessarily over dependence on artificial methods. In other words, the artificial methods introduced were to serve as alternative.

The longer side of the hotel is oriented towards the sun with longer axis running in east-west direction for the building to adapt to the climate of the region. Also, the shape is rectangular with a central void (court yard) and the building composition and form is massive (plate 4.5) which is a great advantage to the indoor environment and a good consideration for bioclimatic comfort in hot-dry climate.



**Plate 4.5** NTI Conference Centre building form and shape

*4.1.6.2 Natural Ventilation*

The building form was designed to make the best use of the prevailing winds for indoor environment comfort. Projection windows were used for ventilation and lighting (plate 4.6). A central courtyard was introduced to promote ventilation and all the guest rooms were designed with a balcony. The large green areas and trees around the hotel also aid ventilation.



**Plate 4.6** Types of windows used for ventilation, NTI Conference Centre.

*4.1.6.3 Visual comfort conditions*

The provision of glass windows as shown in plate 4.7 and the spatial arrangement of the spaces aid natural light into the interior spaces. The natural lighting introduced increased the energy efficiency of the hotel, thereby reducing over dependence on non renewable energy by the hotel. Occupants can therefore live comfortably during the day within the interior spaces without necessarily the need for artificial lighting. According to the field

survey carried out by the researcher, spaces like staircases, guest rooms, meeting and conference halls receive adequate light from the sun, a merit for the hotel in terms of energy consumption and occupants' visual comfort.



**Plate 4.7** Projection windows for lighting, NTI Conference Centre.

*4.1.6.4 Passive Cooling Techniques*

The open spaces around the building and the central courtyard (plate 4.8) serve as heat sink during the day. The green areas and large unpaved areas around the building are seen as principles used to improve the site microclimate because of the absorption of heat and minimisation of re-radiation of the areas. Indoor plants were planted which help in evaporative cooling and in absorption of solar radiation.



**Plate 4.8** Central court yard as a passive technique, NTI Conference Centre.

*4.1.6.5 Thermal protection through shading*

Thermal protection was considered according to the survey carried out, the building façade deep recesses, concrete shading elements and balconies designed to protect the indoor environment from the glaring sun and to provide a buffer between the living spaces and he outdoor environment as shown in plate 4.9. All external walls are shaded to reduce the window area exposure to glaring sun in order to control heat gain for lower indoor temperature. However, despite all the shading techniques introduced in the design, only few large tress can be located near the building which is a demerit to the hotel because large tress can provide shading against the elements of weather.



**Plate 4.9** NTI Conference Centre concrete shading devices and deep recesses

*4.1.6.6 Acoustic protection*

The hotel spaces were properly designed and zoned. According to the research carried out, the guest rooms and private spaces are kept away from the possible noise areas like the parking area or entrance. The rooms were located at the upper floors away from the gathering areas like conference halls and the reception. Plate 4.10 shows deep recesses and the balconies introduced in the design to serve many functions including noise protection. Spaces are also demarcated by thick walls, suspended ceiling, terrazzo floors and other noise reduction techniques were observed during the survey which indeed give the building acoustic protection.



**Plate 4.10** Concrete shading devices and balconies as buffer areas,

NTI Conference Centre

*4.1.6.7 Renewable energy sources*

Despite the consideration of bioclimatic principles in the hotel general design, the source of energy to the hotel is not renewable. The hotel solely depends on non renewable energy sources. In other words, according to the hotel management, arrangements are under way to introduce renewable energy sources because of the changing need of hotels and the world in general. Therefore, it is a demerit to the hotel for depending only on non-renewable energy like generators and national grid system.

### 4.1.7 Summary of the Study

The summary presents the researcher's assessment of the application of Bioclimatic Architecture Principles and the results obtained during the researcher's field survey at the NTI conference centre, Kaduna (see Table 4.1).

**Table 4.1** Assessment of bioclimatic Architecture study variables

| **Bioclimatic Architecture Principles**<br>**Scale Factor:** Excellent=5, Very Good=4, Good=3, Fair=2, Poor=1 | | | | |
|---|---|---|---|---|
| **Variables** | **Features** | **Method Adopted** | **Scale Factor** | **Remarks** |
| Building form, orientation and shape | Simple and rectangular plan, cubical form. Proper positioning of buildings on site | Orientation of the longer axis of the building along the east-west direction, massive building form and rectangular building shape | 4 | Acceptable |
| Natural Ventilation | Use of projection windows and a court yard | Open able windows | 3 | Acceptable |
| Visual comfort conditions | Use of transparent windows | Provision of windows in all the spaces for natural lighting | 4 | Acceptable |
| Passive Cooling Techniques | Courtyard, vast green and unpaved areas around the site | The courtyard promotes ventilation and building cooling | 4 | Acceptable |
| Thermal protection through shading | Concrete shading elements, deep recesses balconies and curtains. | Horizontal shading element on each side of the elevations and deep recesses and balconies | 3 | Lack of large tress around the building |
| Acoustic protection | Thick walls, insulation of floors and ceilings of interior spaces | Proper zoning of spaces and use of elements with good insulation properties | 3 | Largely depends on zoning of spaces |
| Renewable energy sources | Nil | Nil | 0 | Depends on Electricity and generators |

## 4.2 CASE STUDY TWO: KATSINA MOTEL KATSINA

### 4.2.1 Background

Katsina Motel is located at No.1 Muhammad Bashar road G.R.A Katsina, Katsina State. The hotel facilities are recently upgraded by the state government in order to meet the need of the state as shown in plate 4.11. The hotel provides accommodation and conference facilities to visitors and according to the management.



**Plate 4.11** Katsina motel Reception

### 4.2.2 Site Planning and Landscaping

From the field survey carried out, the small building units were well positioned and zoned on the site. The building units were distributed on the site with the longer axis of the rectangular form running along the east-west direction except the multipurpose hall whose orientation is otherwise (longer side facing the east and west). The buildings are connected by well constructed roads, while the reception and the restaurant are accessed directly from the entrance. The hotel has large number of parking spaces with the multipurpose hall

parking different from that of restaurant and reception. The accommodation facilities also have a separate parking.

The hotel has large site area with large tress (plate 4.13), constructed drainage system, access roads for vehicular movement and central garden. The landscaping of the hotel is commendable with large green areas and hedges around the buildings. The large central garden as shown in plate 4.12 is situated in front of the reception and the large trees around the buildings help in the improvement of the microclimate of the site.





**Plate 4.12** Green Court, Katsina Motel **Plate 4.13** Large trees on site, Katsina Motel

### 4.2.3 Spatial organisation

The hotel comprises of 80 rooms of different categories, restaurant, conference and multipurpose hall and other supporting facilities. The spatial arrangement of the hotel is simple and conventional, it comprises of a presidential suite, two executive suites, 67 standard suites and 10 business suites. The presidential and executive suites have two bedrooms en suite, a living room, guest toilet and a kitchen. Plate 4.15 is showing the presidential suites interior arrangement and plate 4.14 is showing the executive suites

living room. The business suite has a living room, guest toilet and one bedroom while the standard room has just a bedroom and toilet.



**Plate 4.14** Executive suite Interior, Katsina Motel.

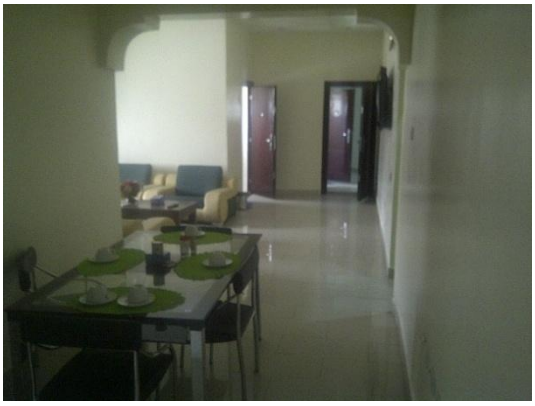


**Plate 4.15 P**residential suite Interior, Katsina Motel.

Moreover, the two conference halls has 300 and 75 person capacity, the restaurant has a small and large dining area, attached kitchen, reception and a counter. The reception houses the front office, reservation area, shop, barbing saloon and waiting area. Other facilities like; swimming pool, mosque, laundry, power house etc are spread across the site.

### 4.2.4 Structure and Materials

From the study carried out, the hotel design is modern and conventional. The walls were made up from concrete/masonry block finished with emulsion paint, the roof is conventional hip roof covered with aluminium roofing sheet.

### 4.2.5 Aesthetics

The paint used was light coloured paint and therefore the surfaces in both the exterior and interior walls are light coloured (see plate 4.16 and 4.17), the floors were finished with

porcelain tiles. Glass sliding windows, POP ceiling and wooden doors were used in the design.



**Plate 4.16** Interior floor and wall finishes

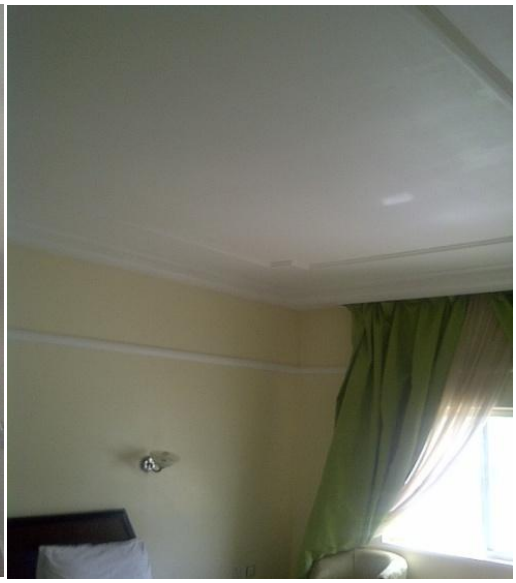


**Plate 4.17** POP ceiling finish

### 4.2.6 Application of Bioclimatic Architecture Principles

*4.2.6.1 Building form, shape and orientation*

According to study carried out by the researcher, Katsina Motel was planned with units of small buildings spread on the large site. All the buildings units observed were rectangular in shape with most of the buildings' longer sides elongated along the east-west direction, that is, with the longer sides facing the north and south in order to make the best use of the sun. The orientation which was according to the consideration of the region's climate, therefore reduced the effect of solar radiation into the guest interior spaces. The small building units in Katsina Motel were simple and bungalow types, with the exception of the new presidential wing which is a duplex as shown in plate 4.18.



**Plate 4.18** Katsina Motel Building form and elongated shape adopted

*4.2.6.2 Natural Ventilation*

The field survey shown that the building form was simple which promotes ventilation within the indoor environment. The mode of natural ventilation was through the sliding windows provided in all the guest areas and large projection windows (see plate 4.19) in the restaurant, multipurpose hall and the reception.



**Plate 4.19** Windows for natural lighting, Katsina Motel.

*4.2.6.3 Visual comfort conditions*

Windows were provided in every single space, therefore guests can live comfortably during the day within the interior spaces without necessarily the need for artificial lighting. The spatial arrangement of the spaces and the windows promote daylight distribution within the interior spaces. During the survey, spaces like staircases, guest rooms, lobbies, restaurant were designed with glass windows for visual comfort.

*4.2.6.4 Passive Cooling Techniques*

The vast green areas (plate 4.20), large unpaved areas and presence of large number of trees around the building were seen as passive principles adopted to improve the site microclimate because of the absorption of heat and minimisation of re-radiation of the areas.



**Plate 4.20** Green areas and large trees, Katsina Motel.

*4.2.6.5 Thermal protection through shading*

The large trees provided shade to the small building units and the minimisation of windows number and sizes also protect the indoor environment from the glaring sun. From plate 4.21 vertical garden can be seen on the exterior walls of the chalets, it shades the building units from the solar radiation.



**Plate 4.21** Katsina Motel Chalets vertical garden for shading.

*4.2.6.6 Acoustic protection*

According to the research carried out, the zoning of the small building units around the site was considered advantageous to noise protection. The building units were properly designed and zoned with the guests' rooms and private areas positioned away from the possible noise areas like the conference/multipurpose halls and the main entrance. However, the internal spaces were demarcated by thick walls, suspended ceiling, floor tiles and other noise reduction techniques were observed during the survey which indeed give the building acoustic protection.

*4.2.6.7 Renewable energy sources*

The hotel solely depends on electricity supplied by the power holding company of Nigeria and the three automatic generators (500KVA, 350 and 250KVA). In other words, the source of energy to the hotel is not renewable. Meanwhile, the hotel introduced a system that reduced the consumption of energy where all electrical appliances automatically switched on when the guest inserted his key card and switched off on exit of the guest from their rooms. The key card switch system (see plate 4.22) introduced was an effective strategy that reduces energy consumption.



**Plate 4.22** Card switch system that reduces energy consumption.

### 4.2.7 Summary of the Study

The summary presents the researcher's assessment of the application of Bioclimatic Architecture Principles and the results obtained during the researcher's field survey at the Katsina Motel as shown in Table 4.2.

**Table 4.2:** Assessment of bioclimatic Architecture study variables

| **Bioclimatic Architecture Principles**<br>**Scale Factor:** Excellent=5, Very Good=4, Good=3, Fair=2, Poor=1 | | | | |
|---|---|---|---|---|
| **Variables** | **Features** | **Method Adopted** | **Scale Factor** | **Remarks** |
| Building form, orientation and shape | Small building units, simple forms and rectangular shape | Orientation of the longer axis of the building along the east-west direction | 4 | Acceptable |
| Natural Ventilation | Sliding and projection windows | Use of sliding windows in guest rooms and projection windows in the restaurant and reception | 2 | Acceptable |
| Visual comfort conditions | Use of windows with transparent glass | Provision of windows in all the spaces for natural lighting | 3 | Acceptable |
| Passive Cooling Techniques | Large green areas and trees around the site | The hedges, large trees and the green areas improves the site microclimate and passive cooling | 3 | Acceptable |
| Thermal protection through shading | Trees around the buildings | Shading is largely from the large trees around the building | 3 | Acceptable |
| Acoustic protection | Thick walls, insulation of floors and ceilings of interior spaces | Proper zoning of spaces | 3 | Largely depends on zoning of spaces |
| Renewable energy sources | Nil | Key card system controlling energy consumption by guest | 0 | Efficient strategy of reducing energy use |

## 4.3 CASE STUDY THREE: NATIONAL COLLEGE OF PETROLEUM STUDIES INTERNATIONAL HOTEL KADUNA

### 4.3.1 Background

National College of Petroleum Studies (NCPS) International Hotel is a newly constructed hotel along the Kaduna-Kano express way at Rigachikun Kaduna. The sky-blue glazed hotel (see plate 4.23) was designed by Archimodes Associates. The hotel has 272 rooms and was built to offer hospitality and accommodation services to guest of the newly built National College of Petroleum Studies, Kaduna and other guests.

However, at the time of this research, the hotel was completed but it was not occupied. The external site works, this is parking areas, external landscaping, were still ongoing. Therefore the hotel has not started full functioning at the time of the research, but since the research was to study the hotel design itself and the application of bioclimatic architecture principles, the research was carried out.



**Plate 4.23** NCPS International hotel façade.

### 4.3.2 Site Planning and Landscaping

From the site plan obtained during the field survey, the hotel has large site area, constructed drainage system, access roads for vehicular movement and parking areas are well demarcated with concrete kerbs as shown in fig. 4.2. However, there was no presence of any green landscaping on site because all works on green areas were not executed at the time of the field survey. Therefore, this could be a demerit of the survey but this alone cannot dent the research.

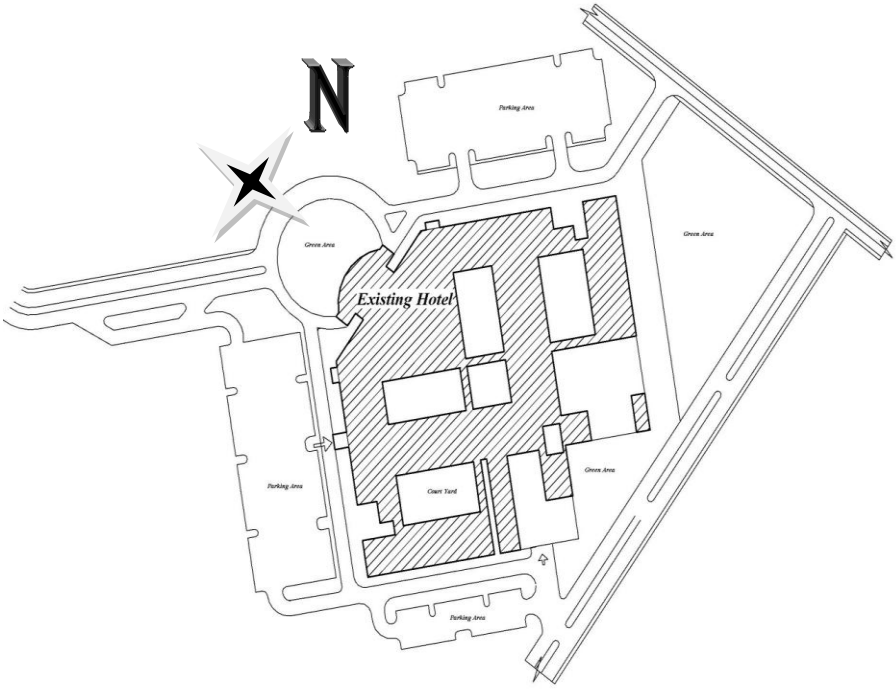



**Figure 4.2** Site lay-out of NCPS Hotel Kaduna.

### 4.3.3 Spatial Organisation

The spatial arrangement of the guests' floors of the hotel was double banking system, the hotel 272 guests' rooms were located on the upper floors and categorised as follows; 236 standard rooms, 30 deluxe rooms and 6 presidential suites. The ground floor houses the

two restaurants, gym lounges, shops, banquet hall, reception, kitchen and other public areas, while the first floor houses the hotel offices, meeting rooms, staff sleeping areas and control rooms. The building was designed with segments but linked together making the hotel spatially one structure. The rectangular plans were linked together by open courtyards as shown in the schematic site plan (fig. 4.2), the courtyards promote natural ventilation and lighting in to hotel spaces.

### 4.3.4 Structure and Materials

The hotel structure is a typical modern design with concrete, curtain walls panel and aluminium cladding as the main building materials used as shown in plate 4.24. The form is simple but massive and with a structural grid framework construction of columns and beams demarcating spaces and floor. Services like; ducts and pipes were integrated into the building massing.



**Plate 4.24** Curtain wall panels and aluminum cladding, NCPS Hotel Kaduna.

### 4.3.5 Aesthetics

The hotel façade has sky blue curtain walls and silver aluminum claddings making the building aesthetics. In the interiors, the walls were painted with light coloured paints and the floors tiles were made up of marble and granite finish. Wooden doors and aluminum railings were placed where necessary and POP ceiling was used in all the guests' areas (see plate 4.25).



**Plate 4.25** NCPS International hotel interior finishes

### 4.3.6 Application of Bioclimatic Architecture Principles

*4.3.6.1 Building form, shape and orientation*

The newly constructed hotel has a compact and massive design layout with court yards as shown in fig. 4.2. The cluster plan and the composition allows minimal exposure to the sun which can improve the thermal condition of the internal environment.

*4.3.6.2 Natural Ventilation*

Large projection windows for ventilation of the interior spaces were embedded in the curtain walls system. The courtyards also promote ventilation in the guest areas and other spaces. However, in some of the corridors the windows were not adequate to ventilate the areas which is a demerit. The hotel also has provision for central cooling system other than the natural means.



**Plate 4.26** Large projection windows for ventilation, NCPS Hotel Kaduna.

*4.3.6.3 Visual comfort conditions*

During the survey, the guests' rooms and many other spaces in the interior spaces appear to have adequate natural lighting during the day from the transparent windows introduced and from the spatial arrangement of the spaces. Plate 4.27 shows the transparent windows that admit natural lighting into the interior spaces.



**Plate 4.27** Large transparent glass windows for lighting. NCPS Hotel Kaduna.

Meanwhile, not all the corridors in the guests' floors receive adequate lighting because of the double banking, therefore artificial lighting was provided in such corridors for visual comfort to guests and which is a demerit according to the researcher. However, in other spaces like staircases, guests' rooms, meeting and conference halls, restaurants and many other public areas other than the one or two corridors mentioned earlier receive adequate natural lighting during the day, which is a merit for the hotel in terms of energy consumption and visual comfort of the guests.

*4.3.6.4 Passive Cooling Techniques*

According to the field survey carried out, the courtyards (see plate 4.28) and the large open spaces around the hotel are the only passive techniques observed. The courtyard serve as heat sink during the day and radiate the heat during the night. The green areas and unpaved surfaces in the courtyards can aid passive cooling of the hotel.



**Plate 4.28** Court yard for passive cooling, NCPS Hotel Kaduna.

*4.3.6.5 Thermal protection through shading*

The survey shown that all external walls were shaded with curtain wall system and aluminum cladding as shown in the plate 4.29.



**Plate 4.29** NCPS Hotel Curtain walls and aluminium cladding protecting the external walls

*4.3.6.6 Acoustic protection*

The hotel spaces were properly designed and zoned according to the research carried out, the rooms were located at the upper floors away from the gathering areas like conference halls and the reception. Spaces are also demarcated by thick walls, doors, suspended ceiling, noise resistance floor tiles and other noise reduction techniques were observed during the survey which indeed give the building acoustic protection.

*4.3.6.7 Renewable energy sources*

The survey carried out indicated that the hotel main source of energy was not renewable. The hotel only depends on non renewable energy sources(electricity and generators) provided. Therefore, it is a demerit to the hotel for depending only on non-renewable energy considering the hotel's capacity.

### 4.3.7 Summary of the Study

The summary presents the researcher's assessment of the application of Bioclimatic Architecture Principles and the results obtained during the researcher's field survey at the National College of Petroleum Studies International Hotel, Kaduna as shown in table 4.3.

**Table 4.3:** Assessment of bioclimatic Architecture study variables

| **Bioclimatic Architecture Principles**<br>**Scale Factor:** Excellent=5, Very Good=4, Good=3, Fair=2, Poor=1 | | | | |
|---|---|---|---|---|
| **Variables** | **Features** | **Method Adopted** | **Scale Factor** | **Remarks** |
| Building form, orientation and shape | Massive form, elongated plan and good building orientation | Rectangular building shape, orientation of the longer axis of the building along the east-west direction, | 3 | Acceptable |
| Natural Ventilation | Projection windows and court yards | Ventilation is by stack effect | 2 | Artificial strategies are required |
| Visual comfort conditions | Large and transparent glass windows | Provision of windows in all the guests' rooms for natural lighting | 2 | Two corridors lack adequate natural lighting |
| Passive Cooling Techniques | Courtyards | The courtyard promotes ventilation and building cooling | 3 | Acceptable |
| Thermal protection through shading | Aluminum claddings and recesses | Thick walls shaded by curtain wall panels and aluminum claddings | 2 | Lack of large tress around the building |
| Acoustic protection | Thick walls, insulation of floors and ceilings of interior spaces | Proper zoning of spaces | 3 | Acceptable |
| Renewable energy sources | Nil | Nil | 0 | Negative |

## 4.4. COMPARATIVE ANALYSIS OF RESULTS/FINDINGS

Table 4.4 summarises and compares the results obtained from the three selected cases. Among all the three cases, NTI Conference centre was found out to be the case with highest consideration of bioclimatic architecture principles, therefore, it offers the most suitable indoor environment for guest passively. However, the Katsina Motel small building units orientation was good and the presence of large trees on site no doubt

improve the micro climate. The NCP International Hotel was the case with lowest consideration of bioclimatic architecture principles.

Meanwhile, all the selected cases failed in the application of renewable energy sources. But in case of Katsina Motel, energy management system was introduced to control energy use of the hotel as stated earlier.

**Table 4.4:** Comparative Analysis of the Cases

| Variables | NTI Conference Centre | Katsina Motel Katsina | NCP Hotel Kaduna |
|---|---|---|---|
| Building form, orientation and shape | The elongated plan shape and the massive building form is good for climate of the region in addition to the good orientation achieved | Almost all the small units of buildings were orientated to make the best use of the climate thus the shape is good for the region | Poor orientation of the guest areas |
| Natural Ventilation | Central courtyard and shaded windows for air movement within the building | Windows provision for air circulation within the interior spaces | Introduction of courtyards to reduce deep planning and for air circulation |
| Visual comfort | Large and transparent shaded windows for day lighting | Provision of windows for natural lighting during the day | Adequate day lighting in the guest spaces but not in some corridors |
| Passive Cooling Techniques | Green areas created in the courtyard and around the building | Large trees and green areas on site | Depends on only the central courtyards introduced to the design |
| Thermal protection through shading | Deep recesses, balconies and horizontal concrete shading devices | Depends on the good orientation of the simple and rectangular small buildings on site | Thick walls shaded by curtain wall panels and aluminum claddings |
| Acoustic protection | Thick walls, insulation of floors and ceilings of interior spaces | Proper zoning of spaces | Thick walls, insulation of floors and ceilings of interior spaces |
| Renewable energy sources | Nil | Nil | Nil |

# CHAPTER FIVE

# DESIGN DEVELOPMENT

## 5.1 SITE SELECTION CRITERIA

Selection of the most suitable site is important to the development of hotel establishments. Three different sites with suitable conditions at Katsina are considered. The most suitable site is selected for the development of the proposed Bioclimatic hotel based on the following criteria:

i. Accessibility
ii. Possibility of Future Expansion
iii. Nearness to Attraction Centres.
iv. Land Use
v. Availability of Services and Utilities

### 5.1.1 Accessibility

The ease of access to the site is considered very important when locating a hotel and should allow for greater vehicular and pedestrian access to and from the city. It is desirable to locate the site close to the city major roads and airport for accessibility by guests.

### 5.1.2 Possibility of Future Expansion

The site to be selected for the hotel development should allow for future expansion. Over time, new hotel policies and the need to expand the existing hotel facilities may require additional land, therefore, it is desirable to select a site with large area of land that will allow for a flexible design and any possible future expansion of the hotel facilities.

### 5.1.3 Nearness to Attraction Centres

Locating a hotel close to the city attraction centres can increase the rate of patronage, tourist visiting tourism sites within the city require accommodation facilities throughout their visit.

### 5.1.4 Land Use

Developing a hotel on a site lay-out that complies with the urban development authority land use is important for the success of the establishment. Land use compliance is considered as one of the most important criteria in developing a hotel.

### 5.1.5 Availability of Services and Utilities

Sites for development needs good services around it, therefore, aavailability of services is a perquisite in selecting a site for the development of hotel. Services like electricity or power lines, water supply mains, drainage systems, constructed roads, telephone line, telecommunication networks and other services attract investors and save cost of development.

## 5..2 SITE SELECTION

There are three possible sites; A-C.

### 5.2.1 Site A

The site is situated at the new commercial lay-out, Gidan Dawa. It is rectangular and flat with large site area (see fig 5.1). It allows for greater vehicular and pedestrian access because of the well connected road networks constructed recently and it is linked by tarred road to popular IBB way, that allows access from other major roads in and out of the city. The site is centrally located between the urban settlement and the airport. The mapped out

area for the proposed site is approximately 6acres and the land use is purposely allocated for hotel development. Services like electricity, water supply, well designed drainage system, tarred roads etc are all available.

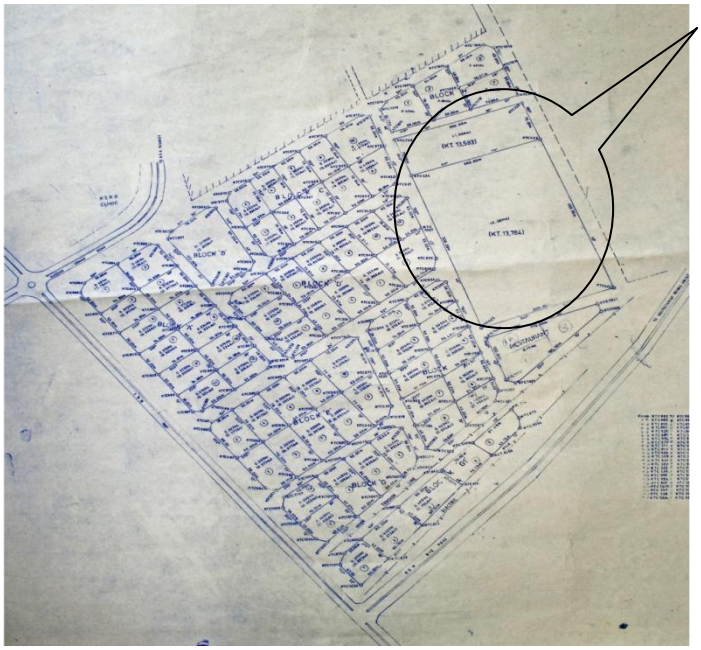


**Figure 5.1** Site A (Source: KTURPB, 2013)

### 5.2.2 Site B

This site is located at Makera along Daura road in Katsina. It is about 2.5km away from the Umaru Musa Yar'Adua airport, few kilometers away from the mobile police compound, the 252 housing units for junior and middle cadre workers and 3.6km away from the Katsina state Hajj transit camp (see fig 5.2). The site is a virgin land with large site area. During the preliminary survey, the site is located around residential area and it is not purposely allocated for the development of hotel because the land use of the area is not clearly defined by the urban development authority.



**Figure 5.2** Site B Google map
(source: Google earth, 2013)

### 5.2.3 Site C

The site is situated at the new commercial lay-out, Gidan Dawa see fig. 5.3. It is easily accessible by the well connected road networks constructed recently and it is linked by tarred road to popular IBB way and the new Katsina bye-pass. The site is centrally located between the urban settlement and the airport and the land use was purposely allocated for hotel development. The mapped out area for the proposed site was approximately 2acres enough for only a small hotel. Services like electricity, water supply, well designed drainage system, tarred roads etc are all available.

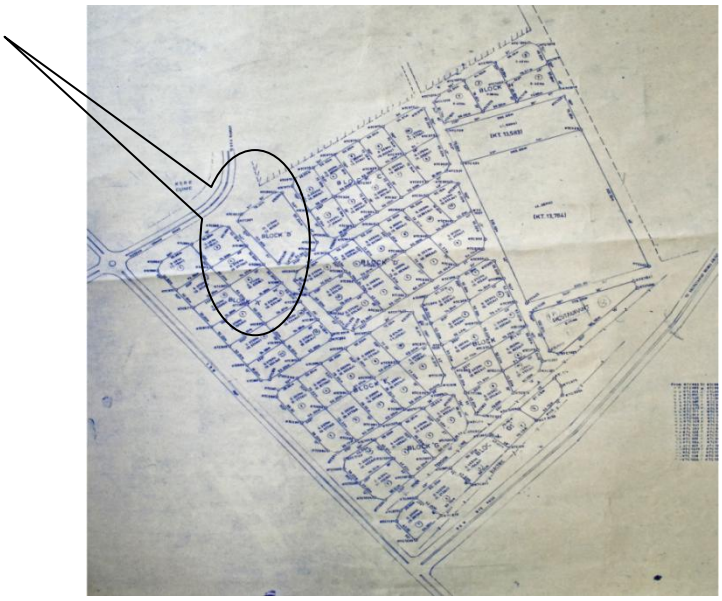


**Figure 5.3** Site C (Source: KTURPB, 2013)

Form the preliminary analysis carried out on the sites, the site with the most suitable features was selected. The rating scale in table 5.1 is adopted with 5 as the strongest rating and 1- as the weakest to analyse the sites according to the selection criteria.

**Table 5.1**: Assessment of alternative Sites

| **Selection Criteria** | **Sites** | | | **Remarks** |
|---|---|---|---|---|
| | Site A | Site B | Site C | |
| Accessibility | 5 | 3 | 5 | All sites are accessible from major roads. |
| Future Expansion possibility | 4 | 5 | 2 | Site A & B favour future expansion. |
| Nearness to Attraction Centres | 4 | 3 | 4 | Site A & C are closer to city ancient tourism sites. |
| Land Use | 5 | 2 | 5 | Site A & C are more compliant |
| Services and Utilities | 5 | 2 | 5 | Presence of most services in Site A & C. |
| **Total** | 23 | 15 | 21 | Site A is considered to be the most appropriate for the development. |

According to Table 5.1, site A being the site with most suitable features is therefore selected for the design of the proposed hotel.

## 5.3 SITE LOCATION

The proposed hotel is to be located at Katsina, Katsina state of Nigeria as shown in figure 5.4. The city is lying between $12^{0}15'$N of the equator and $7^{0}30'$E of the Greenwich Meridian and it is characterised with hot-dry climate. The site is located at the new commercial lay-out called *Gidan Dawa* along the major Katsina-Kano road (IBB Way) Katsina. The site is identified with (KT 13,784) as identification code.

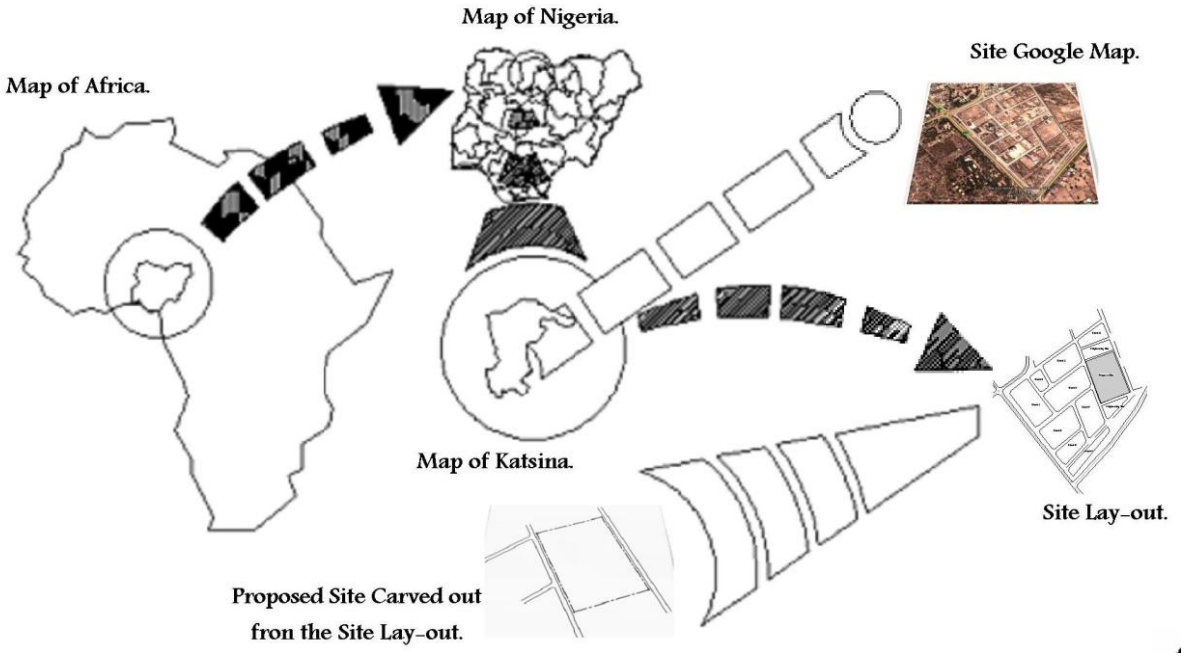



**Figure 5.4** Site Location.

## 5.4 SITE ANALYSIS

This section covers the analyses of the climatic (Temperature, wind, Relative Humidity, precipitation, sunshine) as shown in figure 5.5. It also covers the topography, soil, vegetation, services and neighbouring structures as shown in figure 5.6.

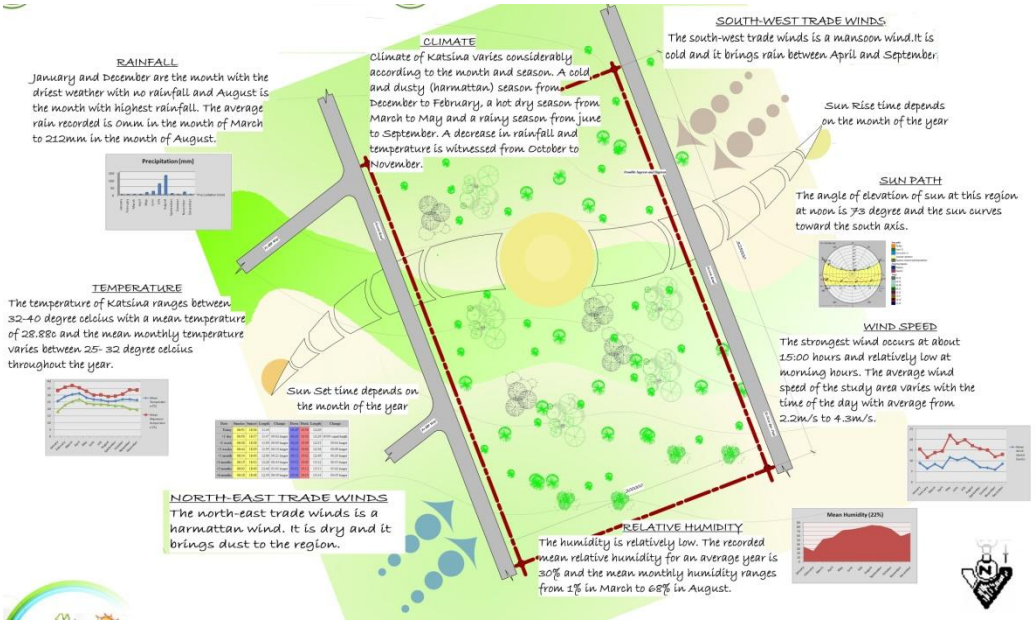



**Figure 5.5** Climatic analysis the study area




**Figure 5.6** Site analysis (topography and existing features)

### 5.4.1 Climate

The climate of Katsina varies considerably with months and seasons for instance during the month of December to February a cold and dusty hammattan season is witnessed and hot dry season from the month of March with temperatures ranging from $32^0$c to $40^0$c (see fig. 5.7). The hot dry season is followed by a raining season from June to September.

#### *5.4.1.1 Temperature*

The study area climate record temperature of up to $40^0$C with the months of April/May as the hottest months of the year. The temperature range is between $32^0$C to $40^0$C with a mean temperature of $28^0$C as shown in fig 5.7. During the cold month January, the mean temperature is about $22^0$C. However, the mean monthly temperature varies between $25^0$C and $32^0$C throughout the year.

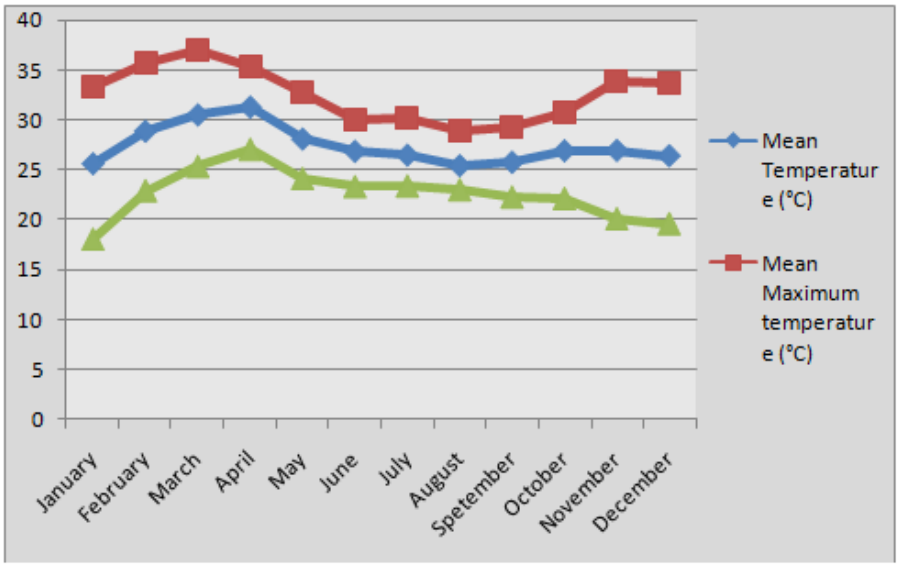



**Figure 5.7** Temperature chart of Katsina
(Source: www.gaisma.com)

*5.4.1.2 Wind*

The average wind speed of the study area varies with the time of the day with average from 2.2m/s to 4.3m/s. The strongest wind occurs at about 15:00 hours and relatively low at morning hours. The region is characterised by the South-West and North-East trade winds attributed to the displacement of inter-tropical convergence zone.

*5.4.1.3 Relative Humidity*

The study area is characterised by relatively low humidity. The recorded mean relative humidity for an average year is 30% and the mean monthly humidity ranges from 20% in February to 86% in August as shown in fig 5.8.

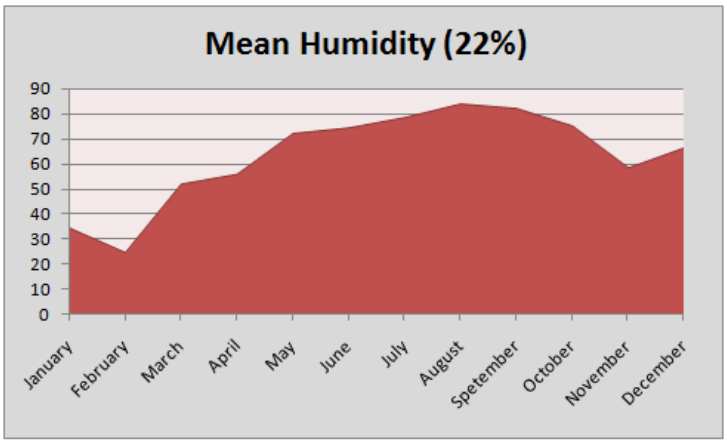



**Figure 5.8** Relative humidity chart of Katsina
(Source: www.gaisma.com)

*5.4.1.4 Precipitation*

The average rain recorded is 0mm in the month of March to 212mm in the month of August and 0mm in the harmattan period. January and December are the month with the driest weather with no rainfall (harmattan) and August is the month with highest rainfall of up to 212mm (see fig 5.9).

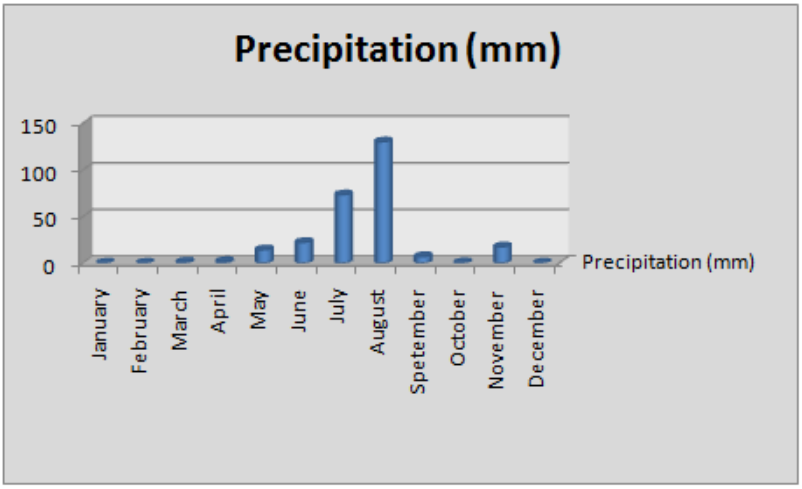



**Figure 5.9** Precipitation chart of Katsina
(Source: www.gaisma.com)

*5.4.1.5 Sunshine and Radiation*

As shown in figure 5.10, the hours of sunshine vary considerably with time of the year with estimated average of 6.5 hours per day in August (wet season) and 10 hours per day in November (dry season). Also, the study area has relatively high daily radiation that ranges from 25MJ/$m^2$ during the dry season and 19MJ/$m^2$ in early August.

| Date | Sunrise | Sunset | Length | Change | Dawn | Dusk | Length | Change |
|---|---|---|---|---|---|---|---|---|
| Today | 06:51 | 18:36 | 11:45 | | 06:29 | 18:58 | 12:29 | |
| +1 day | 06:50 | 18:37 | 11:47 | 00:02 longer | 06:29 | 18:58 | 12:29 | 00:00 equal length |
| +1 week | 06:48 | 18:38 | 11:50 | 00:05 longer | 06:26 | 18:59 | 12:33 | 00:04 longer |
| +2 weeks | 06:44 | 18:39 | 11:55 | 00:10 longer | 06:22 | 19:00 | 12:38 | 00:09 longer |
| +1 month | 06:34 | 18:40 | 12:06 | 00:21 longer | 06:13 | 19:02 | 12:49 | 00:20 longer |
| +2 months | 06:15 | 18:43 | 12:28 | 00:43 longer | 05:53 | 19:05 | 13:12 | 00:43 longer |
| +3 months | 06:03 | 18:49 | 12:46 | 01:01 longer | 05:41 | 19:12 | 13:31 | 01:02 longer |
| +6 months | 06:18 | 18:48 | 12:30 | 00:45 longer | 05:56 | 19:10 | 13:14 | 00:45 longer |

**Figure 5.10** Sunrise, sunset, dawn and dusk time table
(Source: www.gaisma.com)

### 5.4.2 Topography and Soil

The topography of the site relatively flat and has a gentle slope towards the south-west of the site. Site drainage would take this direction in order to use the concept of natural gravity. While the water supply should come from North-eastern direction in order to also use the principle of natural gravity.



**Plate 5.1** Site soil and topography

The soil is laterite (see plate 5.1) which has good bearing capacity but the hydrological and geological survey should be conducted to confirm the actual load bearing capacity of the site. For the purpose of this research and based on the observation carried out, the site soil shown strong indication of good load bearing capacity.

### 5.4.3 Vegetation

The vegetation of the study area (Katsina) is Sahel savannah characterised by few trees (see plate 5.2) scattered around the site and small grass distributed sparsely.



**Plate 5.2** Site vegetation

### 5.4.4 Services

Services like electricity power lines, water supply lines, telephone services, well constructed tarred roads and pedestrian paths, well designed drainages are all available on site (see plate 5.3). The site is accessed from the main Katsina-Kano road or the new bye-pass. Also, high tension electrical cables can also be sited from the site.



**Plate 5.3** Site Services

### 5.4.5 Neighbouring Developments

The area is a new lay-out developed by the State Government to support commercial activities within Katsina city, therefore all the neighbouring developments are commercial. Adjacent to the site is a site allocated to private organisation for the development of restaurant. A new Federal Inland Revenue Office which is under construction is also neighbouring the site (see plate 5.4) and many other office and commercial buildings development. The new built PDP State secretariat Complex is also not far from the site (see plate 5.5).



**Plate 5.4** FIRS new building



**Plate 5.5** PDP State Secretariat

### 5.4.6 Source of Noise

The site is located off the Katsina-Kano road and off the new bye-pass, it is not located along the two major roads. Therefore, the noise is at reduced level if compared to the developments along the two major roads. The possible source of noise is from moving vehicles moving along the hotel the minor access roads and is considered negligible.

## 5.5 SCHEDULE OF ACCOMMODATION

Schedule of accommodation gives an approximate or precise number and size of spaces that will be required and the relationships between the spaces as shown in the table 5.2.

**Table 5.2** Schedule of Accommodation

| **Accommodation Facilities** | | | |
|---|---|---|---|
| Rooms/ Suite Types | Room Area (sqm) | Number (Rooms) | Total Area |
| Presidential Suite | 140sqm | 2 | 280sqm |
| Executive Suite | 110sqm | 5 | 550sqm |
| Business suite | 72sqm | 12 | 864sqm |
| Double Room | 36sqm | 43 | 1548sqm |
| Standard Room | 24sqm | 103 | 2472sqm |
| Total | | 165 | 5164sqm |
| **Conference/Event Halls** | | | |
| Facilities | Area of Spaces (sqm) | Number | Total Area |
| Multipurpose Hall | 1.2sqm/person | 300 | 360sqm |
| Meeting/seminar | 1.2sqm/person | 15x2 | 36sqm |
| Control Room | 18sqm | 1 | 18sqm |
| Stage | 37sqm | 1 | 37sqm |
| Backstage | 22sqm | 1 | 22sqm |
| Stage Manager | 18sqm | 1 | 18sqm |
| Projection Room | 14sqm | 1 | 14sqm |
| Ticket Office | 12sqm | 1 | 14sqm |
| Restrooms | 1.8sqm | 10 | 18sqm |
| Stores | 15sqm | 1 | 15sqm |
| Total | | 347 | 552sqm |

| Commercial Facilities | | | |
|---|---|---|---|
| Facilities | Area of Spaces (sqm) | Number | Total Area |
| Cyber Cafe | 48sqm | 1 | 48sqm |
| Boutique | 24sqm | 2 | 48sqm |
| Let able Space | 25sqm | 5 | 50sqm |
| Barbing Saloon | 25sqm | 1 | 125sqm |
| Beauty Parlour | 35sqm | 1 | 35sqm |
| Fast Food | 15sqm | 2 | 30sqm |
| Mini mart | 40sqm | 1 | 40sqm |
| Total | | 13 | 376sqm |
| **Sports and Fitness** | | | |
| Facilities | Area of Spaces (sqm) | Number | Total Area |
| Tennis Court | 18.27x36.57m | 2 | 1336.27sqm |
| Badminton | 9.1x17.4m | 2 | 316.68sqm |
| Gymnasium | 80sqm | 1 | 80sqm |
| Swimming Pool | 16.66x25m | 1 | 416.50sqm |
| Changing Rooms | 1.8sqm | 6 | 10.8sqm |
| Total | | 12 | 2160.25sqm |
| **Catering Facilities** | | | |
| Facilities | Area of Spaces (sqm) | Number | Total Area |
| Restaurants | 1.2sqm/person | 250 | 300sqm |
| Outdoor Eating | 1.2sqm/person | 80 | 96sqm |
| Tea & Coffee | 1.2sqm/person | 50 | 60sqm |
| Total | | 380 | 456sqm |

| Back House | | | |
|---|---|---|---|
| Facilities | Area of Spaces (sqm) | Number | Total Area |
| Main Kitchen | 216sqm | 1 | 216sqm |
| Stores | 36sqm | 4 | 144sqm |
| Laundry | 72sqm | 1 | 72sqm |
| House keeping | 6.25sqm | 26 | 162.5sqm |

**Table 5.3** Staff and Management offices

| Staff Offices/Front Desk | | | |
|---|---|---|---|
| Offices | Approx. Area(sqm) | Number | Total Area |
| General Manager | 27sqm | 1 | 27sqm |
| Secretary | 13.5sqm | 1 | 13.5sqm |
| Account Office | 13.5sqm | 1 | 13.5sqm |
| Cash Office | 13.5sqm | 2 | 27sqm |
| Front Desk Offices | 20sqm | 2 | 40sqm |
| Reservation Office | 27sqm | 1 | 27sqm |
| Human Resources Manager | 13.5sqm | 1 | 13.5sqm |
| Personnel Manager | 13.5sqm | 1 | 13.5sqm |
| Maintenance Office | 13.5sqm | 1 | 13.5sqm |
| Record Office | 13.5sqm | 1 | 13.5sqm |
| Staff Offices | 13.5sqm | 3 | 108sqm |
| Total | | 15 | 310sqm |

## 5.6 FUNCTIONAL FLOW

A functional flow chart is a diagrammatic representation that illustrates the relationship between spaces in the early stage. A functional flow within a hotel shows the relationship between accommodation facilities and other areas like circulation, reception, services, recreation and sporting areas etc (see fig. 5.11). Functional flow gives a visual idea of the

location of services and exits, it shows the linkage between related areas. The accommodation facilities and lounges are located on higher levels; while the reception, service areas (e.g. kitchen, laundry, etc), sporting areas and events facilities are located on the lower levels.

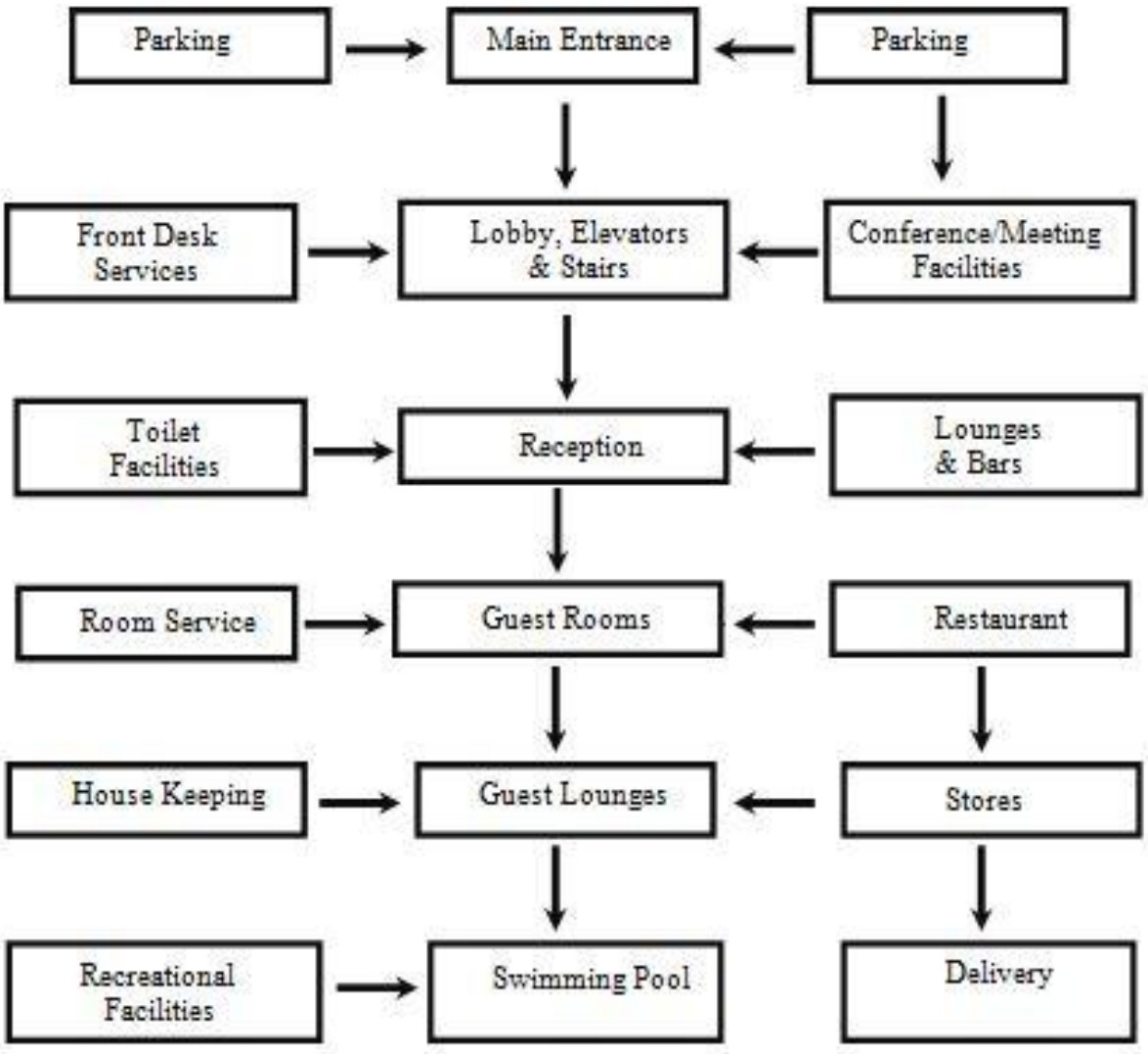



**Figure 5.11** Functional Flow Chart

## 5.7 CONCEPT DEVELOPMENT

The approach to this project is exploratory to find a possible sustainable solutions that would utilise climatic conditions of hot-dry climate of Katsina, while satisfying occupants' comfort. The conceptual design plan of the hotel takes the U-shape and oriented on site to make the best use of the site climatic factors. The U-shape architectural plan configuration gives more flexibility to the design with single banking of the guest rooms, green courtyard and green open spaces at each level for bioclimatic comfort of the guest (see fig.5.12).

The proposal is designed conceptually and architecturally to improve micro-climate of the interior spaces by incorporating nature. Also, deep recesses provide thermal protection and shading. The orientation and the shape allow for air circulation and exploitation of solar energy. Nature and technology is the primary tectonic expression of the building.

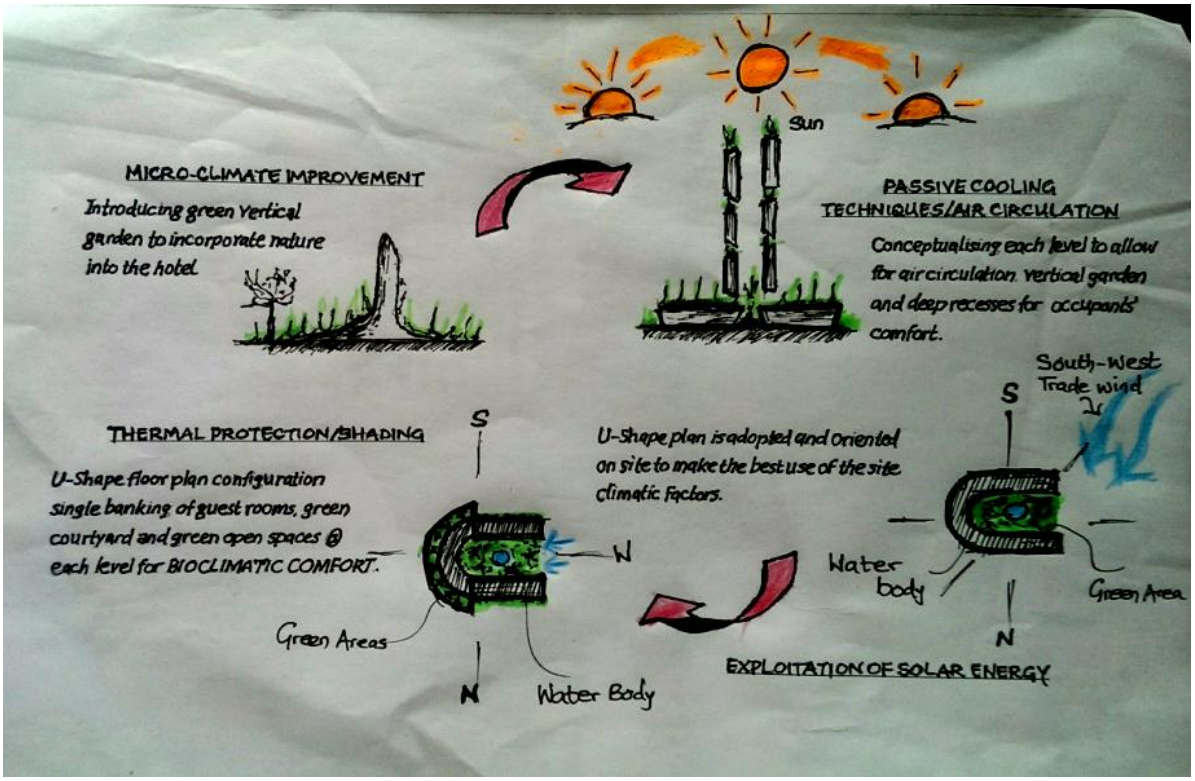



**Figure 5.12** Concept Development

# CHAPTER SIX

# DESIGN REPORT

## 6.1 INTRODUCTION

The hotel design is proposed as a four star hotel. The architectural design of the hotel is described according to bioclimatic design principles as outlined and discussed in the previous chapters.

## 6.2 SITE PLANNING AND LANDSCAPING

The orderly arrangement of building units and other supporting facilities allow for effective flow of traffic within the site and for proper utilization of both the site and climatic element (see fig. 6.1). The zoning of areas on site was carried to appropriately allocate areas best suited for various facilities and activities.Vehicular, pedestrian and services entrance were clearly defined. The main hotel building was the centre of attraction with access roads leading guests to the hotel main entrance. The parking area, multi-purpose hall, recreational and sporting facilities are connected to the main building by pedestrian walkways and small access roads as shown in figure 6.1. Recreational and relaxation areas were privately located and zoned for maximum privacy of the guest. Services and back-house were however located away from the sight of the hotel guests.

The hotel has large site area well landscaped with green areas, green central courtyard, large trees for shading and shrubs. The court yard was properly landscaped with green areas, swimming pool and outdoor green spaces. The unpaved parking area and the number of large tress purposely to improve the microclimate for thermal comfort.




**Figure 6.1** Hotel Site Planning and Landscaping.

The U-shape of the hotel building allows for the utilization of the site climatic factors. Therefore, the shape and the concept of the proposed hotel minimizes the exposure to the sun and allows for air circulation within the different units of the buildings. Orientation

was according to the region bioclimatic needs ( longer sides along the east and west axis) as shown in figure 6.1.

## 6.3 SPATIAL ORGANIZATION

The compact shape of the building units reduce the surfaces exposure to the elements of weather and its openings are given an appropriate orientation (south and north). The interior spaces were also laid out according to their privacy requirements.

For the main hotel building, the U-shape of the hotel makes the spatial arrangement flexible and the design is in such a way that the guest rooms are located on the upper floors. On the ground floor, the reception is the central area connecting the vertical access (Lifts and stair cases) and other spaces of the hotel. The restaurant, back-house, staff offices/areas, commercial areas etc are located on the ground floor plan. The first floor is the services floor, this allows for effective control of grey water and soil water from the rooms to channel them for recycling.

Mean while, from the second floor up to the fourteenth floor was design to house the guest room. The spatial arrangement of the guest room floors is single banking system and each room was designed with a green balcony and was given access to the vertical garden in the corridor (see fig. 6.2). The hotel guest room total number was 174 rooms comprising of 96 standard rooms, 56 double luxury, 14 business suites, 6 and 2 executive and presidential suites respectively.

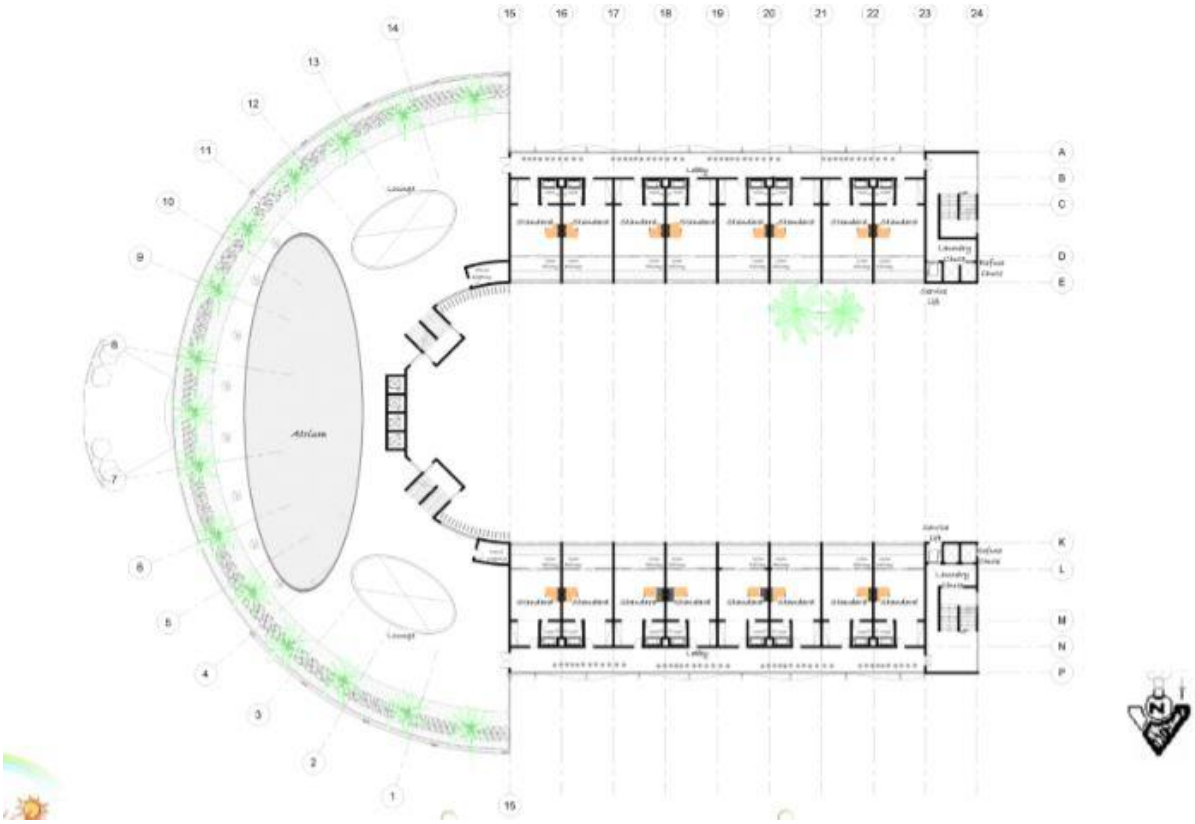


**Figure 6.2** 2nd floor plan showing the hotel spatial arrangement.

## 6.4 STRUCTURE AND MATERIALS

The hotel is designed to be simple but modern. A structural grid framework of construction is adopted. Appropriate techniques are applied to the external envelope and its openings to protect the building from elements of weather primarily by shading but also by the appropriate treatment of the building envelope (i.e. use of reflective colours and surfaces) as shown in fig. 6.3.



**Figure 6.3** View showing the structure and materials of the hotel Building.

Concrete and steel is used as the major structural materials. Concrete has structural integrity and fluidity while the steel serve as reinforcing element on the hotel because of its rigidity and strength. The concrete used has 20% fly ash in the first two floors and 17% in the upper two floors, the structural steel contain 80-100% recycled content, wood paneling would be supplied from sustainably harvested forests and local materials were specified to come from within a 100km radius of the site.

## 6.5 AESTHETICS

The concrete and steel structure was covered with aluminum cladding, reflective paints and glass panels which all combined give the building a sense of modern architecture. Honey comb like shading panels were introduced to the western side of the hotel building and the multi-purpose hall also which shade the buildings from solar radiation and also added aesthetical value to the two building facades (see fig. 6.4).

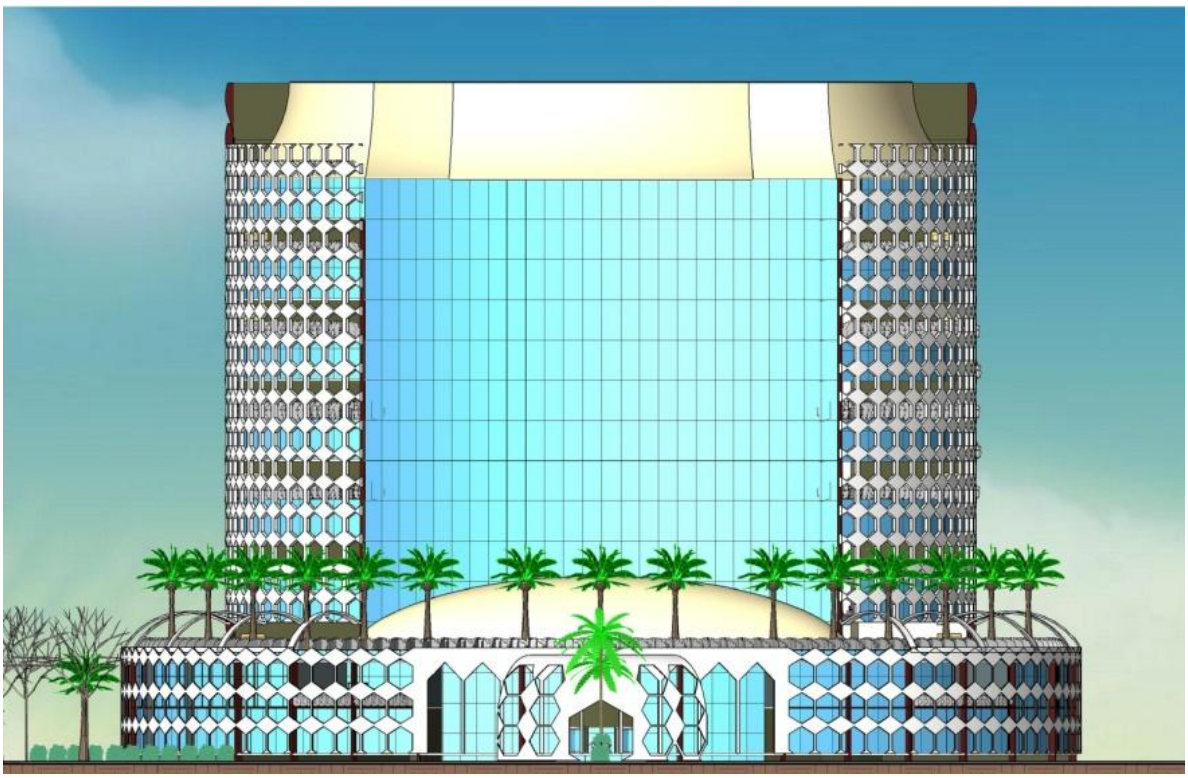


**Figure 6.4** Hotel Façade.

## 6.6 APPLICATION OF BIOCLIMATIC ARCHITECTURE PRINCIPLES

### 6.6.1 Building Form, Shape And Orientation

The U-shape concept of the hotel building is to achieve an elongated plan shape and use the void as a green courtyard. The shape and composition of the design also enable the elongated side to be positioned along the desired direction in order to achieve maximum natural lighting, provide proper ventilation and shade the interior spaces from the intense solar radiation of the region. The ground level open courtyard system provide an outdoor living space to the guest for relaxation and for comfortable atmosphere to the building (see fig. 6.5).

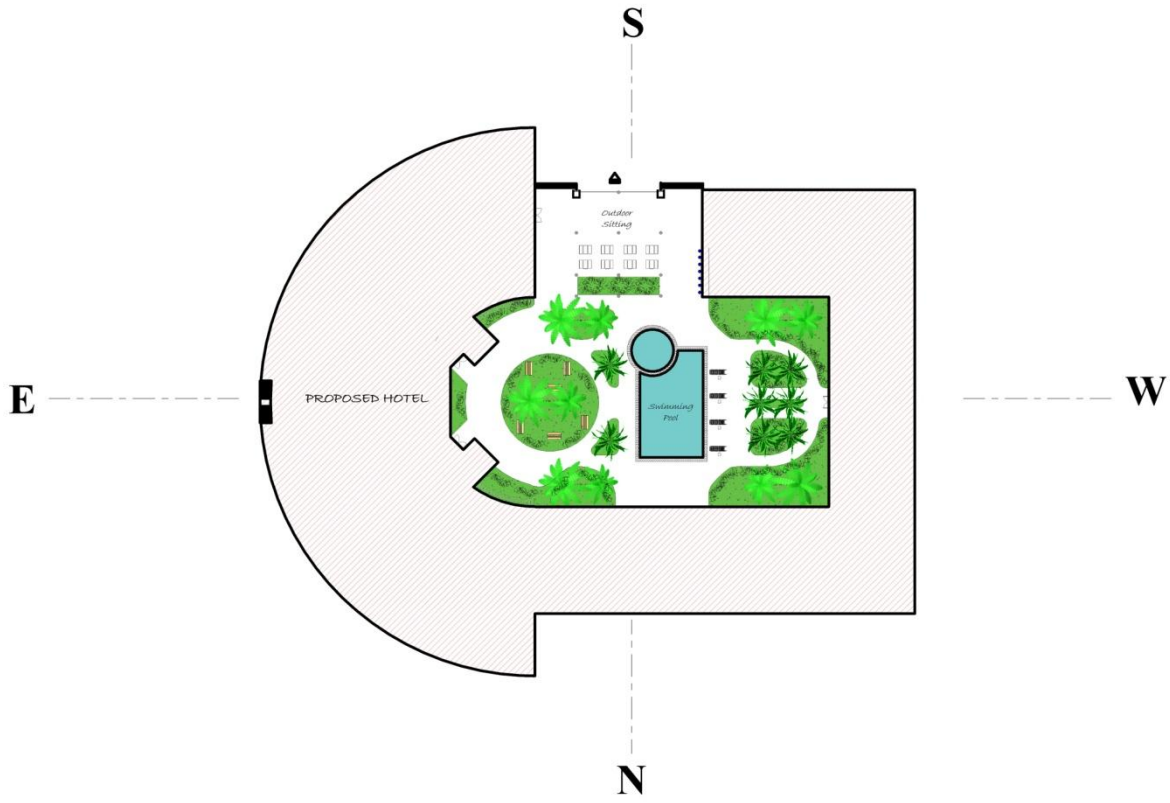



**Figure 6.5** building shape, orientation and the green courtyard.

### 4.6.2 Air Ventilation

In both the main hotel building and the multi-purpose hall, operable and glass windows are designed along with the curtain wall systems for air circulation. The windows are designed with a small sensor on the window frame which turns off the mechanical system when the windows are open. All the guest rooms were opened to the central courtyard and have fenestration were introduced on at least two sides of all most every single space for proper air circulation within the interior spaces (see fig. 6.6). Therefore adequate windows and fenestrations are designed for adequate air circulation. The orientation is also in such a way that the south-west wind cool air breezes into the court-yard and to the interior spaces.

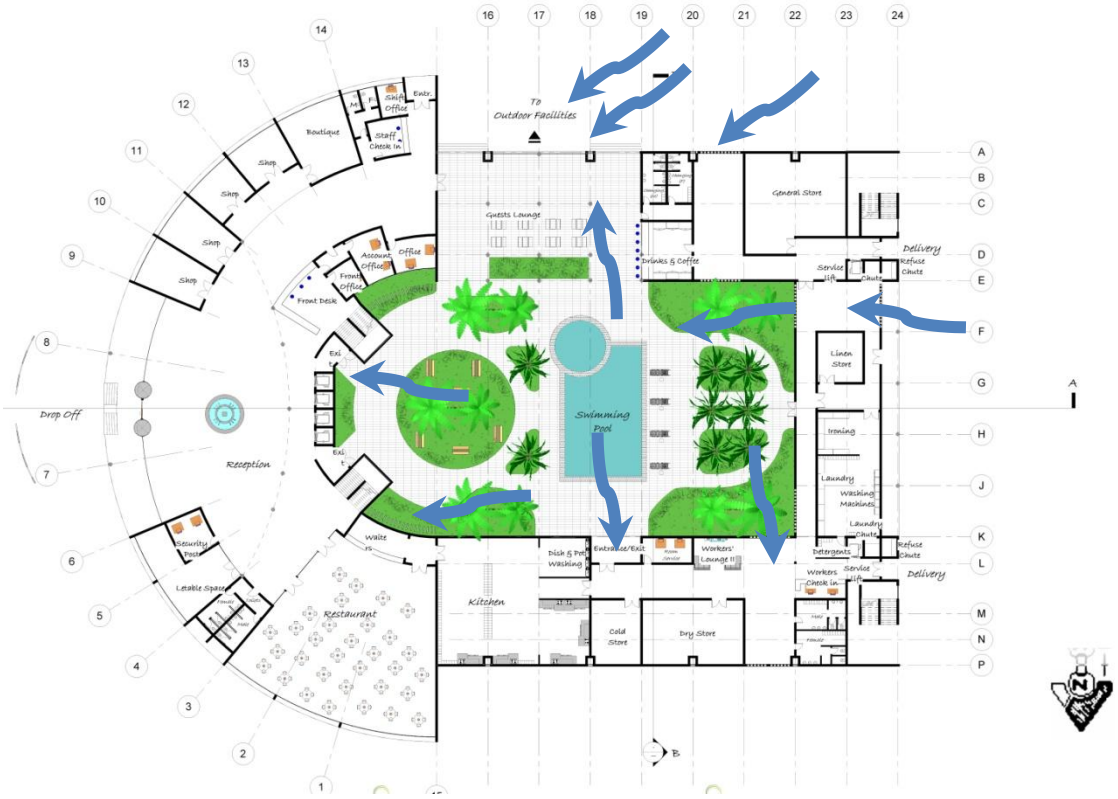



**Figure 6.6** Ground floor plan showing the air circulation in the building.

### 4.6.3 Visual Comfort Conditions

Glass windows and curtain wall systems were introduced to the design purposely to achieve visual comfort during the day time (see fig.6.7). However, to achieve this principle without admitting the intense solar radiation of the region, double-sided glass was specified. The glass has a thin metal coating on the outer surface which refracts the sun's ultraviolet rays and thus prevents the interior from overheating. While the inside face is coated with a thin silver layer that protects the building from the infrared radiation. This type of glass therefore allows for admission of light into the interior spaces but not heat.



**Figure 6.7** South Elevation Showing the curtain wall system.

### 4.6.4 Passive Cooling Techniques

The two major passive cooling techniques introduced were the open central courtyard (see fig. 6.8) system where swimming pools and green outdoor spaces were designed and the vertical gardens introduced in the floors corridors and the guests rooms balconies. These two major techniques aid natural cooling and improve the building micro-climate. Also, the orientation of the windows and the thermal massing insulation of the walls to some extent helps.

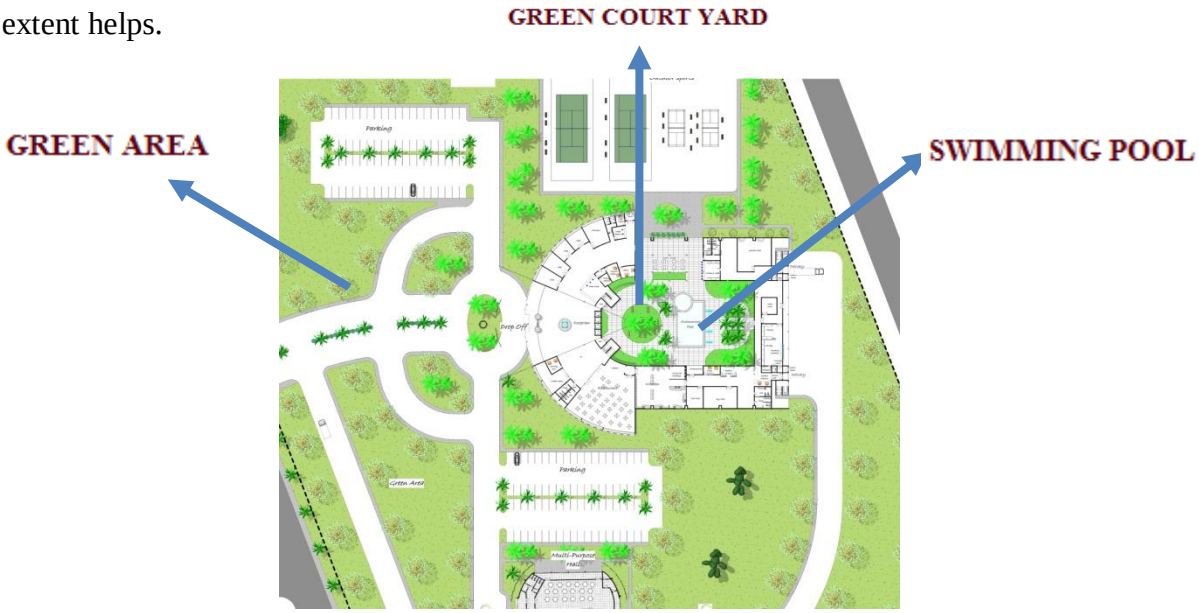



**Figure 6.8** Ground floor plan showing the site landscape.

### 4.6.5 Thermal Protection Through Shading

The buildings were designed to achieve shading. In the case of the main hotel design, the major concept was the façade deep recesses, honey comb like shading elements and green balconies all designed to protect the indoor environment from the glaring sun and to provide a buffer between the living spaces and the outdoor environment. From the figure 6.9 all external walls were designed with shading elements (honey comb like and the vertical stripes on the south and north. These shading devices were integrated in the design to reduce the window area exposure to glaring sun in order to control heat gain for lower indoor temperature. However, despite all the shading techniques introduced in the design, vertical gardens were also introduced at all levels.

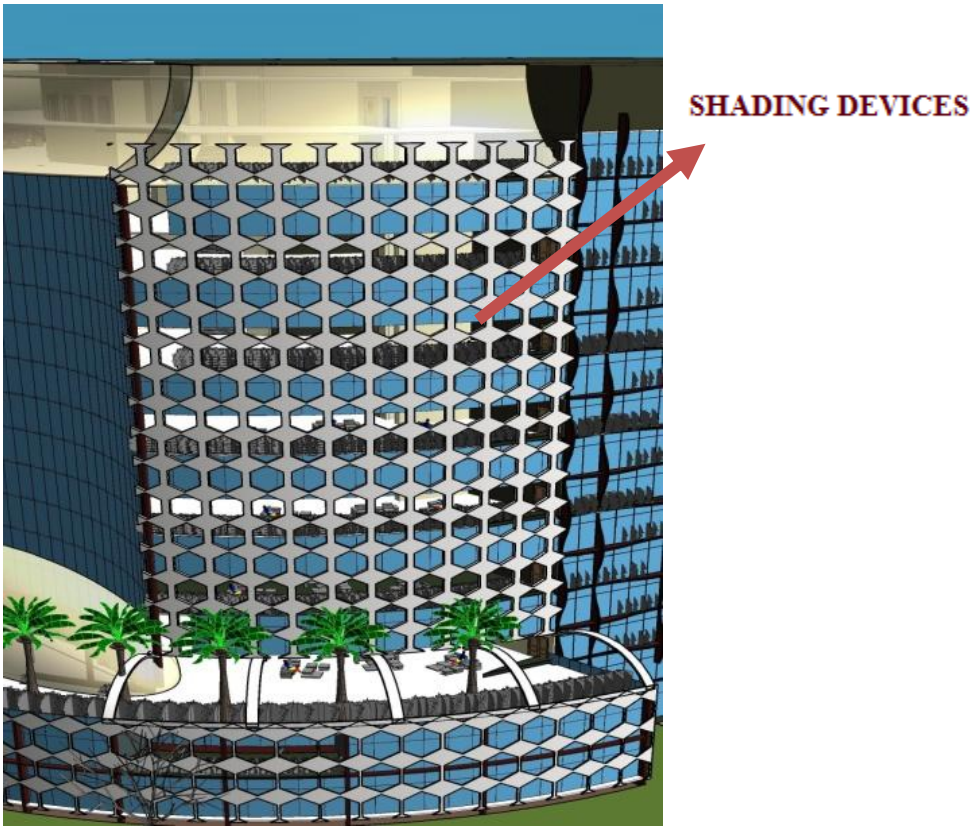



**Figure 6.9** The honey comb shading devices on the facade.

### 4.6.6 Renewable Energy Sources

The proposal considered renewable energy source as the alternative to the non renewable and non dependable energy sources of the country. Solar panel systems (photo voltaic panels) were integrated on the roof in order to generate energy for the building. Also, a system was introduced to monitor the electricity and water systems usage. In the case of electricity usage, a system was incorporated where all electrical appliances automatically switched on when the guest inserted his key card and switched off on exiting from their rooms. While, for the water system, a system was incorporated to collect rainwater and grey water for recycling.

# CHAPTER SEVEN

# SUMMARY, RECOMMENDATIONS AND CONCLUSION

## 7.1 SUMMARY

From the research carried out, majority of the hotels in Nigeria generate their energy privately to sufficiently cater for the energy demands of their visiting guests. This resulted in the corresponding increase in hotel tariff which has crippling effect on the tourism industry. Moreover, Bioclimatic Architecture principles are not widely applied in hotel designs in Nigeria as seen in the cases studied in chapter 4, where it shown that in all the studied cases only a few number of the principles are applied. Therefore, this thesis studied the major bioclimatic principles and the contemporary ways of achieving a sustainable hotel design specifically in the hot-dry climate. Research was carried out on the hot-dry climate, the architectural design requirement of the study area and bioclimatic design requirement of the area in order to achieve the research objectives. Finally this research applied the applicable Bioclimatic architecture principles to hotel designs.

The architectural design of the hotel was conceptualized to improve the micro-climate of the hotel through exploitation of energy, incorporation of passive cooling techniques (vertical gardens, water bodies and green courts) and renewable energy strategies like the use of solar panels and photovoltaic glass/panels as an alternative solution to the high energy demands and for stable, safe and cheaper energy to hotels in Nigeria.

## 7.2 RECOMMENDATION

i. It is recommended that hotel designs should be conceptualised to incorporate multiple bioclimatic principles in order to achieve energy efficiency and sustainable designs for thermal comfort of the target occupants.

ii. With the recent awareness about the future climate, Bioclimatic design strategies and new sustainable methods will be more important for the future climate. Therefore, building professionals should work together in an integrated approach focusing on how to improve the energy performance of buildings; introducing new environmental and bioclimatic architecture policies and encourage the development of more efficient, integrated and accessible simulation techniques for predicting and improving the future environment.

## 7.3 CONTRIBUTION TO KNOWLEDGE

i. The study has demonstrated that the studied bioclimatic principles and energy management systems which will not only increase the effectiveness of the built environment but reduce the energy problems of the developing countries like Nigeria.

ii. The study demonstrated that micro climate improvement strategies (Bioclimatic Architecture Principles) are minimally incorporated in the hot-dry climate region of Nigeria.

## 7.4 CONCLUSION

Using bioclimatic architecture principles to conserve energy is ideal. This thesis studied and applied multiple bioclimatic architecture principles through different ways in the proposed hotel design such as shading of the interior spaces, exploitation of solar energy, incorporation of passive cooling techniques (vertical gardens, water bodies and green courts), air circulation within spaces, natural lighting and renewable energy strategies like the use of solar panels and photovoltaic glass/panels.

The overall thesis found out that the incorporation of multiple bioclimatic architecture principles certainly enhance the quality of the interior spaces and give thermal and bioclimatic comfort to the guest/occupants. It also reduces the over dependence on non-renewable energy sources. The research also found out that there are possibilities that in the near future, bioclimatic designs can be an alternative solution to architectural developments in developing countries like Nigeria.

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# APPENDIX




**Figure I** Site Layout of the Proposed Hotel

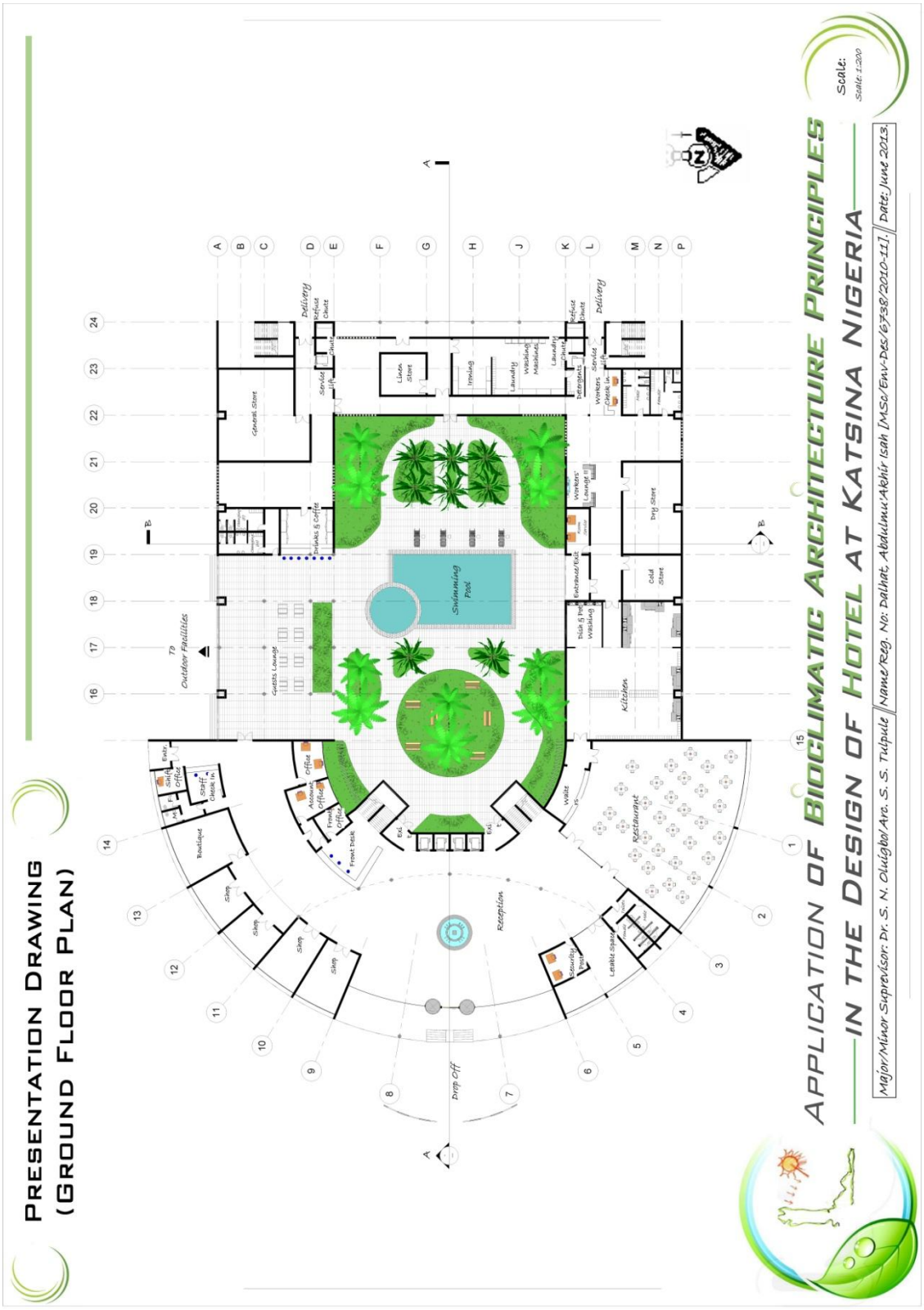



**Figure II** Ground floor Plan (Main Building)




**Figure III** Approach and Rear Elevations (Main Building)




**Figure IV** East and West Elevations (Main Building)

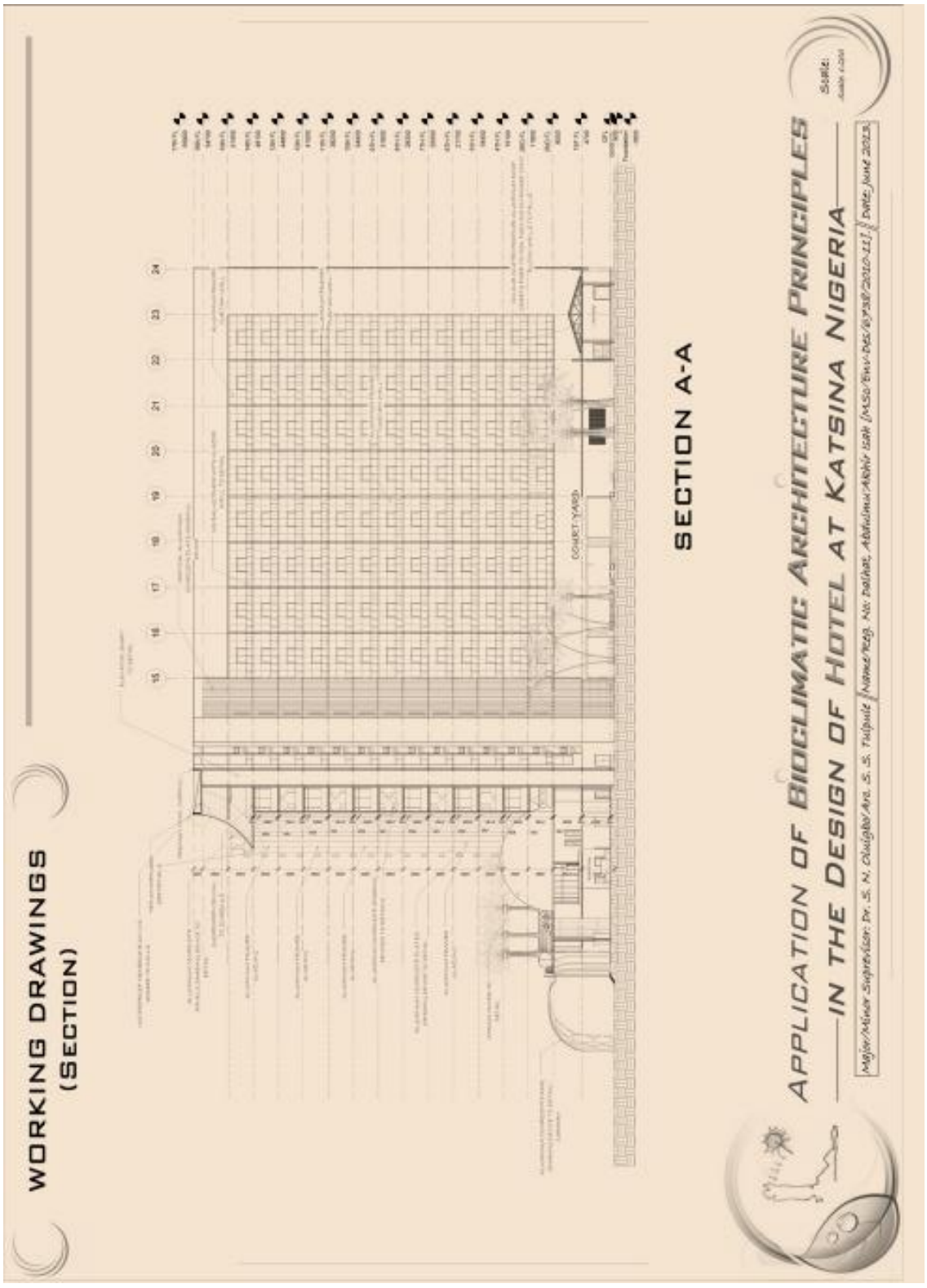



**Figure V** Section I (Main Building)

**Figure VI** Section II (Main Building)

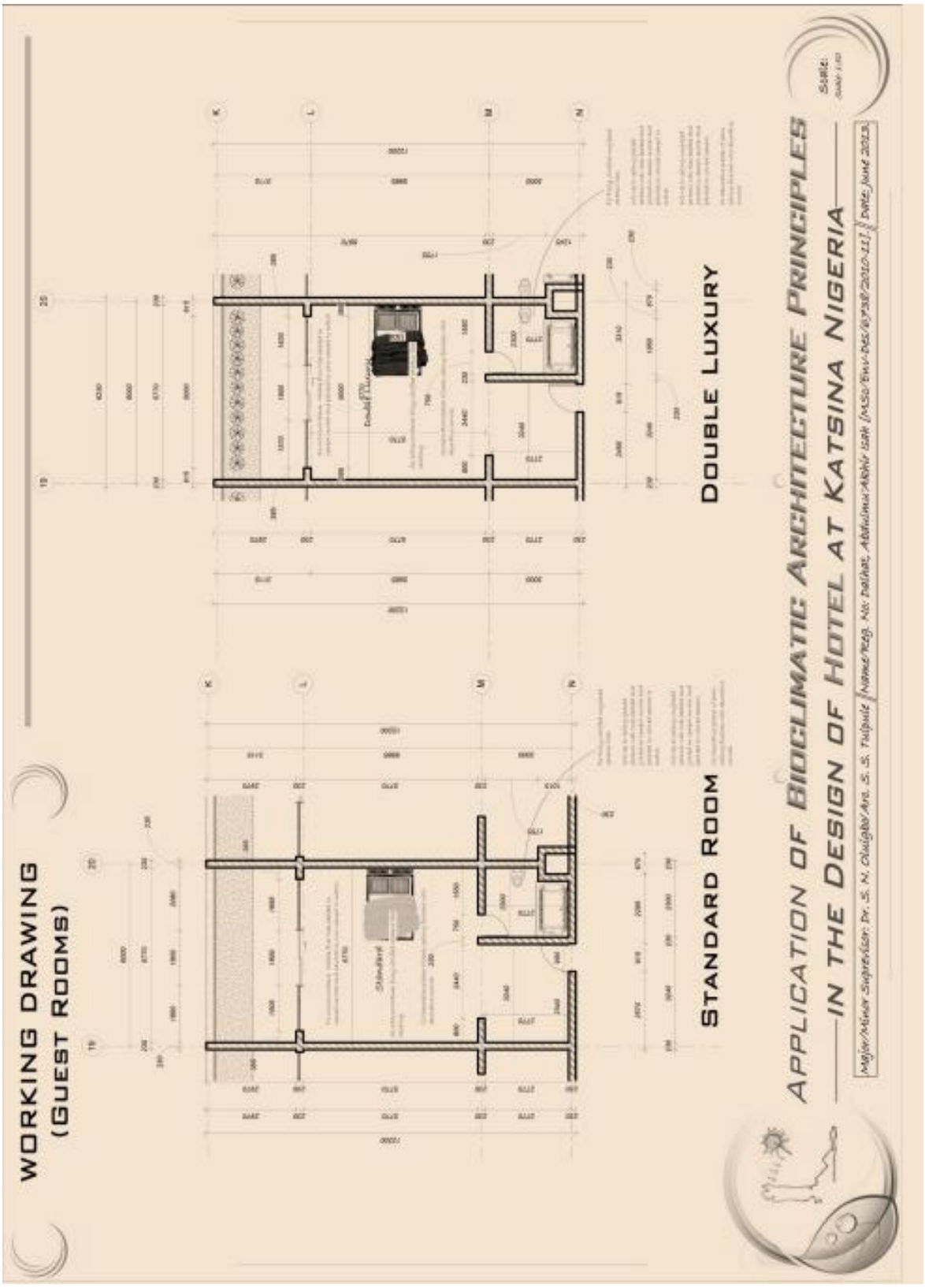



**Figure VII** Guest Rooms lay-out (Standard & Double Room)

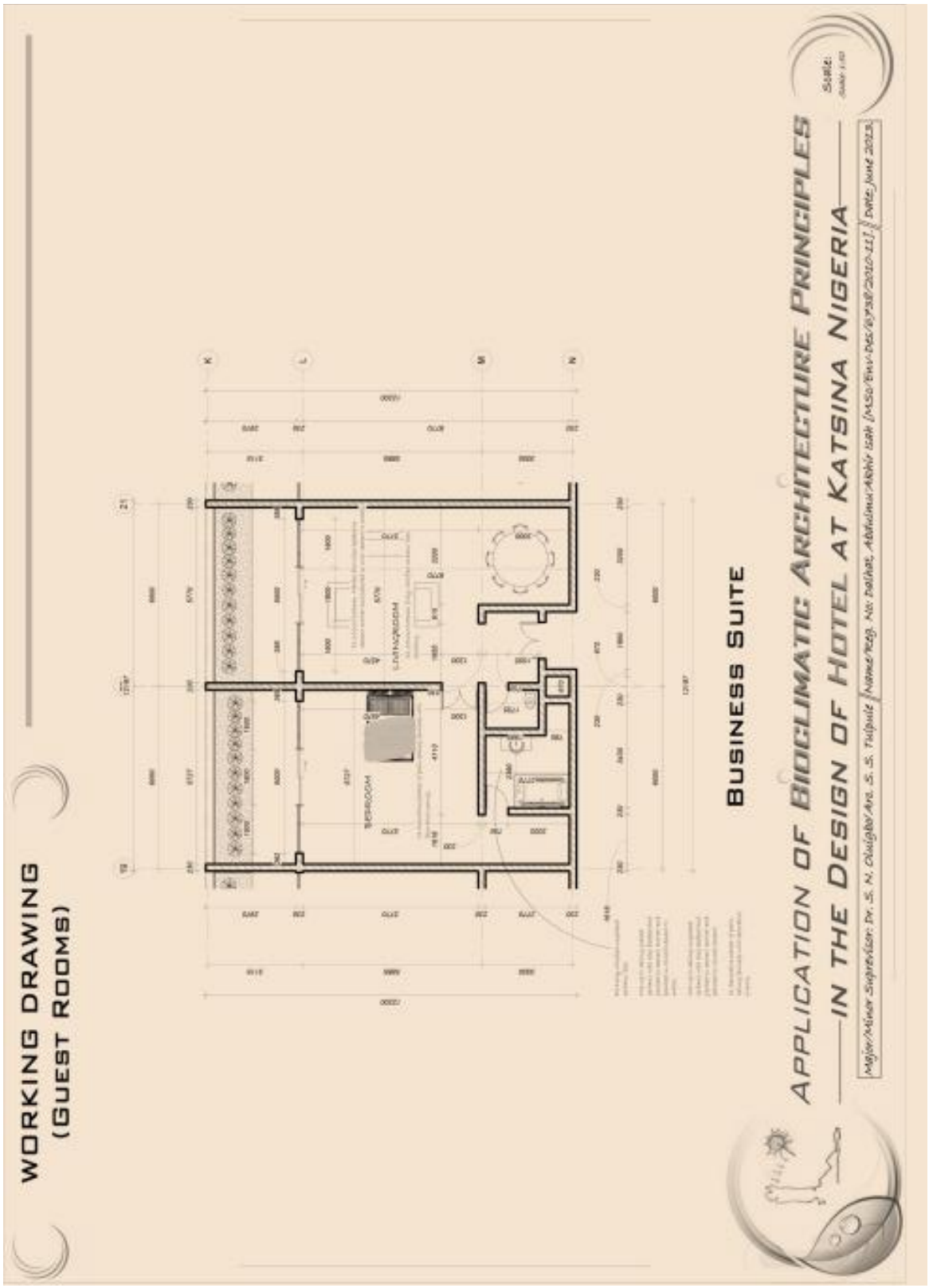



**Figure VIII** Guest Rooms lay-out (Business Suite)

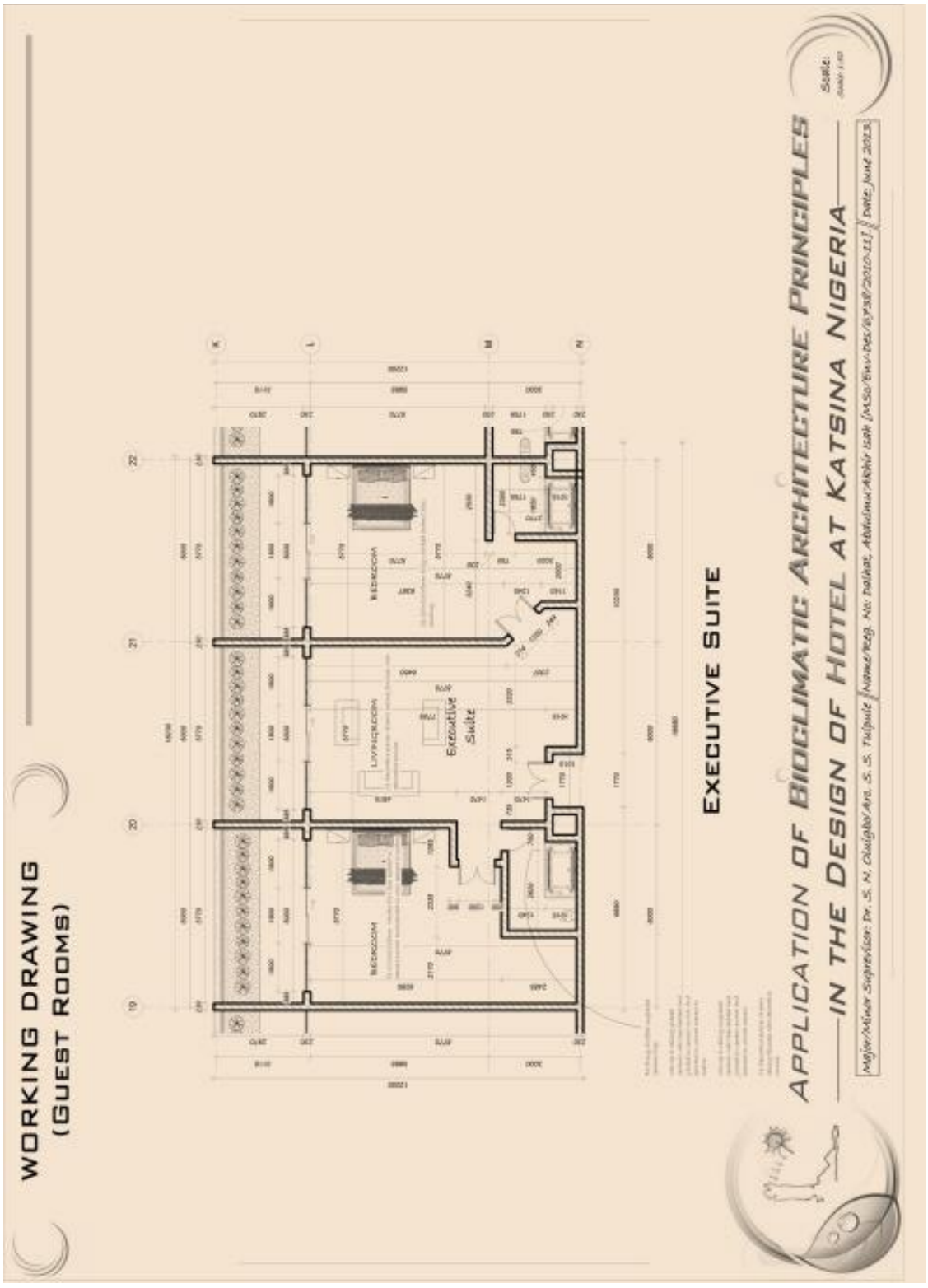



**Figure IX** Guest Rooms lay-out (Executive Suite)

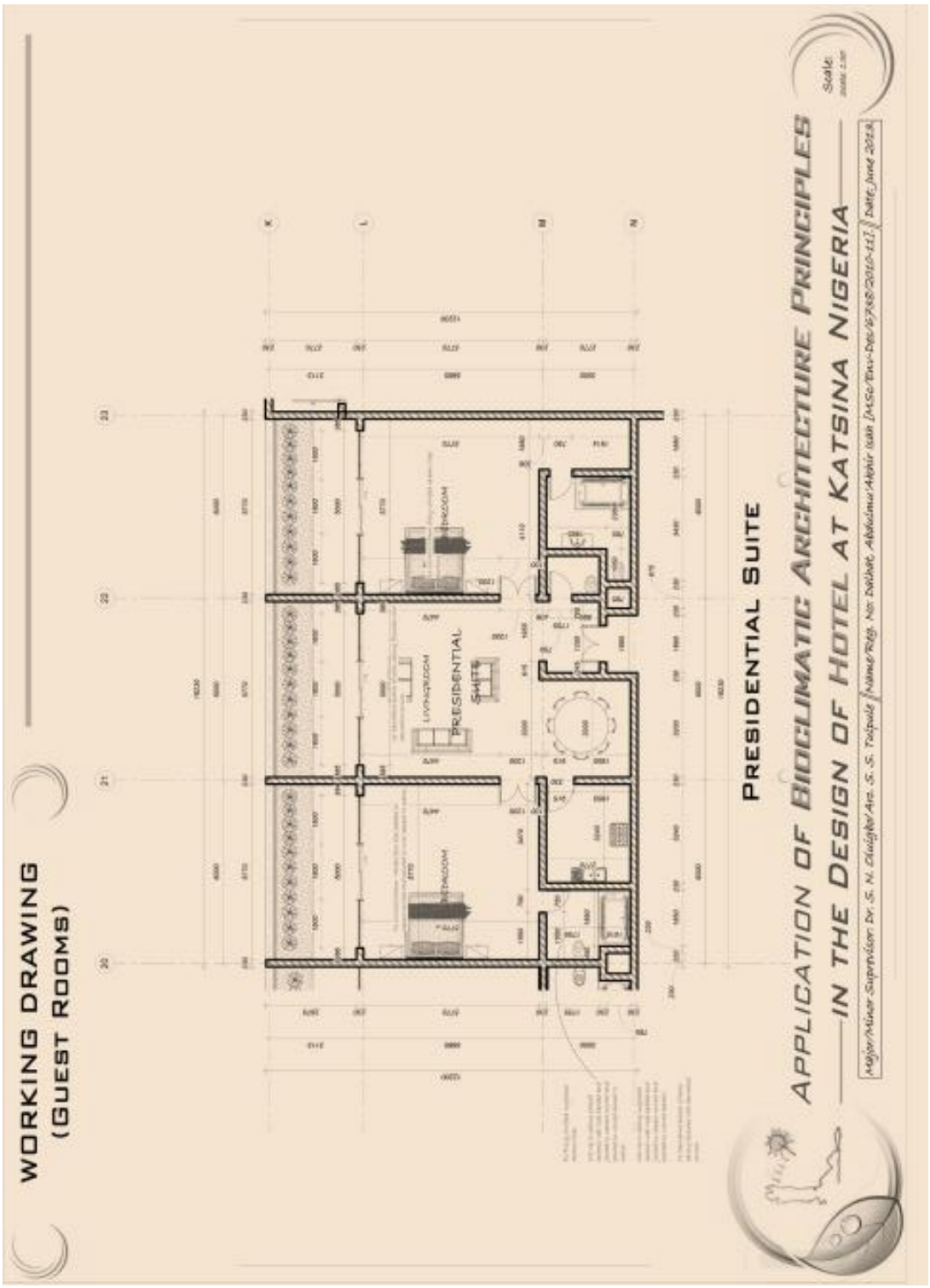



**Figure X** Guest Rooms lay-out (Presidential suite)

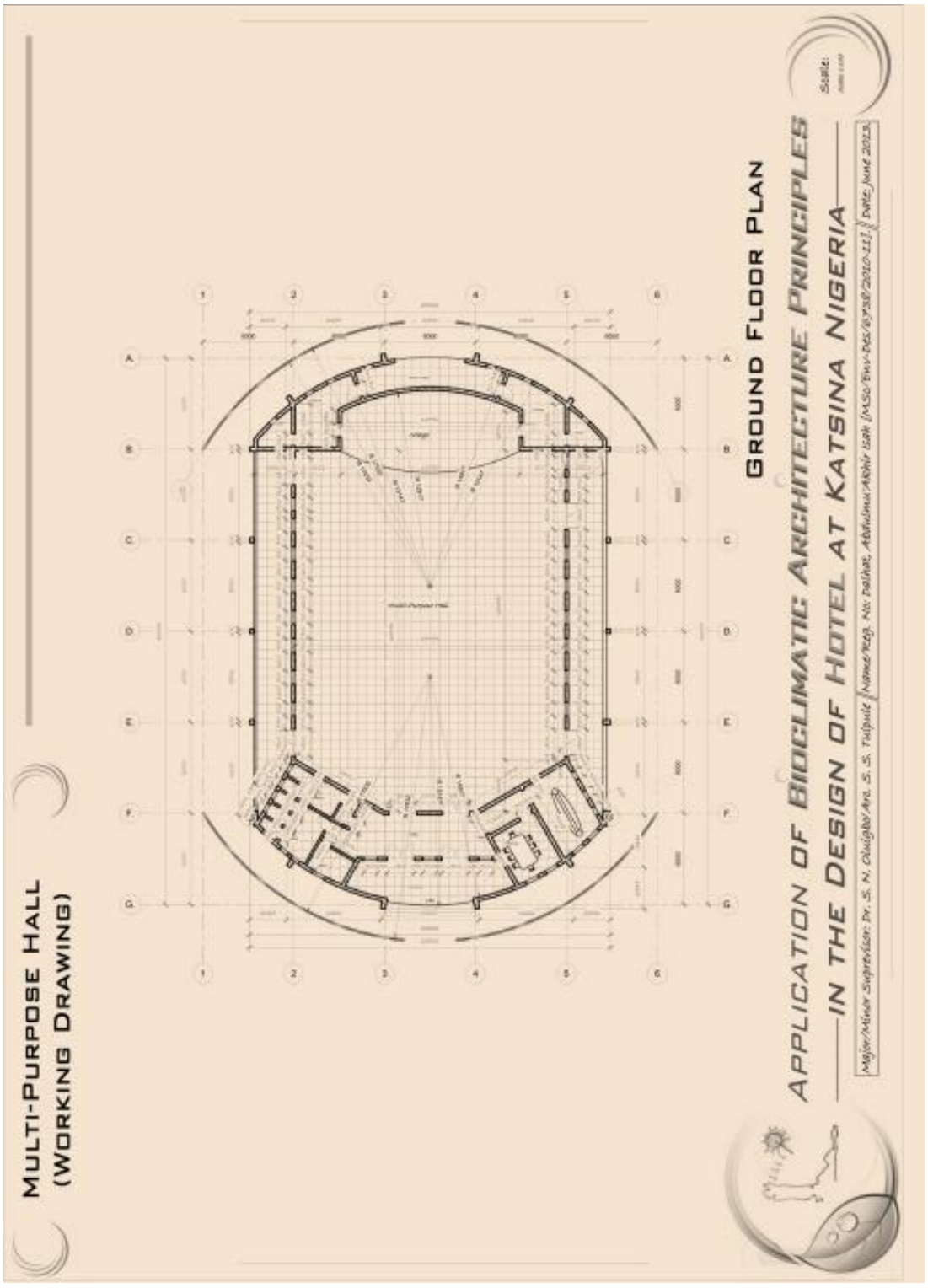



**Figure XI** Floor Plan (Multi-Purpose Hall)

**Figure XII** Multi-Purpose Hall Elevations

**Figure XIII** Multi-Purpose Hall Sections

**Figure XIV** Section Details I

**Figure XV** Section Details II



**Figure XVI** Perspective View Showing the Main Hotel & Multi-Purpose Hall



**Figure XVII** Perspective View Showing the Main Hotel