BIOCLIMATIC ARCHITECTURE IN THE DESIGN OF A SECONDARY SCHOOL, UGWUOMU, ENUGU STATE.

BY

OKPE DIAMOND
GOU/U22/ARC/180

DEPARTMENT OF ARCHITECTURE,
FACULTY OF NATURAL SCIENCE AND ENVIRONMENTAL STUDIES,
GODFREY OKOYE UNIVERSITY, ENUGU.

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A REPORT PRESENTED TO THE DEPARTMENT OF ARCHITECTURE. GODFREY OKOYE UNIVERSITY FOR THE DEGREE OF BACHELOR SCIENCE (B.Sc.) IN ARCHITECTURE.

SUPERVISOR: ARC CHUKWUCHINECHETAM

JULY 2026.

APPROVAL

Okpe Diamond, Registration number GOU/U22/ARC/180, A student of the department of Architecture, Faculty of Natural Sciences, and Environmental Studies, of Godfrey Okoye University, Enugu has satisfactorily completed the requirements for the course and research work for the award of bachelor of science (B. Sc) Degree in Architecture.

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Arc Chukwu	**Signature**	**Date**
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CERTIFICATION

I certify that this dissertation has been prepared under my constant supervision in the department of architecture, Godfrey Okoye University, Enugu.

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(Student)		

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Arc Chukwuchetam	**Signature**	**Date**
(Supervisor)		

DEDICATION

This project is dedicated to Almighty God for his endless grace, wisdom, strength, and guidance throughout my academic journey. I am grateful for his fatefulness and for making the successful completion of this work possible. To him alone be all the glory

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First and foremost, I return all glory, honor, and praise to Almighty God, the Author and Finisher of my faith, for His immeasurable grace, mercy, unfailing love, wisdom, strength, protection, and divine guidance throughout my academic journey. His faithfulness has been my source of hope during difficult times, my strength in moments of weakness, and my light through every challenge. I am deeply grateful for the gift of life, good health, knowledge, and the opportunity to complete this project successfully. Indeed, without Him, this achievement would not have been possible.

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TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study explores the application of bioclimatic architectural principles in the design of a co-educational day secondary school for 900 students in Ugwuomu Nike, Enugu East Local Government Area, Enugu State, Nigeria. The research addresses the critical gap in climate-responsive educational infrastructure in Nigeria, where conventional school designs produce thermally uncomfortable environments, excessive dependence on mechanical cooling, and diminished student performance. Drawing from a comprehensive literature review, six case studies (three foreign and three local), and detailed site analysis, the study develops an evidence-based design proposal integrating passive design strategies with the specific climatic conditions of the study area. The methodology combines qualitative descriptive research with direct observation of existing school buildings and physical survey of the proposed site at Godfrey Okoye University Farm. Climate data analysis reveals a tropical savanna climate (Köppen Aw) with temperatures from 25°C to 35°C, high humidity (40–85%), and significant solar radiation, demanding strategies centred on natural ventilation, solar shading, and thermal comfort. The design concept. "The Open Book" translates educational symbolism into a functional Y-shaped campus that channels prevailing south-westerly winds through classroom blocks oriented east-west to minimise solar heat gain. Key bioclimatic strategies include: raised roof ventilation gaps inspired by Gando Primary School; cross-ventilation through louvred windows on opposite walls; horizontal and vertical shading devices calculated for latitude 6.47°N; 3.5-metre ceiling heights for hot air stratification; and strategic landscape planting with indigenous tree species. The study demonstrates that passive design can eliminate the need for mechanical air conditioning while creating comfortable, energy-efficient, and symbolically meaningful educational spaces. It contributes to Nigerian architectural knowledge by providing a replicable, site-specific model for climate-responsive school design and recommends policy integration of bioclimatic criteria into public school construction standards.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The increasing concern for energy consumption, environmental sustainability, and user comfort has led to the development of climate-responsive design approaches in architecture. One of the most important of these approaches is bioclimatic architecture. Bioclimatic architecture is an approach to building design that considers the relationship between climate and the built environment in order to achieve thermal comfort for occupants (Olgyay, 2015). Bioclimatic architecture is derived from two key terms: “bio” and “climatic”. The term “bio” refers to life or living organisms, particularly humans and their interaction with the environment, while “climatic” relates to the prevailing weather conditions of a particular area, including temperature, humidity, solar radiation, and wind patterns. Together the term “bioclimatic architecture” refers to a design approach that considers the relationship between living organisms and climatic conditions in order to create comfortable and energy-efficient buildings (khahro *et al*., 2021). In tropical regions such as Enugu, buildings are often exposed to high temperatures, intense solar radiation, and seasonal wind variations, which significantly affect indoor comfort (Okonkwo & Chinonso, 2020). Bioclimatic strategies such as proper building orientation, cross ventilation, shading devices, thermal insulation, and landscape design can significantly improve the indoor environmental quality of school buildings (Adebayo, 2020; Munonye *et al*., 2023).

Education is a fundamental pillar of national development, contributing significantly to social, economic, and technological growth (UNESCO, 2022; World Bank, 2020). It is structured into different levels, including primary, secondary, and tertiary education (Federal Ministry of Education, 2019). Among these, secondary education plays a crucial role as it serves as a transitional stage between basic education and higher learning, shaping students’ intellectual abilities, social behaviour, and future career paths (UNICEF, 2021). Secondary schools are composed of various functional spaces such as classrooms, laboratories, libraries, administrative offices, assembly halls, and recreational areas. These facilities must be properly designed to provide a conducive learning environment that supports both academic and extracurricular activities. However, many school buildings in Nigeria are designed without proper consideration of climatic factors, leading to overheating, poor ventilation, and excessive reliance on mechanical systems such as fans and air conditioners (Agboola *et al*., 2022).

The integration of bioclimatic principles into secondary school design is essential for creating conducive learning environments, particularly in regions with challenging climatic conditions. (Adunola, 2021) emphasized that the quality of the indoor environment especially temperature, ventilation, and lighting has a direct impact on occupants' comfort and productivity. In warm-humid climates like Enugu, high temperatures, humidity, and solar radiation can negatively affect students' concentration and performance if not properly addressed. Bioclimatic strategies such as proper orientation, cross ventilation, shading devices, and landscaping can significantly enhance indoor environmental quality.

Recent studies have also shown that poorly designed school environments can lead to discomfort, reduced concentration, and lower academic performance, while well-ventilated and naturally lit spaces improve students' health and learning outcomes (Munonye, 2021). Despite these benefits, many secondary school buildings in Nigeria still rely on conventional design approaches that neglect climatic responsiveness, resulting in increased dependence on artificial cooling and lighting systems.

Therefore, this study seeks to explore the application of bioclimatic architectural principles in the design of a secondary school complex in Ugwuomu.

1.2 Statement of the Problem

Despite the benefits of bioclimatic architecture, its application in the design of secondary schools in Nigeria remains limited. Most of the existing school buildings in the study area rely heavily on conventional design approaches that do not adequately respond to climatic conditions. This results in uncomfortable learning environments and increased dependence on artificial cooling systems, which may not be sustainable or affordable.

1.3 Aim and Objectives of the Study

Aim

This study aims to apply bioclimatic architectural principles in the design of a secondary school complex in Ugwuomu, with the goal of creating a comfortable and sustainable learning environment.

Objectives

1.To Identify bioclimatic architecture principles relevant for the design of a secondary school.

2.To examine the concept of bioclimatic architecture in existing secondary schools.

3.To analyze the effects of building orientation, shading, and natural ventilation on thermal comfort

4.To apply bioclimatic design principles in the architectural design of a secondary school complex.

1.4 Research Questions

1 Are there any application of bioclimatic architecture in existing secondary school??

2.How does orientation, shading, and ventilation affect indoor environmental quality?

3.How can bioclimatic principles be applied in the design of a secondary school complex in Ugwuomu, Enugu?

1.5 Significance of the Study

This study highlights the importance of climate-responsive design in improving the quality of educational buildings. The findings will help architects and designers understand how to incorporate bioclimatic principles into school design to achieve better thermal comfort and energy efficiency.

The study will also contribute to improving learning environments for students by creating more comfortable classrooms, which can enhance academic performance. Additionally, it will serve as a reference for future research on sustainable and climate-responsive architecture in Nigeria.

1.6 Scope and Delimitation

Scope

This study focuses on the application of bioclimatic architectural principles in the design of a secondary school complex in Ugwuomu. It will consider factors such as building orientation, natural ventilation, shading devices, and landscaping. The study is limited to architectural design strategies and does not cover detailed structural or mechanical system design. It will also focus specifically on secondary school buildings and may not fully address other building types.

1.7 Definition of Special Terms

1.Bioclimatic Architecture: A design approach that responds to local climate conditions to improve indoor comfort.

2.Thermal Comfort: A condition in which occupants feel satisfied with the surrounding temperature.

3.Natural Ventilation: The movement of air through a building without mechanical systems

4.Shading Devices: Architectural elements used to reduce heat gain from sunlight.

5.Building Orientation: The positioning of a building in relation to sun and wind direction.

CHAPTER TWO

LITERATURE REVIEW AND CASE STUDIES

2.1 Introduction

This chapter reviews existing knowledge and real-life examples that are relevant to the design of a bioclimatic secondary school in Ugwuomu, Enugu State. It covers what bioclimatic architecture means and how it works, the design strategies used to keep buildings cool in hot and humid climates, the link between building comfort and how well students learn, and the design requirements for secondary schools in Nigeria. After the literature review, six case studies are presented and analysed, three foreign and three local. Each case study is examined for its design features, strengths, weaknesses, and what lessons it offers for this project. The chapter ends with a summary of the key points that will guide the design in later chapters.

2.2 Review of Related Literature

2.2.1 What is Bioclimatic Architecture?

Bioclimatic architecture is a way of designing buildings that takes the local climate into account so that people inside are comfortable, energy use is reduced, and the building fits well into its natural surroundings. The idea was first properly explained by architect Victor Olgyay in 1963, when he argued that buildings should be designed by first studying the local climate and then shaping the building to work with natural forces like sun, wind, and rain rather than fighting against them (Hyde, 2018; Givoni, 2016).

The main idea behind bioclimatic architecture is that the walls, roof, windows, and openings of a building act as a filter between the outside weather and the inside environment. If these elements are designed well, they can keep the inside cool in hot weather, well-lit without glare, and well-ventilated without electric fans or air conditioners. According to Ness *et al*. (2019), this approach encourages the use of free natural resources; sun, wind, and shade, before turning to any energyconsuming systems. This is especially important in tropical regions like southeastern Nigeria, where high temperatures and humidity make thermal comfort a major challenge in buildings (Emmanuel, 2017; Pan *et al*., 2024).

Researchers have continued to develop and test bioclimatic design principles in tropical countries. Recent studies, including one published in the MDPI Journal of Sustainability (2025) based on Cambodia's tropical climate, showed that when architects apply orientation, ventilation, and shading strategies using a structured design guide, the indoor temperature and comfort of buildings improve significantly. Similar research in Burkina Faso, a West African country with a hot climate similar to Nigeria's, also confirmed that passive strategies like natural ventilation and smart window design can reduce the need for cooling energy in school and office buildings (ScienceDirect, 2023).

2.2.2 Passive Design Strategies for Hot and Humid Climates

Passive design strategies are design decisions that use the shape, materials, and layout of a building to control indoor conditions without using electricity or machines. In hot and humid climates like that of Enugu State, the most important passive strategies are: building orientation, natural cross-ventilation, solar shading, daylighting, thermal mass, and landscape design (Ojo & Adebayo, 2019; Hyde, 2018).

Building orientation means deciding which direction a building faces on its plot. In tropical regions, buildings should be positioned so that their longest walls face north and south, not east or west. This reduces the amount of direct sunlight hitting the windows and walls, which in turn reduces heat inside the building. A study by Adesanya and Adeyemi (2022) on school buildings in southwestern Nigeria found that classrooms oriented correctly were up to 4°C cooler than those facing east or west during the hottest part of the day, without any cooling equipment.

Natural ventilation means using wind or air movement to cool the inside of a building without fans or air conditioners. The most effective type is cross ventilation, which is achieved by placing openings on opposite walls so that the wind blows straight through the building. Low-level openings let cool air in, while high-level openings or vents let hot air escape near the ceiling. Research by Nwosu and Ezema (2020) on school buildings in southeastern Nigeria showed that classrooms with proper cross-ventilation had better air quality and lower temperatures than those with only one-sided ventilation, even in the same climate. The stack effect is another way to ventilate buildings naturally: since hot air is lighter than cool air, it rises and escapes through high openings like clerestory windows or raised roof vents, pulling fresh air in from below.

Solar shading devices are features added to a building to block direct sunlight from entering through windows and heating the inside. These include overhanging roof edges, horizontal shelves above windows, vertical fins on walls, louvred screens, and deep verandas. A study by Okonkwo and Ibekwe (2021) found that adding correctly sized horizontal overhangs above south-facing classroom windows in Enugu reduced solar heat gain by about 35% during the dry season, making classrooms noticeably more comfortable.

Daylighting means using natural sunlight to light the inside of a building instead of electric lights. In school buildings, good natural light is important because students need to be able to read and write comfortably without strain. The goal is to get enough natural light into every part of the classroom, without causing glare on books or boards. This can be achieved through the careful sizing and positioning of windows, the use of clerestory windows near the top of walls, and light-coloured interior surfaces that reflect daylight deeper into the room (Adeyemi & Balogun, 2020).

Thermal mass refers to the ability of a building material to absorb, store, and release heat slowly. In a hot and humid climate like Enugu's, this works best when combined with good night ventilation: heavy materials like concrete or brick absorb heat during the day, and at night, when the air is cooler, ventilation removes the stored heat before the next day begins (Givoni, 2016; Hyde, 2018).

Trees and plants around a building can also significantly reduce heat. They shade walls and roofs from direct sunlight, release moisture through their leaves which cools the surrounding air, and can be positioned to direct wind towards building openings. A study by Akinsola *et al*. (2022) found that planting large trees on the east and west sides of school buildings in Nigeria's humid tropical zone reduced surface temperatures on those walls by up to 6°C, improving the indoor environment without any energy cost.

2.2.3 Indoor Comfort and Student Performance

Many studies have shown a direct link between how comfortable a school building is and how well students learn. Indoor environmental quality (IEQ) includes thermal comfort (how hot or cool it feels), air quality, natural light, and noise levels. Each of these affects how well students can concentrate, how healthy they feel, and how often they attend school (Ibrahim & Musa, 2021; Okeke & Onyema, 2022).

When classrooms are too hot, students find it hard to concentrate and often feel tired and restless. A 2022 report by the World Green Building Council reviewed over 100 schools in tropical regions and found that improving classroom thermal comfort through passive design led to measurable improvements in student performance, including better scores in reading and mathematics.

Poor ventilation also causes problems. When classrooms are not well ventilated, carbon dioxide and moisture build up in the air, making students feel drowsy, giving them headaches, and reducing their ability to focus. Research by Nwosu and Ezema (2020) in Nigerian secondary schools found that poorly ventilated classrooms regularly exceeded safe carbon dioxide levels, even during normal lessons, while well-ventilated classrooms remained within healthy limits throughout the school day.

Natural light has also been shown to improve student concentration, reduce eye strain, and support healthy sleep patterns. A study by Abdullahi and Musa (2023) in Nigerian secondary schools found that students in classrooms with good natural lighting performed better academically than those in darker classrooms, which is consistent with findings from research in other tropical countries (Adeyemi & Balogun, 2020).

2.2.4 Design Standards for Secondary School Buildings in Nigeria

The Federal Ministry of Education of Nigeria has set out guidelines for how secondary school buildings should be designed. These are contained in the Universal Basic Education (UBE) School Building Specifications and the National Policy on Education (Federal Ministry of Education, 2020). These documents specify minimum classroom sizes, window requirements, ventilation standards, and the facilities that a complete secondary school should have.

According to these guidelines, a standard classroom should hold between 35 and 40 students, with a minimum floor area of about 56 square meters. Windows should cover at least 20% of the floor area to allow adequate natural light and ventilation. Ceiling heights should be at least 3.0 meters, though heights of 3.5 to 4.0 meters are recommended in tropical climates because higher ceilings allow hot air to rise away from students and improve ventilation (FME, 2020; Okonkwo & Ibekwe, 2021).

Science laboratories need direct outdoor ventilation for chemical areas, non-porous work surfaces, and access to water. Library spaces need controlled light to prevent glare. Assembly halls need large, well-ventilated spaces with good acoustics. These specific requirements will all be addressed in the design brief and accommodation schedule in Chapter Five of this report.

Nduka and Ugwu (2021) argued that if passive design strategies were made a standard part of public-school building design in Nigeria, it would greatly reduce electricity bills for schools, improve comfort for students and teachers, and make buildings last longer by reducing wear on mechanical equipment. This study agrees with that position and aims to contribute a specific, climate-appropriate school design for the Enugu State context.

2.2.5 Bioclimatic Architecture in Nigeria and West Africa

Research on bioclimatic design in Nigeria and West Africa has grown in the past ten years, driven by rising energy costs, climate change, and the need for more sustainable buildings. Several researchers have studied traditional Nigerian building types to understand how they managed to stay cool without modern technology. For example, the traditional Igbo compound house (obi) in southeastern Nigeria uses a central courtyard to pull air through the building: cool air enters at the lower parts of the courtyard while hot air rises and escapes upward through convection. The deep overhangs and thatched roofs of traditional structures also shaded the walls and kept indoor temperatures comfortable throughout the year (Ezema & Olotuah, 2020).

These traditional design principles; courtyard ventilation, sheltered walkways, raised floors, and deep overhangs are directly relevant to the proposed school in Ugwuomu and offer locally proven bioclimatic solutions that can be adapted into a modern school design.

In more recent research, a study by Akinola (2020) evaluated school buildings in Enugu State and found that schools with south-facing classrooms, horizontal overhangs, louvred windows, and planted buffer zones consistently had better indoor conditions than schools without these features. The study recommended that passive design criteria should be made a compulsory part of all publicly funded school building projects in Enugu State. A separate study by Akinsola *et al*. (2022) in southwestern Nigeria also showed that combining natural ventilation, shading devices, and landscape planting reduced peak classroom temperatures significantly in the humid tropical zone. Both studies directly support the design approach of this project.

2.3 Case Studies

This section presents six case studies relevant to the design of a bioclimatic secondary school in Ugwuomu, Enugu State. Three are from other countries (foreign) and three are from Nigeria (local). Each case study includes a basic information table, an overview of the project and its design features, a list of merits and demerits, and an explanation of why it is relevant to this project.

2.3.1 Foreign Case Study 1: Gando Primary School, Burkina Faso

Location	Gando Village, Boulgou Province, Burkina Faso, West Africa
Year of Commissioning	2001
Architect	Diébédo Francis Kéré (Kéré Architecture)
Type	Public Primary School; 3 Classrooms; Co-educational
Award	Aga Khan Award for Architecture, 2004

Overview

Gando Primary School was designed by Burkina Faso-born architect Francis Kéré to solve the problem of poor lighting and ventilation in school buildings in his home village. Burkina Faso is a hot, dry country in West Africa, and the existing school buildings were extremely uncomfortable for students and teachers. Kéré used simple materials and a clever design to create classrooms that stay cool without any electricity or air conditioning (Kéré Architecture, 2001; Dezeen, 2025).

The school has three rectangular classrooms connected under one large roof. The most important design feature is the raised roof: instead of sitting directly on the walls, the roof is lifted above the ceiling on a steel frame, leaving a continuous gap all around the top of the building. Hot air that builds up inside rises through holes in the clay brick ceiling and escapes through this gap, while cool air enters through louvred windows at the bottom of the walls. This creates a constant natural airflow that keeps the classrooms cool even in the intense West African heat (ArchDaily, 2016; Pritzker Architecture Prize, 2022).

The walls and ceiling are made from compressed earth blocks produced by villagers from local clay mixed with a small amount of cement. These blocks are strong, easy to make on site, and their thickness helps absorb heat during the day and release it slowly at night. The roof extends well beyond the walls on all sides, shading the walls from rain and direct sunlight, and creating covered outdoor spaces that students use for outdoor learning and socialising (Pritzker Architecture Prize, 2022; Earth Architecture, 2024).

The entire school was built with the help of the local community, who contributed their labour and local knowledge. This made the project affordable and ensured the building matched the needs of the people who use it. After the school opened, student numbers grew from 120 to 700, leading to the construction of teacher housing, a school extension, and a library on the same site.

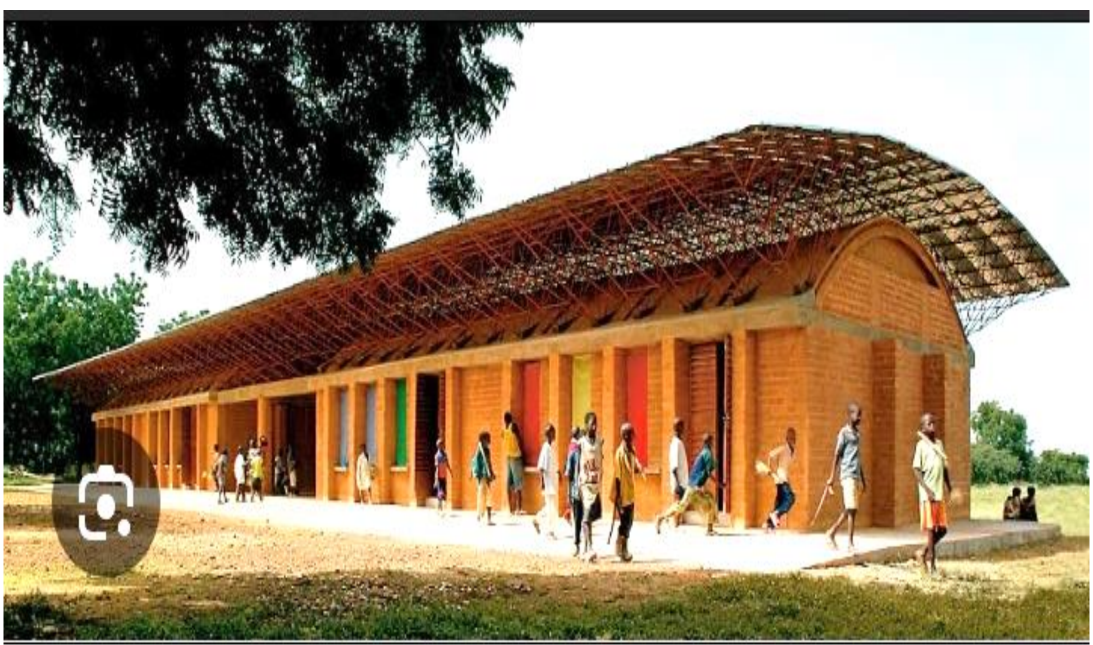


Figure e 2.1: Showing the 3d view (**source:** google)

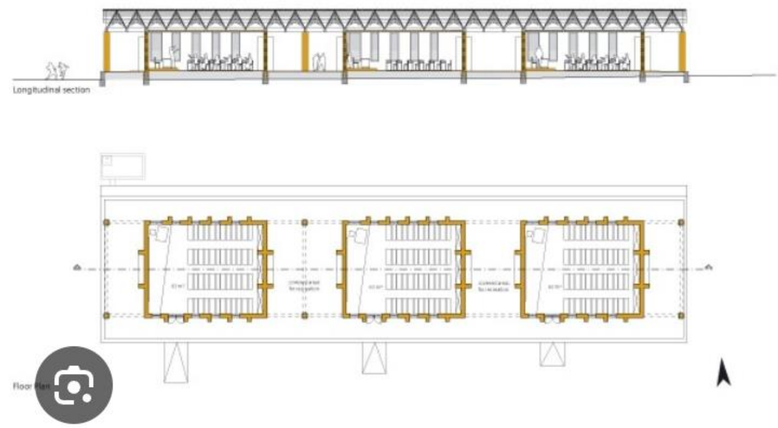


Figure 2.2 Showing floor plan and section (**Source:** google)

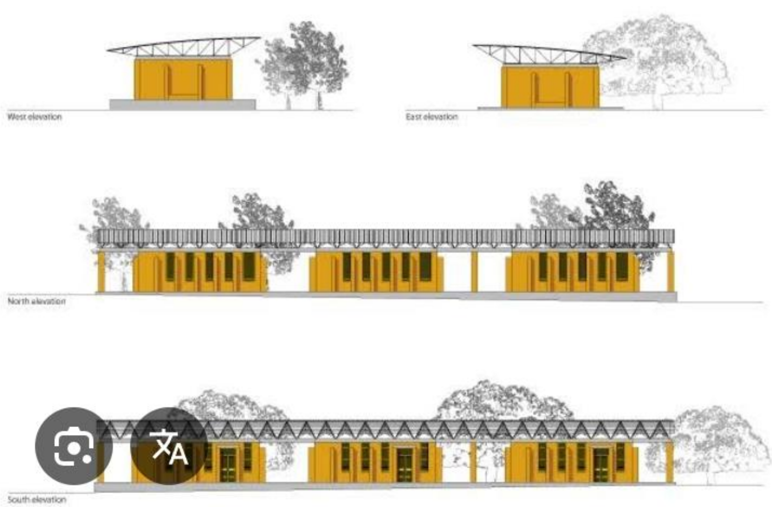


Figure 2.3 Showing elevations (**Sources:** google)

Merits

- The raised roof with a ventilation gap is a simple, but very effective way to keep classrooms cool in a hot climate without using any energy.
- The use of locally made compressed earth blocks shows that traditional materials can perform well as bioclimatic building elements and reduces construction costs.
- The wide overhanging roof shades all walls and creates useful covered outdoor spaces.

- Building the school with community participation is a good model for affordable, locally appropriate school construction.

Demerits

- The building was designed for a small primary school with simple spaces. Adapting it for a larger, more complex secondary school programme requires significant changes.
- Compressed earth blocks work well in the dry Sahelian climate of Burkina Faso, but in the wetter climate of southeastern Nigeria, they would need extra protection from rain and moisture.
- The single roof form over three classrooms limits the variety of spaces that can be designed.

Relevance to the Proposed Project

This project is very relevant because both Burkina Faso and Enugu State are in tropical West Africa and face similar challenges of heat and solar radiation. The ventilation strategy, using a raised roof with a gap, low-level air inlets, and high-level air outlets can be adapted for the classrooms and laboratories of the proposed school in Ugwuomu. The project also shows how locally available materials like sandcrete blocks, laterite, and timber in the Enugu context can be used to build a thermally comfortable school without expensive imported materials. The community-based approach is also a good inspiration for the proposed project.

2.3.2 Foreign Case Study 2: Green School Bali, Indonesia

Location	Jalan Raya Sibang Kaja, Abiansemal, Bali, Indonesia
Year of Commissioning	2008 (with ongoing expansion)
Founder/Designer	John & Cynthia Hardy; PT Bambu Pure / Ibuku Architecture
Type	Private International School (Pre-school to Secondary); Co-educational
Recognition	Widely recognised as a global model of sustainable school design

Overview

Green School Bali is a private international school built in a forested area on the outskirts of Ubud, Bali, Indonesia. It was founded in 2008 by John and Cynthia Hardy with the goal of creating a school that teaches students to care for the environment, while also demonstrating that sustainable, eco-friendly buildings can provide excellent spaces for learning (Wikipedia, 2026). Bali has a hot and humid tropical climate that is very similar to Enugu State's, with high temperatures, high rainfall, and high humidity throughout the year.

Every building on the campus is made from bamboo, a fast-growing natural material that local Balinese craftspeople have used for centuries. The campus has over 70 large bamboo structures, including classrooms, a library, offices, sports facilities, and social spaces (Hotels.com, 2024). The most iconic building is called the "Heart of the School” a 60metre long, three-storey structure on bamboo stilts, with a sweeping thatched roof and deep overhangs that protect the open interior from rain while allowing the wind to blow through freely (Designboom, 2012).

The buildings are designed to be as open as possible, with no walls on some sides, allowing natural breezes to ventilate all spaces without any fans or air conditioning. The bamboo structure and thatched roof are lightweight, which means the buildings do not store up heat during the day in the same way that thick concrete walls do. The campus is also surrounded by rice fields, gardens, fish ponds, and trees that cool the air around the buildings through shade and moisture (Wikipedia, 2026; ResearchGate, 2018).

In addition to the buildings, the school generates its own electricity from a small hydroelectric generator on the nearby Ayung River and from solar panels. It also uses composting toilets and collects rainwater, making it a very complete example of sustainable school design. More recently, a new learning hub called the "Living Bridge" designed partly by students has been added to the campus, continuing to push the boundaries of what eco-friendly architecture can look like (Parametric Architecture, 2025).

Figure 2.4 Showing the perspective (**Sources:** google)

Figure 2.5 Showing interior perspective (**sources:** google)

Merits

- The open-sided bamboo buildings gets excellent natural ventilation and thermal comfort in a hot and humid tropical climate without any mechanical cooling systems.

- Connecting the school buildings with the surrounding landscape creates a rich and exciting learning environment that supports both academic learning and environmental awareness.
- Bamboo sequesters carbon as it grows, making the school one of the most environmentally friendly educational buildings in the world.
- The school is a globally recognized example that sustainable bioclimatic design can produce high-quality educational spaces in tropical climates.

Demerits

- The school is privately funded and serves fee-paying international students. The cost of bamboo construction by specialized craftspeople makes it impossible to replicate directly in a public-school context in Nigeria.
- The fully open-sided building design offers limited security and may be inadequate in areas with very heavy seasonal rain, strong winds, or security concerns, all of which are relevant in some Nigerian settings.

Relevance to the Proposed Project

Although Green School Bali cannot be copied directly in Ugwuomu due to differences in budget, materials, and programme, it offers several useful lessons. The idea of creating deep verandas, shaded walkways, and semi-open classroom spaces that blur the line between indoors and outdoors is practical and relevant to the proposed school. The school also shows the importance of designing the whole site as a system, where buildings, trees, water, and open spaces all work together to create a comfortable microclimate. This site-wide thinking about passive design will inform the site planning and landscape strategy of the proposed school.

2.3.3 Foreign Case Study 3: Panyaden International School, Chiang Mai, Thailand

Location	Hang Dong District, Chiang Mai Province, Thailand
Year of Commissioning	2011 (campus); Bamboo Sports Hall completed 2017
Architect	Chiangmai Life Architects (CLA) and 24H Architecture (Netherlands)
Type	Private International School (Primary to Secondary); Co-educational
Recognition	Shortlisted, World Architecture Festival 2018 (Sport Category)

Overview

Panyaden International School is located among rice fields on the edge of Chiang Mai, Thailand. The school combines a strong academic programme with Buddhist values and a deep commitment to environmental responsibility. The entire campus was designed and built using only natural materials, mainly bamboo and compressed earth to keep students close to nature and to show that natural materials can be used to create beautiful, high-performing school buildings (Dezeen, 2017; Stirworld, 2022). Chiang Mai has a hot and humid tropical climate with a strong rainy season, making it climatically similar in many ways to Enugu State.

The campus was first designed by Dutch architects 24H Architecture, and then Chiangmai Life Architects (CLA) took over and built the rest of the campus, including a celebrated Bamboo Sports Hall completed in 2017 (Stirworld, 2022; ArchDaily, 2021). All buildings are kept low and are integrated with gardens, water features, and planted spaces between them. The secondary school buildings are arranged in small clusters, or "pods", each one oriented and detailed for natural ventilation and shading.

The Bamboo Sports Hall is the most technically impressive structure on the campus. It was inspired by the shape of the lotus flower and spans 782 square metres, large enough for 300 students and courts for basketball, volleyball, badminton, and futsal (ArchDaily, 2021; Designboom, 2017). The entire hall is built from treated bamboo with no steel reinforcements. Seventeen-meter-long bamboo trusses span the full width of the hall. The sides of the hall are open with adjustable bamboo screens, allowing free airflow to keep the space comfortable during physical activity. Hot air rises through the peak of the high bamboo roof and escapes naturally, creating a stack-effect ventilation system similar to that at the Gando Primary School. The carbon footprint of the Sports Hall is zero because the bamboo absorbed more carbon while growing than was released during its treatment and construction (CLA, 2022).

The whole Panyaden campus has a negative carbon footprint, meaning it absorbs more carbon from the atmosphere than it produces. This is a remarkable achievement for an active school and demonstrates what is possible when bioclimatic design is applied consistently across an entire campus.

Figure 2.6 showing the perspective (**sources:** google)

Merits

- The Sports Hall shows that a large, open structural space can be built entirely from bamboo with zero carbon footprint while still providing excellent natural ventilation and comfort.
- The pod-cluster layout of the secondary school buildings, each oriented and shaded individually for passive performance, is a flexible and effective spatial organization model for a tropical school campus.
- The school demonstrates that it is possible to build a complete secondary school with a full sports and assembly facility in a hot and humid tropical climate using only natural materials and passive design.
- The design embeds the school's educational values, respect for nature, sustainability directly into the architecture, creating a building that teaches as well as shelters.

Demerits

- Like Green School Bali, Panyaden is a private school, and the specialized bamboo construction requires skilled craftspeople and material treatment processes not available in the Nigerian construction industry.
- Maintenance of bamboo structures requires ongoing specialist attention that may be difficult to sustain in a public-school context in Nigeria.

Relevance to the Proposed Project

Panyaden International School is one of the most directly relevant foreign case studies for this project because it is a complete secondary school campus designed for a hot and humid tropical climate. The pod-cluster arrangement of classrooms grouped around shared outdoor courtyards is a useful model for the spatial planning of the proposed school, as it promotes natural ventilation, creates a variety of communal and private spaces, and allows the school to grow in phases. The principle of designing each classroom block with its own specific orientation, overhanging roof, and ventilation strategy can be directly applicable to the proposed school. The Sports Hall's ventilation approach, open sides, a high-apex roof, adjustable screens is also a good precedent for the design of the proposed school's assembly hall.

2.3.4 Local Case Study 1: Federal Government College, Enugu

Location	Independence Layout, Enugu, Enugu State, Nigeria
Year of Commissioning	1973
Owner	Federal Government of Nigeria (Unity School)
Type	Co-educational Day and Boarding Secondary School (JSS 1 – SSS 3)
Student Population	Approximately 3,000 – 4,000 students

Overview

Federal Government College, Enugu (FGCE), widely known as "Fedi", is one of Nigeria's 104 federal unity schools. It was established in January 1973 by the Federal Government of Nigeria to bring together students from different parts of the country in a shared learning environment (Wikipedia, 2026; FGCEOSA, n.d.). The school is located on a large campus in Independence Layout, a residential part of Enugu city, and serves both boarding and day students from JSS1 through SSS3. It currently has about 3,000 to 4,000 students.

The campus has a wide range of facilities including three-storey classroom blocks, science laboratories, a modern library, administrative offices, technical workshops, specialized classrooms for Home Management, Fine Art, Business Education, and Music, dormitory blocks, sports fields, and staff quarters (FGCEnugu.sch.ng, n.d.). The classroom and administration blocks are reinforced concrete structures with louvred windows, built in the 1970s in a style that was common in government school construction during that era.

The buildings were generally positioned with east-west orientation to reduce solar exposure, but no detailed bioclimatic design strategy was applied in the original design. As a result, the lower floors of multi-storey classroom blocks tend to be poorly ventilated, especially where surrounding buildings block the wind. However, the campus is well planted with large, mature trees that shade many of the walkways, courtyards, and building facades, which helps to cool the outdoor and indoor environment considerably.

Figure 2.7 Showing the 3d view (**sources:** field work)

Merits

- The campus provides a complete, real-life example of the full range of facilities needed for a large Nigerian secondary school, including labs, workshops, library, assembly hall, dormitories, and sports facilities.
- The trees on the campus clearly show how much difference strategic landscape planting can make to the microclimate of a Nigerian school campus.
- The campus layout, with separate zones for academic, short-term accommodation, recreational, and administrative uses, is a useful reference for the spatial organization of the proposed school.

Demerits

- The three-storey classroom blocks were not designed with a proper bioclimatic strategy. Lower floor classrooms in particular suffer from poor natural ventilation and high solar heat gain through east and west facing windows.
- The buildings were designed based on the international architectural style of the 1970s rather than the requirements of the local Enugu climate, leading to uncomfortable indoor conditions that require electric fans and sometimes air conditioning to manage.
- Unplanned additions and extensions over the years have reduced air movement across the campus in some areas by blocking previously open corridors and courtyards.

Relevance to the Proposed Project

Federal Government College, Enugu is most useful to this project as a reference for the full list of facilities and spaces that a large secondary school in Enugu State needs. The school also serves as an example of what happens when bioclimatic design is left out of the original building design: the discomfort of the lower-floor classrooms contrasts sharply with the pleasant outdoor environment created by the campus trees, reinforcing the argument for a systematic, whole-building bioclimatic approach where orientation, ventilation, shading, and landscape are all designed together from the start.

2.3.5 Local Case Study 2: Queen's School, Enugu

Location	Annang street, Ogui new layout, Enugu State, Nigeria
Year of Commissioning	1954 (founded); developed over subsequent decades
Owner	Enugu State Government
Type	Government Girls' Boarding Secondary School (JSS 1 – SSS 3)
Student Population	Approximately 2,000 – 2,500 students

Overview

Queen's School, Enugu is one of the oldest and most respected girls' secondary schools in Nigeria. It was founded on 4 October 1954 by the Government of Eastern Nigeria as the only girls' government secondary school in the region at that time (NAAQSEUSA, n.d.). The original buildings were designed and constructed to high standards, with well-equipped science laboratories, a school library, a hall with a polished wooden floor, dormitory blocks, an administrative block, a home economics block, and sports grounds.

The older school buildings were designed in a style that, while not explicitly called "bioclimatic", naturally included several passive design features suited to the hot and humid Enugu climate. These include wide covered verandas that shade the windows and walls from direct sunlight, high-pitched roofs that create an insulating air layer above the ceiling, and large louvred windows that allow good cross ventilation in all classrooms and dormitories. The generous floor-to-ceiling heights of the original buildings also helped hot air to rise away from the occupants.

Over the decades, additional buildings have been constructed on the campus. Some of these newer additions, especially those built during periods of reduced government funding, were not designed with the same attention to passive environmental quality as the original buildings. Despite this, the campus remains relatively well planted with trees, and the original low-density, single-storey layout of the campus continues to allow good natural air movement across the site.

Figure 2.8 Showing the school building (**sources:** field work)

Merits

- The original colonial buildings are a locally proven example of passive bioclimatic strategies like verandas, high-pitched roofs, louvred windows, and generous ceiling heights that work well in the Enugu climate.
- The low-density campus layout keeps buildings well-spaced from each other, which helps wind to move freely across the site and through the buildings.

- The school provides a comprehensive functional reference for a full boarding girls' secondary school, including dormitories, a dining hall, a school hall, laboratories, library, and sports facilities.

Demerits

- Newer building additions to the campus were designed without following the passive design principles of the original buildings, leading to mixed environmental quality across the campus.
- Some dormitory blocks are overcrowded relative to their original design capacity, which reduces ventilation performance and indoor air quality for residents.
- Many of the original buildings are old and require significant maintenance and environmental improvement to meet modern comfort and safety standards.

Relevance to the Proposed Project

Queen's School, Enugu is a very relevant case study for this project because it is in the same climatic zone as the proposed school in Ugwuomu, and its original buildings demonstrate practical bioclimatic design strategies that are proven to work in the Enugu environment. The design features of the original buildings; wide verandas, louvred windows, high pitched roofs, and generous ceiling heights provide a locally tested reference that will directly inform the design of the classrooms, dormitories, and circulation spaces of the proposed school. The school also provides a useful functional reference for a full boarding secondary school programme.

2.3.6 Local Case Study 3: University of Nigeria Secondary School, Nsukka

Location	University of Nigeria Campus, Nsukka, Enugu State, Nigeria
Year of Commissioning	January 1983
Owner	University of Nigeria, Nsukka (UNN)
Type	Co-educational Day and Boarding Secondary School (JSS 1 – SSS 3)
Student Population	Approximately 1,500 – 2,000 students

Overview

The University of Nigeria Secondary School, Nsukka (UNSSN) was established in January 1983 as part of the University of Nigeria, Nsukka (UNN), Nigeria's first indigenous university (Edusko, n.d.; UNSSN, n.d.). It was set up mainly to serve the educational needs of the university community, but over time it has opened its doors to students from across Nigeria. The school is located at the entrance to the UNN Nsukka campus, about 80 kilometers north of Enugu, in the guinea savannah ecological zone.

Nsukka has a hot and humid tropical climate similar to that of Enugu and Ugwuomu, though the dry season is slightly more intense due to its position further north and its higher elevation. This makes UNSSN a particularly useful comparison for the proposed school, since the two sites face broadly similar climate challenges. The school's campus benefits greatly from being located within the large, well-planted UNN campus, which has extensive trees, open grassland, and a pleasant natural environment that keeps the area noticeably cooler than a typical urban school site (UNSSN, n.d.).

The school has a good range of facilities including modern classrooms, science laboratories, a library, sports complexes, and boarding facilities (UNSSN, n.d.). The buildings are mostly single to double-storey structures built from sandcrete blocks with louvred windows and metal or concrete roofs, typical of Nigerian institutional construction from the 1980s and 1990s. The generous spacing between buildings and the surrounding university landscape allow good natural airflow across the site, making the school environment considerably more comfortable than many urban Nigerian secondary schools that are more tightly developed.

Although the school was not designed with a formal bioclimatic brief, it performs reasonably well in terms of indoor comfort. This is largely because of the low density of the campus, the good natural ventilation that the spacing between buildings allows, and the cooling effect of the large

UNN campus landscape. The school has a strong academic record and is widely regarded as one of the better secondary schools in Enugu State.

Figure 2.9 showing perspective (**sources:** field work)

Merits

- The campus demonstrates the environmental benefit of generous landscape integration and low building density, even without a formally designed bioclimatic strategy.
- Being located within the UNN campus provides a good example of a secondary school that is embedded in a larger, well-planned landscape and institutional environment, similar to the way the proposed school will be embedded in the Ugwuomu community landscape.
- The school's full facilities programme, modern classrooms, laboratories, library, sports complex, and boarding provide a locally grounded and up-to-date reference for the proposed school's accommodation needs.

Demerits

- The standard construction of the campus buildings; sandcrete walls, louvred windows, metal roofs does not include advanced bioclimatic strategies like properly designed overhangs, passive ventilation stacks, or thermal mass optimization. This means that significant passive design potential is not being used.

- The school's relatively comfortable indoor environment is largely due to its fortunate campus setting rather than deliberate design decisions. This means the approach cannot easily be copied on sites that do not have the same natural advantages.
- Some classrooms and dormitory areas have been expanded in ways that reduce natural ventilation, reflecting the common Nigerian problem of uncoordinated campus growth without an overall design strategy.

Relevance to the Proposed Project

The University of Nigeria Secondary School, Nsukka is the geographically closest of the three local case studies to the proposed project site in Ugwuomu. The climate of Nsukka is broadly comparable to Ugwuomu's, which makes the school's real-world performance a useful reference. The school shows clearly how much difference a well-planted, low-density campus setting makes to indoor comfort in the Nigerian humid tropical climate, reinforcing the case for integrating landscape into the bioclimatic design strategy of the proposed school from the beginning. The school also shows the risk of depending on good site fortune rather than deliberate design: as the campus fills in over time, the natural advantages may reduce. The proposed school in Ugwuomu will therefore aim to achieve good environmental performance through a well-designed, systematic bioclimatic strategy that does not depend on luck.

2.4 Summary of Literature Review and Case Studies

This chapter has reviewed the main literature and case studies relevant to the design of a bioclimatic secondary school in Ugwuomu, Enugu State. The following key points emerge from the review.

The literature confirms that bioclimatic architecture is a proven and well-researched approach to building design that improves indoor comfort, reduces energy use, and creates better learning environments in tropical climates. The most effective passive design strategies for the hot and humid climate of Enugu State are correct building orientation, natural cross ventilation, solar shading, daylighting, and landscape integration. These strategies are most effective when they are designed together as a system, rather than added separately.

Research also confirms that the quality of the indoor environment in school buildings directly affects how well students learn and how healthy they are. Better thermal comfort, ventilation, and natural light all lead to improved concentration, attendance, and academic performance. This gives a strong reason beyond just saving energy for investing in bioclimatic design in the proposed school.

From the foreign case studies, the Gando Primary School gives a practical model for a simple, effective passive ventilation system using a raised roof and local materials, directly adaptable for the classrooms of the proposed school. Green School Bali shows the value of designing the entire site as an integrated sustainable system and demonstrates the full potential of open, biophilic school design in a hot and humid climate. Panyaden International School provides the most directly applicable precedent for a full secondary school campus in a comparable tropical climate, particularly its pod-cluster layout, individual building orientation, and open-sided ventilation strategies.

From the local case studies, Federal Government College, Enugu provides a detailed reference for the full facilities programme of a large Nigerian secondary school, and demonstrates what happens when bioclimatic design is ignored in the original building design. Queen's School, Enugu shows that the traditional colonial school building type with verandas, louvred windows, high-pitched roofs, and low-density layout is a locally proven bioclimatic model that should inform the design of the proposed school. The University of Nigeria Secondary School, Nsukka demonstrates the environmental benefits of landscape integration and low building density, and shows the risk of depending on a good site setting rather than deliberate design.

All these lessons will be used to shape the design brief, site planning, building form, and passive design strategy of the proposed secondary school complex in Ugwuomu, as set out in Chapters Four and Five of this report.

CHAPTER THREE

THE STUDY AREA

3.1 Geographical Location and Setting

Ugwuomu is a community in the Nike group of towns, located in Enugu East Local Government Area (LGA) of Enugu State, southeastern Nigeria. It lies within the broader Nike district, which is one of the three main district zones of Enugu East LGA alongside Ugwogo and Mbuli Njodo (Wikipedia, 2026). The Nike communities, of which Ugwuomu is a part, are situated in the eastern flank of Enugu city, stretching from the urban fringe of Enugu metropolis towards the more rural outskirts of the local government area. Ugwuomu Nike is located at approximately latitude 6.31°N and longitude 7.50°E, placing it within the southeastern quadrant of Nigeria, in the heart of Igbo territory.

Enugu East LGA, within which Ugwuomu is located, covers a total area of approximately 383 square kilometres and has a population of about 277,119 people (ResearchGate, 2022). The LGA is bounded to the north and west by Enugu North and Enugu South LGAs respectively, and to the east by Isi-Uzo LGA. Ugwuomu itself is a semi-rural community situated at the transitional zone between the urban built-up area of Enugu city and the more rural hinterland of Enugu East. This location gives the community a distinct character: it is close enough to the city to benefit from urban services and infrastructure, yet retains the relatively open, low-density character of a rural Igbo community with generous land areas, natural vegetation, and farmland interspersed among residential plots.

The wider Enugu State lies in the South-East geopolitical zone of Nigeria and is bordered to the north by Benue and Kogi States, to the east and southeast by Ebonyi State, to the south by Abia State, and to the west by Anambra State (Enugu State Wikipedia, 2026). The state covers a total area of approximately 7,161 square kilometres and is home to an estimated population of 4.69

million people based on the 2022 census (Wikipedia, 2026). Enugu is the state capital and largest city, serving as the main administrative, commercial, and educational hub of the state. Ugwuomu, while not a major urban centre, falls under the administrative influence of Enugu city and is connected to it by road infrastructure that provides residents with access to the facilities and services of the state capital.

The site proposed for the secondary school project is located in Ugwuomu Nike, in close proximity to Godfrey Okoye University, a private Catholic university established in the community. The proposed site takes advantage of the established road infrastructure, utility connections, and institutional environment that the university has brought to the area. It is an open, relatively flat piece of land accessible from the main access road serving the university and the surrounding community, with a mix of residential buildings, farmland, and natural vegetation in its immediate surroundings. The site benefits from good natural breezes due to the semi-rural, low-density character of the area, and the openness of the land around the university precinct, which is an important advantage for the natural ventilation strategy of the proposed bioclimatic school design.

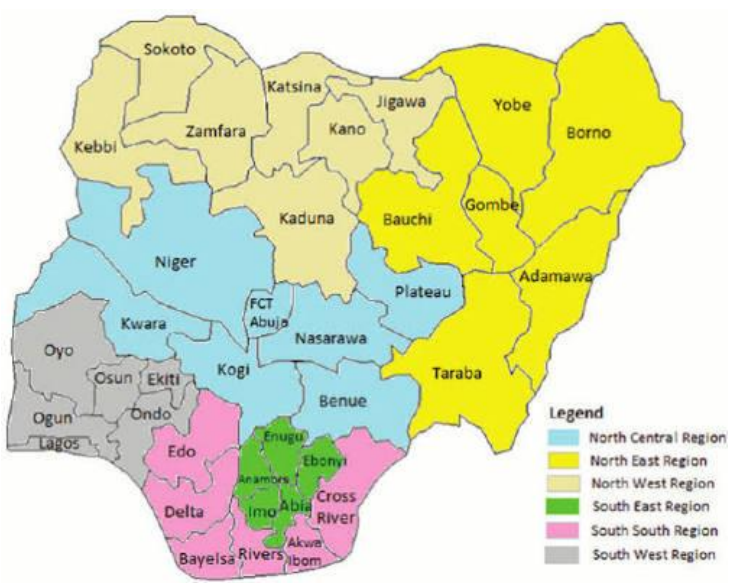


Figure 3.1 showing map of Nigeria (**sources:** google)

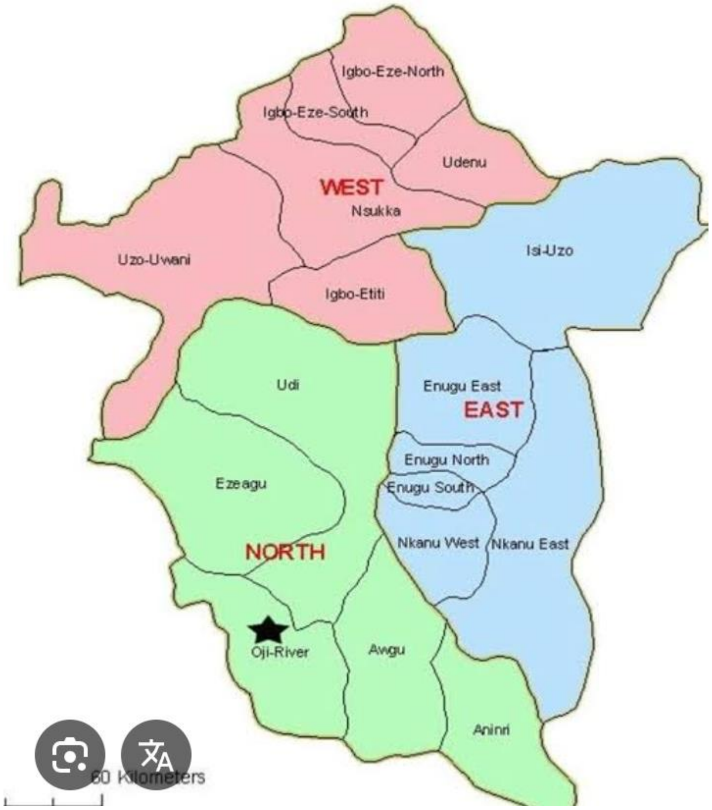


Figure 3.2 Showing map of Enugu state (**sources:** google)

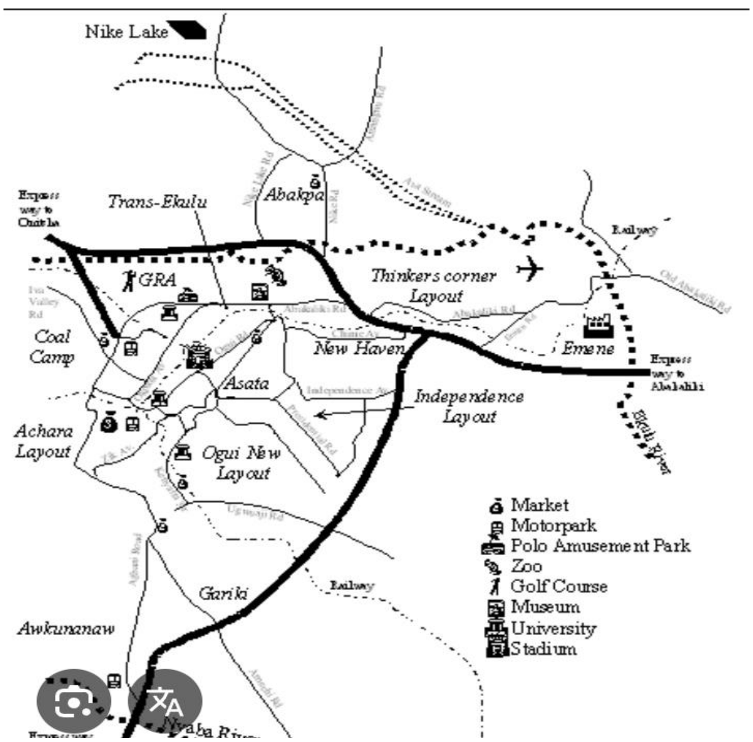


Figure 3.3 Showing map of Enugu east (**source:** google)

3.2 Site Selection Criteria

The selection of the proposed site for the secondary school in Ugwuomu Nike was guided by a set of practical and design-related criteria that ensure the site is suitable for educational use and supports the bioclimatic design goals of the project. The following criteria were considered:

I. Accessibility: The site should be easily reachable from the main roads and residential areas of Ugwuomu and surrounding communities, so that students and staff can get to school safely and conveniently.

II. Land size and shape: The site should be large enough to accommodate a full secondary school complex, including classrooms, laboratories, a library, sports fields, administrative spaces, and landscaping, with room for future expansion. A minimum land area of approximately 3 to 4 hectares is desirable.

III. Topography: A relatively flat or gently sloping site is preferred to reduce the cost of earthworks and to allow good site drainage. Gentle slopes can also be used to assist natural ventilation by directing airflow across the site.

IV. Orientation potential: The shape and orientation of the site should allow buildings to be positioned along an east-west axis, with the long sides of classroom blocks facing north and south, to minimize solar heat gain in line with bioclimatic design principles.

V. Natural ventilation exposure: The site should be relatively open on the south and southwest sides to allow prevailing winds to reach the buildings without obstruction, supporting the natural cross ventilation strategy of the design.

VI. Distance from hazards: The site should be located at a safe distance from industrial activities, waste sites, busy roads, and other sources of noise, pollution, or danger.

VII. Availability and ownership: The land should be available for acquisition or allocation, with clear ownership that can support the legal establishment of a public secondary school.

VIII. Community proximity: The site should be located within or immediately adjacent to the Ugwuomu community so that it serves the educational needs of the local population effectively.

The proposed site near Godfrey Okoye University in Ugwuomu Nike satisfies all of these criteria. Its location close to the university gives it good road access, reliable utility infrastructure, and proximity to an established institutional environment. The site is sufficiently large for the proposed programme, relatively flat, well oriented for passive solar design, and open to the prevailing south-westerly winds from the surrounding low-density landscape. The semi-rural character of the area ensures good natural air movement and minimal noise and pollution, making it well suited for a bioclimatic school campus.

Figure3.4 showing master plan of Godfrey Okoye University (**source:** school library)

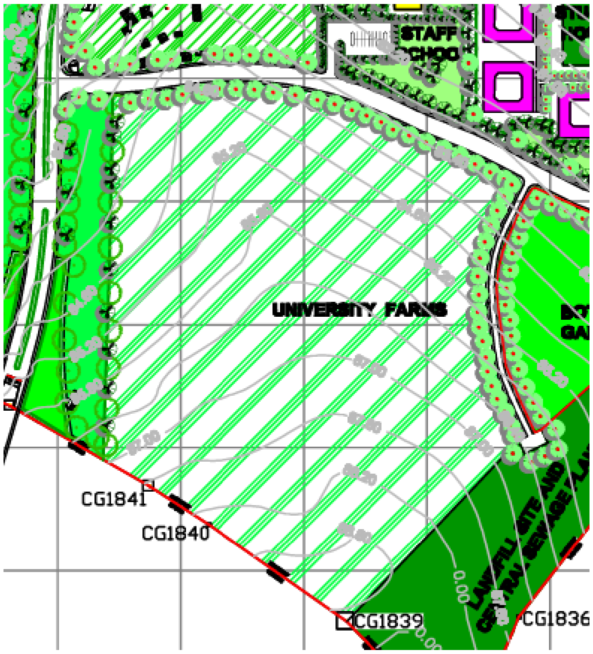


Figure 3.5 showing selected site area (**source**: master plan)

3.3 Brief History of the Study Area

Ugwuomu is one of the communities in the Nike group of towns, a cluster of Igbo communities that have inhabited the area now known as Enugu East since at least the seventeenth century. The word "Nike" in the Igbo language means "with strength or power", and the Nike people are known historically for their warrior culture, their role in regional trade networks, and their close relationship with the Aro people of Arochukwu, who were prominent traders and slave dealers in the pre-colonial era (Wikipedia – Nike Community, 2025; History of Enugu, ngimun.com, 2023). The Nike communities, including Ugwuomu, are part of the Igbo ethnic group that forms approximately 95% of the population of Enugu State. The Igbo people of this region trace their origins to a complex network of lineage groups, with legend holding that the Nike people share a common ancestral mother, Ugwunye, who was said to have been married to the god Awuwa (Wikipedia – Nike Community, 2025). Historically, the Nike communities occupied the eastern flank of the area that would later become Enugu city, using their strategic position to control trade routes and maintain territorial boundaries.

The arrival of British colonial administration in the early twentieth century significantly transformed the Enugu area. The discovery of coal in 1909 by British geologist Albert Kitson in the nearby Udi Ridge led to the rapid development of Enugu as a colonial mining and administrative centre (History of Enugu, Familysearch.org, 2026). The expansion of Enugu city as a railway terminus, administrative headquarters, and later as the capital of the Eastern Region gradually absorbed many of the Nike communities into the growing urban fabric. However, communities like Ugwuomu, located further from the city centre, retained a more rural character, preserving their traditional settlement patterns, agricultural practices, and community governance structures alongside the influence of modern development.

After Nigerian independence in 1960, Enugu became the capital of the Eastern Region and later the capital of East Central State and subsequently Anambra State before Enugu State was created in 1991 (Familysearch.org, 2026). Through these changes in administrative structure, the Nike communities have remained part of the Enugu East area. Ugwuomu today is a growing community that benefits from proximity to Enugu city while maintaining a distinct local identity. It has a functioning community governance structure, active local markets, churches, and primary schools, but lacks a dedicated secondary school of its own — a gap that this project seeks to address.

3.4 Physiography, Climate and Vegetation

3.4.1 Physiography and Topography

Enugu State is characterised by a varied physiography that includes the Udi-Nsukka Plateau to the north and west, the Cross River basin lowlands to the east, and the Niger Delta-influenced lowland forests in the far south (Wikipedia – Enugu State, 2026). The city of Enugu itself is located at the foot of the Udi escarpment, a prominent geological feature formed by sedimentary rock layers that include sandstone, shale, and coal-bearing strata of Cretaceous age. The name "Enugu" is derived from the Igbo words Enu Ugwu, meaning "the top of the hill", reflecting the hilly landscape that characterises the broader area (History of Enugu, ngimun.com, 2023).

Ugwuomu Nike lies in the transitional zone between the escarpment highlands and the lowland plains of Enugu East LGA. The community sits at an elevation of approximately 150 to 200 metres above sea level, on gently undulating terrain that is less dramatically elevated than the Udi escarpment but still higher than the low-lying areas further east. The soils in the area are predominantly red lateritic soils derived from the weathering of underlying sandstone and shale, which are well-drained but susceptible to gully erosion if vegetation cover is removed. Gully erosion is a known environmental challenge in parts of Enugu State, driven by the high rainfall intensity during the wet season and the susceptibility of the sandy soils to surface runoff (Wikipedia – Enugu City, 2026).

The topography of the proposed school site is relatively flat with a gentle slope that facilitates natural drainage without causing flooding or erosion problems. This gently sloping terrain is beneficial for bioclimatic design as it supports passive ventilation by allowing air drainage and directs surface water away from buildings naturally.

3.4.2 Climate

Enugu State, including the Ugwuomu Nike area, experiences a tropical savanna climate (Köppen classification Aw), characterised by two distinct seasons: a wet season and a dry season. This climate type is typical of the Guinea savanna ecological zone of West Africa and shares many characteristics with the humid tropical climates of other West African and Southeast Asian countries, making the bioclimatic design lessons from the foreign case studies in Chapter Two directly applicable here.

Table 3.1: Summary of Climatic Data for Enugu State / Ugwuomu Nike Area

Climate Classification	Tropical Savanna (Köppen: Aw)
Annual Rainfall	1,500 – 2,000 mm per year
Wet Season	April to October (peak: July – September)
Dry Season	November to March
Average Annual Temperature	25°C – 32°C
Peak Temperature (Dry Season)	Up to 35°C (Jan – April)
Coolest Months	July – August (average high ~29°C)
Average Relative Humidity (Wet Season)	70% – 85%
Average Relative Humidity (Dry Season)	40% – 65%
Prevailing Wind (Wet Season)	South-Southwesterly
Prevailing Wind (Dry Season / Harmattan)	Northeast (Harmattan winds from Sahara)
Average Sunshine Hours	12 hours daylight; 4 – 7 hours bright sunshine per day
Elevation of Study Area	Approx. 150 – 200 m above sea level

Source: NearWeather.com (2024); Weather Atlas (2024); Sunheron (2024); Meteoblue (2024)

Temperature: Enugu has warm to hot temperatures throughout the year, with relatively small variation between seasons. The hottest period runs from January to April, when daytime temperatures regularly reach between 32°C and 35°C. The coolest period falls between July and August during the peak wet season, when cloud cover and rainfall bring average highs down to about 28°C to 29°C (Weather Atlas, 2024; Sunheron, 2024). Even in the coolest months, indoor spaces without ventilation or shading can become uncomfortably warm, particularly in the afternoons. Night-time temperatures drop to between 20°C and 23°C during the dry season and around 22°C to 24°C during the wet season.

Rainfall: Annual rainfall in the Enugu area ranges from 1,500 to 2,000 millimetres, with the heaviest rain falling between June and September. The month of September is typically the wettest, with average monthly rainfall of up to 293 mm (Sunheron, 2024). The dry season from November to March sees very little rainfall — December and January average less than 10 mm each (Weather Atlas, 2024). The high rainfall intensity during the wet season is important for the design of the school, particularly in terms of roof drainage, overhanging eaves to protect walls from rain, and site grading to manage surface water runoff.

Humidity: Relative humidity in Enugu is high for most of the year, ranging from 40% in the dry season to over 85% during the peak wet season (NearWeather.com, 2024; Weather Atlas, 2024). High humidity combined with high temperatures creates a "feels-like" temperature that is often higher than the actual air temperature, making thermal comfort a significant challenge in buildings. This makes natural ventilation and air movement the most important passive strategy for comfort in school buildings in this climate, as moving air provides relief from the sensation of heat even when actual temperatures are not extreme.

Wind: Prevailing winds in the Enugu area shift with the seasons. During the wet season (April to October), winds come predominantly from the south and south-southwest, driven by the moist maritime air mass from the Atlantic Ocean (NearWeather.com, 2024). These winds are warm and humid but provide useful cooling relief when they move through well-ventilated buildings. During the dry season (November to March), the Harmattan wind blows from the northeast, bringing dry, dusty air from the Sahara Desert. The Harmattan causes reduced humidity, hazy visibility, and increased dust, but also brings cooler night temperatures (Enugu State NearWeather.com, 2024). For the purposes of building orientation and ventilation design, the south-southwesterly wet season winds are the most important reference, as they blow during the majority of the school year and during the hottest periods when ventilation is most needed.

Solar Radiation: Enugu has approximately 12 hours of daylight throughout the year, given its proximity to the equator. Actual bright sunshine hours average between 4 and 7 hours per day, with the most sunshine occurring during the dry season (NearWeather.com, 2024). Solar radiation is intense, particularly during the dry season months of January to March when cloud cover is minimal. The high solar radiation during these months is the primary driver of solar heat gain in poorly shaded buildings, making solar shading a critical element of bioclimatic school design in this area.

The combined effect of high temperatures, high humidity, and intense solar radiation for most of the year creates a demanding thermal environment for school buildings in Ugwuomu. The bioclimatic design strategy for the proposed school must address all three of these climate challenges simultaneously through building orientation, solar shading, natural cross ventilation, and landscape-based cooling strategies, as identified in the literature review in Chapter Two.

3.4.3 Vegetation

Enugu State lies within the Guinea savanna and derived savanna ecological zones of West Africa, with the southern parts of the state transitioning into the tropical rainforest belt (Wikipedia – Enugu State, 2026). Ugwuomu Nike, located in Enugu East LGA, falls within the derived savanna zone, where the original tropical rainforest has been modified over centuries of human habitation and agricultural activity into a mosaic of farmland, secondary bush, and planted trees. The natural vegetation of the area consists of a mix of oil palm trees (Elaeis guineensis), iroko (Milicia excelsa), mahogany (Khaya ivorensis), mango (Mangifera indica), pawpaw (Carica papaya), and various species of shrubs, grasses, and undergrowth typical of the Guinea savanna transition zone. Within the community itself, the vegetation is shaped by human activity. Residential compounds are typically surrounded by planted trees, including mango, breadfruit, and oil palm, which provide shade for homes and outdoor spaces. Farmland on the outskirts of the community supports subsistence crops such as yam, cassava, maize, and cocoyam, which are the main agricultural products of Enugu State (Zodml.org – Enugu State, 2024). Patches of secondary forest and bush are found on uncultivated land, providing a natural vegetation buffer that contributes to local air quality and microclimate moderation.

For the proposed school, the existing vegetation on and around the site is an important design resource. Mature trees on or near the site boundaries can be retained and used as natural shading elements for outdoor spaces and as windbreaks or wind-channelling features for the bioclimatic design. The strategic planting of new trees, particularly fast-growing species like neem (Azadirachta indica) and African locust bean (Parkia biglobosa), can further enhance the microclimate of the school campus over time, reducing solar radiation on building surfaces and cooling the surrounding air through evapotranspiration.

3.5 Population, Culture and Economic Development

3.5.1 Population

Enugu State had an estimated population of approximately 4.69 million people based on the 2022 national census, covering an area of about 7,625 square kilometres, giving a population density of around 615 persons per square kilometre (Wikipedia – Enugu East, 2026). Enugu East LGA, the local government area within which Ugwuomu Nike is located, has a population of approximately 277,119 people based on earlier census data (ResearchGate, 2022), though the current population is likely higher given the rate of urbanisation and population growth in the Enugu metropolitan area.

Ugwuomu Nike is a community of moderate size, with a population estimated in the low thousands. Like many communities in the Nike group, it has experienced steady population growth in recent decades, driven partly by natural population increase and partly by the migration of people from more congested parts of Enugu city towards the relatively more affordable and spacious semi-urban fringe communities. This population growth has increased demand for educational facilities, health services, and social infrastructure in the community, making the proposed secondary school a timely and necessary intervention.

In terms of the school-age population, the community currently lacks a dedicated secondary school. Students from Ugwuomu and surrounding Nike communities must travel to secondary schools in other parts of Enugu East or Enugu city to access secondary education, which creates challenges of distance, transport cost, and safety for young students. A secondary school located within the community would serve not only Ugwuomu itself but also the broader catchment area of neighbouring Nike communities.

3.5.2 Culture and Social Life

The people of Ugwuomu are predominantly of the Igbo ethnic group and are part of the wider Nike community, whose cultural identity is shaped by Igbo traditions and values. The Igbo people are known for their strong emphasis on education, entrepreneurship, and community solidarity. Educational achievement is highly valued in Igbo culture, and parents typically make significant sacrifices to ensure their children have access to good schools (Familysearch.org – Enugu State, 2026). This cultural value placed on education makes the proposed secondary school a project of deep community significance, not just as a building but as an expression of the community's commitment to the educational future of its children.

The predominant religion in Ugwuomu and the wider Enugu State is Christianity, with a large proportion of the population belonging to Catholic, Anglican, and Pentecostal churches (Wikipedia – Enugu City, 2026). Churches play an important social role in the community, serving as centres for education, community gathering, and welfare support. The community also maintains traditional Igbo governance structures, with a council of elders (Ndi Eze) providing cultural leadership alongside the formal local government structures of Enugu East LGA.

Social life in Ugwuomu revolves around the family compound, the local market, churches, and community events. The local market, which operates on the traditional Igbo four-day market cycle (Eke, Orie, Afor, Nkwo), is an important centre of economic activity and social interaction.

Traditional festivals, title-taking ceremonies, new yam festivals, and community meetings are regular features of social life. These cultural activities take place in open public spaces, courtyards, and community grounds — a spatial tradition that informs the design of the proposed school's outdoor gathering spaces and assembly areas.

3.5.3 Economic Activities

The economy of Enugu State is predominantly rural and agrarian, with approximately 60% of the workforce engaged in farming (Zodml.org – Enugu State, 2024). The principal crops grown in and around Ugwuomu include yam, cassava, maize, rice, cocoyam, oil palm, and cashew, a mix of food crops and cash crops that reflects the agricultural character of the Guinea savanna zone. Trading is the second most important economic activity, with small-scale retail trade, market vending, and informal commerce providing livelihoods for a significant proportion of the population.

Enugu State also has a notable industrial sector, particularly in the areas of brewing, textiles, and cement production, with the largest concentration of industries in and around Enugu city (Wikipedia – Enugu State, 2026). However, the immediate Ugwuomu Nike area is primarily residential and agricultural, with economic activity centred on subsistence farming, small-scale trading, and service employment in Enugu city. Many residents of Ugwuomu commute daily to Enugu city for work in government, commerce, and services.

The relatively low-income profile of many Ugwuomu households makes the availability of a good public secondary school in the community even more important. Private secondary schools in Enugu city are often beyond the financial reach of lower-income families, and a well-designed, publicly funded secondary school in Ugwuomu would provide quality education to a population that currently has limited access to it. The proposed school is thus not only an architectural and environmental design project but also a socially important public investment in the community's human capital and long-term development.

3.6 Summary

This chapter has described the study area of Ugwuomu Nike, Enugu East LGA, Enugu State, in terms of its geographical location, history, physical environment, climate, vegetation, population, culture, and economic character. The key findings relevant to the bioclimatic design of the proposed secondary school are summarised below.

Ugwuomu Nike is a semi-rural community located in the eastern fringe of Enugu city, within the Nike district of Enugu East LGA. It sits at approximately 150 to 200 metres above sea level on gently undulating lateritic terrain, which is suitable for the development of a school campus with minimal earthworks.

The climate of the area is a hot and humid tropical savanna, with annual temperatures ranging from 20°C to 35°C, average humidity of 40% to 85%, annual rainfall of 1,500 to 2,000 mm concentrated in the wet season (April to October), and intense solar radiation during the dry season. Prevailing winds blow from the south-southwest during the wet season and from the northeast during the Harmattan dry season. These conditions demand a bioclimatic design strategy centred on cross ventilation using the south-westerly winds, solar shading through overhangs and fins, east-west building orientation to minimise solar heat gain, and landscape cooling through strategic tree planting.

The vegetation of the area is a mix of derived savanna, farmland, and planted trees, offering useful natural design resources including existing trees for shade and wind management, and a range of locally available plant species suitable for the proposed school's landscape strategy.

The community is predominantly Igbo, Christian, and places a high cultural value on education. The absence of a local secondary school is a clear community need that the proposed school directly addresses. The local economy is based primarily on agriculture and trade, with many residents commuting to Enugu city for work, which means the school will serve a predominantly modest-income community for whom a well-designed public school is an important social resource.

All of these findings will directly inform the site analysis, design brief, and bioclimatic design strategy of the proposed secondary school complex in Ugwuomu, as developed in Chapters Four and Five of this report.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.0 Introduction

Every research project needs a clear plan for how information will be gathered and used. This chapter explains the approach taken in this study to collect and analyse the data needed to design a bioclimatic secondary school in Ugwuomu Nike, Enugu State. It covers the research design, what data was needed and where it was sourced, how the data was collected, and how it was analysed.

4.1 Research Design

This study is a design-based architectural research project. The approach used is qualitative and descriptive, which means the focus is on understanding, describing, and interpreting information rather than on measuring or testing numerical data. Three main methods were combined to gather the information needed:

1. A review of published literature,
2. Observation of case study buildings and,
3. A physical survey of the proposed project site.

Each of these methods served a specific purpose. The literature review helped build a solid theoretical understanding of bioclimatic architecture and what it means to design a school for a hot and humid tropical climate. The observations made when conducting these case studies provided real-world evidence of how these principles have been applied in actual school buildings, both in Nigeria and in other tropical countries. The site analysis gave the researcher an understanding of the physical conditions, climate, and context of the chosen site at Godfrey Okoye University, Ugwuomu Nike, where the proposed school is to be located. Together, these three methods produced a well-rounded and reliable evidence base for the design proposal (Groat & Wang, 2019).

4.2 Data Needs and Sources

Before data collection could begin, it was necessary to identify clearly what information was needed and where it could be found. The data needed were; the theoretical data on bioclimatic design and educational building standards, empirical data from case study observations and site-specific data on the physical Climatic and contextual characteristics of the proposed site. The table below summarizes the data that was needed for this study and the sources used to obtain it.

Table 4.1: Data Needs and Sources

Data Category	Specific Data Needed	Source
Bioclimatic Design Theory	Passive design strategies, orientation, ventilation, shading, daylighting principles	Published books, journals, and articles (2016–2025)
Educational Building Standards	Nigerian secondary school design standards, classroom sizes, ventilation ratios, facility requirements	Federal Ministry of Education guidelines; NBS standards
Case Study Data	Design features, materials, bioclimatic strategies, and performance of selected schools	Direct observation visits; ArchDaily; Dezeen; academic sources
Site and Climate Data	Site dimensions, topography, solar angles, wind direction, rainfall, temperature, vegetation	Site visit; GOU master plan (2008); Weather Atlas; NearWeather
Community Context Data	Population, land use, access routes, community needs	Site observation; published demographic data; Enugu State records

4.3 Population of Study and Sampling

In architectural design research, the population of study refers to the people whose needs the building is intended to serve. For this project, the primary users of the proposed secondary school are a total of 900 students from JSS 1 to SSS 3, along with approximately 50 to 65 teaching and non-teaching staff. The broader Ugwuomu Nike community also forms part of the population, since the school will serve as a public educational facility for the area.

In regards to the case studies conducted, the six schools analysed in Chapter Two were not selected randomly. Instead, purposive sampling was used, which means they were chosen based on specific criteria relevant to this study (Creswell & Creswell, 2018). The criteria included whether the school was located in a tropical climate similar to that of Enugu State, whether it incorporated bioclimatic or passive design features, and whether enough documented information was available for a meaningful analysis.

4.4 Methods and Instruments for Data Collection

4.4.1 Literature Review

The starting point for this research was a thorough review of existing published work on bioclimatic architecture, passive design strategies for tropical climates, indoor environmental quality in schools, and secondary school design standards in Nigeria. The goal was not simply to collect information but to understand the field well enough to make informed design decisions. Books, peer-reviewed journal articles, reports from organizations such as UNESCO and the World Green Building Council, and official guidelines from the Federal Ministry of Education of Nigeria were all consulted. Sources were limited to work published within the last ten years, from 2015 to 2025, to ensure the information is current and relevant.

The search was carried out using academic databases including Google Scholar, ResearchGate. Reading through these sources helped sharpen the focus of the research and highlighted the specific design strategies most applicable to the climate of Ugwuomu-Nike.

4.4.2 Case Study Observation

One of the most valuable parts of this research was visiting real secondary school buildings to see first-hand how they perform in the Nigerian climate. Three local schools were visited for direct observation: Federal Government College Enugu, Queen’s School Enugu, and the University of

Nigeria Secondary School Nsukka. During each visit, the researcher walked through the campus and paid careful attention to the following:

I. How the campus was laid out and whether there was a clear organization of spaces.
II. The size and type of windows, and whether shading devices like overhangs or verandas were present.
III. How warm or cool the classrooms felt inside, particularly during the afternoon hours.
IV. How much natural light reached different parts of the classroom.
V. The amount and quality of trees and vegetation on the campus.

Notes and photographs were taken throughout each visit. These observations were not just academic exercises. Seeing through the researcher's point of view, how uncomfortable some poorly ventilated classrooms were, and how much cooler others felt simply because of a veranda or a row of trees, made the importance of bioclimatic design very real and concrete. The three foreign case studies; Gando Primary School, Green School Bali, and Panyaden International School, could not be visited in person but were studied using published photographs, architectural drawings, project descriptions, and documented academic papers.

4.4.3 Site Survey and Analysis

A site visit was also carried out at the chosen site within the University Farm, Godfrey Okoye University, Ugwuomu Nike, to gather direct information about the proposed school site. The visit involved walking the site boundaries, observing the surrounding land uses and vegetation, noting the direction of the prevailing wind, and recording observations about the topography and general character of the land. The GOU master plan from December 2008 was also studied to understand the size and shape of the farm plot and how it relates to the rest of the university campus.

Climate data for the area; including temperature ranges, humidity levels, rainfall patterns, solar radiation, and wind direction was collected from published online climate databases including

Weather Atlas, NearWeather, and Sunheron. This data was essential for understanding the specific thermal challenges the design would need to address.

4.5 Methods of Data Analysis and Presentation

Once all the data had been collected, the next step was to make sense of it. The approach used was a qualitative descriptive analysis, which involves reading, comparing, and interpreting the collected information to identify the key themes and lessons most relevant to the design.

For the literature review, the main findings were organized around the central themes of the study: what bioclimatic architecture is, how passive design strategies work in hot and humid climates, how indoor comfort affects student learning, and what Nigerian school design standards require. For the case studies, each school was examined using the same framework overview, design features, merits, demerits, and relevance to this project so that comparisons could be made fairly. For the site analysis, the findings were summarized in tables that clearly linked each site characteristic to a specific design response.

The most important outcome of this analysis was a clear, evidence-based understanding of what the proposed school needed to look like, how it needed to be oriented, how it needed to be ventilated, and how the site needed to be organized. This understanding is what made it possible to develop a design concept and proposal that is genuinely responsive to its context rather than a generic or arbitrary solution.

CHAPTER FIVE

DESIGN SYNTHESIS AND DEVELOPMENT

5.0 Introduction

This chapter is where all the research comes together. Everything covered in the preceding chapters, the bioclimatic design principles from the literature, the lessons from the case studies, the climate and site data from the analysis, is now used to develop the actual design of the proposed secondary school. The chapter works through the design brief, the planning standards and accommodation requirements, the site analysis summary, and the design concept and proposal. It is, in many ways, the core of the entire project.

5.1 The Design Brief

The proposed project is a co-educational day secondary school for 900 students, covering JSS 1 through SSS 3, to be located at the site in Godfrey Okoye University in Ugwuomu Nike, Enugu East LGA, Enugu State. Therefore, this study aims to apply bioclimatic architectural principles in the design of a secondary school complex in Ugwuomu, with the goal of creating a comfortable and sustainable learning environment.

The need for this school is straightforward. The community has grown significantly due to the university's presence, increasing local demand for a school directly serving the immediate Ugwuomu Nike population and university staff\community. The proposed school will enhance this by bringing quality secondary education directly into the community. A dedicated bus transport service will ensure that students from Ugwuomu and the surrounding Nike communities can get to school safely every day. The client is the Ugwuomu Nike Community, supported by the Enugu State Ministry of Education and Enugu East Local Government Council.

5.2 Design Requirements for Activities and Planning Data

5.2.1 Classroom Design Standards

According to the Federal Ministry of Education of Nigeria, a standard secondary school classroom should accommodate maximum of between 35 to 40 students in a minimum net floor area of 56 square meters (FME, 2020). In this project, the classrooms have been designed for 30 students, each an area of 90 square meter. This is intentionally below the maximum standard because smaller class sizes mean less body heat and carbon dioxide per room, which directly improves indoor thermal comfort and air quality. At a simple area per student level, this gives 90 square meters divided by 30 students = 3 square meter per student, which is well above Nigerian minimum standard of 1.4square meter per student. However, this figure represents the total room area divided evenly across all occupants, and does not on its own show how the space is shared within the room. After the teacher's zone, circulation space and desk area has been considered the student seating space is approximately 1.6 to 1.7 square meter, this is still above the minimum standard.

Ceiling heights in all classrooms are set at a minimum of 3.5 meters, higher than the Nigerian minimum of 3.0 meters. This extra height is not arbitrary. In a hot and humid climate, a higher ceiling means that hot air rising from the occupants collects well above head level before it escapes through high-level ventilation outlets, keeping the zone where students sit and work noticeably cooler. All windows will be louvred rather than fixed glass, so that students and teachers can adjust ventilation levels as needed, including during the Harmattan season when dust entry needs to be managed.

5.2.2 Laboratory Design Standards

Each of the science laboratories; biology, chemistry, and physics etc. will have a minimum net floor area of 65.5 square meters. This is sufficient to accommodate laboratory benches, storage, and safe movement around equipment during practical sessions. All laboratories will be ventilated directly to the outside through louvred openings on at least two walls. The chemistry laboratory will also have a dedicated fume extraction provision for the safe removal of chemical fumes. Work surfaces will be non-porous and heat-resistant throughout.

5.2.3 Library Design Standards

The school library will have a minimum net floor area of 200 square meters. It will be positioned and designed to receive controlled natural daylighting, providing consistently bright and glare-free reading conditions throughout the day without direct sunlight falling on books or reading surfaces. Bookshelves will be arranged perpendicular to the window walls to prevent shelves from casting shadows across reading areas. The ceiling height will be a minimum of 3.5 meters.

5.2.4 Circulation and Accessibility

Internal corridors within all buildings will be a minimum of 1.8 meters wide to allow comfortable two-way pedestrian movement during class changeovers. External covered walkways connecting buildings will be a minimum of 2.0 meters wide. At least two accessible toilets will be provided in the administration block and near the academic zone.

5.2.5 Toilet Provision

Toilet facilities will be provided at a ratio of at least one toilet per 35 students, giving a minimum of 4 partitions for boys and 6 partitions for girls across the academic zone. Separate toilet facilities are provided for male and female staff. Every toilet block will be naturally ventilated through high-level louvred openings or ventilation shafts to the outside.

5.3. Schedule of Accommodation

The table below sets out all the spaces required in the proposed school, organized by functional zone.

Table 5.1: Academic Zone

Space	No.	Area per Room (m²)	Total (m²)
Standard Classrooms (30 students each)	30	90	2,700
Biology Laboratory	2	65.5	131
Chemistry Laboratory	2	65.5	131
Physics Laboratory	2	65.5	131
Computer Laboratory	2	65.5	131
Home Economics Room	2	65.5	131
Fine Art / Technical Drawing Room	2	75	150
Music Room	1	75	75
Lab Store / Preparation Rooms	3	25	75
Academic Zone Subtotal			3,655

Table 5.2: Administration Zone

Space	No.	Area per Room (m²)	Total (m²)
Principal's Office	1	30	30
Vice Principal's Office	2	20	40
General Reception	1	88.5	88.5
Staff Common Room	1	60	60
HOD Offices (6 departments)	3	15	45
Conference / Board Room	1	40	40
Records / Archive Room	1	20	20
Admin Toilets	2	14.5	29
Administration Zone Subtotal			377.5

Table 5.3: Common Academic Zone

Space	No.	Area per Room (m²)	Total (m²)
Assembly Hall (500 capacity)	1	475.2	475.2
Stage and Backstage Area	1	80	80
School Canteen	1	180	180
Kitchen and Food Store	1	60	60
Library / Resource Centre	2	214.8	429.6
Common academic Zone Subtotal			1224.8

Table 5.4: General Amenities Zone

Space	No.	Area per Room (m²)	Total (m²)
Generator House	1	20	20
Student Toilets – Boys	4	15	60
Student Toilets – Girls	4	15	60
Caretaker Flat	1	60	60
General amenities Zone Subtotal			200

Table 5.5: Overall, Gross Floor Area Summary

Zone	Net Area (m²)
Academic Zone	3,655
Administration Zone	377.5
Common academic Zone	1,224.8
General amenities Zone	200
Transport / Arrival Zone	Outdoor — not included in GFA
Sports and Landscape	Outdoor — not included in GFA
Total Net Floor Area	5,457.3

5.3. Special Considerations

Bus Transport and Arrival Zone: Because this is a day school with a dedicated bus service, the arrival and departure experience of students is something that needed careful thought. The bus bay is located at the main eastern entry. It has a covered waiting canopy so students are not standing in the sun or rain while waiting for buses. Vehicles follow a one-way route with a minimum of ten parking spaces. A separate access road is provided for parents dropping or collecting students by private car and staffs coming, this is kept clearly apart from the pedestrian entry to the academic zone to prevent the kind of chaotic congestion that is common at many Nigerian school gates during rush hours.

Accessibility: Circulation routes between all key spaces are step-free. Accessible toilets are provided at the administration block and in the academic zone.

Security: The entire campus is enclosed by a perimeter fence, with all entry and exit controlled through the main gate and a service gate. A gate house at the entrance provides security coverage throughout the school day. Since this is a day school, securing the campus after hours is important.

Fire Safety: Every building has at least two clearly marked emergency exits. Fire extinguishers are provided in the library, assembly hall, and all laboratory spaces. The chemistry laboratory has its own dedicated fume extraction system and a separate chemical storage room that is directly ventilated to the outside.

Water and Sanitation: The school will be served by a water tanker and a dedicated borehole, supplemented by rainwater harvesting from roof surfaces for use in landscape irrigation and toilet flushing. A septic tank and soak-away system, sized for the full school population of 900 students and 55 staff, will be provided on site.

Electricity: The school will be connected to the national electricity grid, with a diesel generator for backup. Solar panels will be used for outdoor lighting and low-energy common areas, which is consistent with the broader sustainable design approach of the project.

5.4. Site Inventory and Analysis

A detailed site inventory and analysis was carried out for the selected site at Godfrey Okoye University, Ugwuomu Nike. What follows here is a summary of the most important findings and their implications for the design.

The University Farm is a large and open piece of agricultural land, with a relatively gentle slope, located at the immediate south of the main GOU campus buildings. It covers approximately 4 to 6 hectares and is bordered on the west by a paved 12-kilometre access road that connects the site to Adoration Junction, Emene, and the wider Enugu Road network. The site sits at approximately latitude 6.47°N and longitude 7.53°E, in the tropical savanna climate zone of southeastern Nigeria.

Table 5.6: Summary of Site Analysis Findings and Design Responses

Site Factor	Key Finding	Design Response
Solar Path	Sun tracks south of overhead for most of the year; low-angle east and west sun in morning and afternoon	East-west building orientation; horizontal overhangs or fins on north and south facades; solid or shaded east and west walls
Prevailing Wind	South-southwest during the wet season, which covers most of the school calendar	Y-shape of campus opens north south; ventilation inlets face south and sweeps through the interior and exits through the north
Topography	Gently sloping from north to south; generally flat and open	Natural slope used for surface water drainage; minimal earthworks required
Vegetation	Open farmland with boundary trees at edges; mature GOU campus trees to the north	Existing boundary trees retained; new shade trees planted east and west of all buildings
Access	Paved road runs along the western boundary of the site	Main school entry located on western boundary; bus bay at west gate; administration block faces the road
Surrounding Context	GOU main campus to the north; open community land to the south and east	Y-shape of academic block opens northward the accessible road.
Utilities	GOU campus services including electricity and water available close to the site	School connects to GOU electricity grid; dedicated borehole and septic system provided on site
Soil	Red lateritic soil; well-drained but susceptible to erosion if ground cover is removed	Ground cover protected during construction; tree planting established early to stabilize soil

5.5 Data Analysis and Presentation

5.5.1 Problem Analysis

One of the most useful outcomes of the research process was being able to clearly identify the specific problems that the design needed to solve. seven key problems emerged from the combination of literature review, case study observation, and site analysis. These are not abstract or theoretical problems. Several of them were observed directly during the visits to the local case study schools, which made it clear just how widespread and serious these issues are in Nigerian secondary school buildings. The table below presents each problem alongside the design response developed to address it.

Table 5.7: Problem Analysis

Problem Identified	Design Response
Classrooms in existing Nigerian schools are often too hot, making it hard for students to concentrate	Apply bioclimatic strategies throughout: east-west orientation, cross ventilation, solar shading, and raised roof ventilation
Many classrooms have windows on only one wall, causing poor air circulation and heat build-up	Provide louvred windows on opposite walls of every classroom; add high-level ventilation outlets for stack-effect cooling
Buildings facing east or west allow direct morning and afternoon sun to heat up classroom interiors	Orient all classroom blocks east-west so long facades face north and south; provide horizontal overhangs on all window openings
Classrooms are often too dark, forcing reliance on artificial lighting even during the day	Size and position windows to achieve a minimum daylight factor of 2%; use light-coloured interior finishes to spread natural light further
Dependence on electric fans and air conditioning creates high electricity bills that many schools cannot afford	Design out the need for mechanical cooling entirely through passive bioclimatic strategies; use solar panels for outdoor lighting
School campuses in Nigeria typically have little or no deliberate landscape design, leaving buildings exposed to harsh sun	Integrate a full landscape strategy with shade trees on east and west of all buildings, planted courtyards, and green buffer zones
Many school campuses have grown without a clear plan, mixing vehicles, pedestrians, and activities unsafely	Organize the campus into clear, well-defined functional zones connected by safe, shaded, covered walkways

5.5.2 Climate Data Analysis

The climate data collected for Ugwuomu Nike paints a clear picture of the thermal challenge that the proposed school must be designed to handle. Average temperatures range from 25°C to 32°C throughout the year, with peaks of up to 35°C during the dry season between January and April. Humidity levels are high for most of the year, reaching over 85% during the peak wet season months of July to September. Annual rainfall is substantial, between 1,500 and 2,000 millimeters, with the heaviest downpours in September. The prevailing wind during the wet season which coincides with most of the school calendar comes from the south-southwest.

What this data tells the designer is straightforward: the biggest challenge is heat and humidity, not cold. Mechanical air conditioning would be expensive, unreliable given the state of electricity supply in the area, and entirely unnecessary if the building is designed correctly. Natural ventilation driven by the south-westerly wind is freely available and abundant. Solar shading is achievable with simple horizontal overhangs or fins. East-west orientation costs nothing extra to achieve at the design stage. These are the tools this design uses, and the climate data confirms they are the right ones for this site.

5.6 Design Concept and Design Proposal

5.6.1 Design Concept: The Open Book

Every good architectural design begins with a clear idea a concept that gives the project meaning and guides every decision from the overall campus layout down to the smallest detail. For this project, that idea came from thinking about what a school fundamentally is. A school is a place of knowledge. It is where young people come to learn, to read, to question, and to grow. And the most universal symbol of all of that is an open book.

Initially the concept was translated into a simple V shaped form to reflect the two open pages of a book. However, through the design development process and in response to functional and environmental considerations, the form evolved into a Y shaped configuration.

The central node of the Y represents the spine of the book which serves as the admin zone connecting all other functions\activities. The three wings extending from the central core represents the open pages of the book spreading knowledge in different directions. This allows the functions of the school to be organized into distinct zones, improving circulation, and making movement within the school more efficient.

From a bioclimatic perspective, the Y shaped arrangement enhances the environmental performance of the building. The separation of the wings creates open courtyards and breezeways that encourage natural cross-ventilation throughout the school. The orientation of the wings allows classrooms to receive adequate daylight while minimizing excessive solar heat gain through appropriate positioning and shading. The open spaces between the wings also provide opportunities for landscaping which helps improve the microclimate, and strengthens the connection between the built environment and nature.

The final form is not only a symbolic representation but also a climate responsive design solution that promotes sustainability, thermal comfort, energy efficiency and an effective learning environment.

5.6.2 Campus Layout and Zoning

With the open book concept established, the rest of the campus organization followed a clear logic. The western boundary of the University Farm, where the paved access road runs, became the natural front of the school. Moving from west to east and south, the campus is organized as follows:

1. **Entry and Administration Zone (West - Front of Campus):** This is the first part of the school that anyone sees when approaching from the road. The main gate, gate house, bus bay with covered canopy, car park, and drop-off lane are all located here. Directly behind them, the administration block provides a visible and welcoming presence at the entry. it has been designed with compensatory deep overhangs and louvred screens on its east and west-facing walls to manage the solar exposure.

2. **Academic Zone: The Y-Shape (center of Campus):** The two wings of the Y-shaped classroom block sit at the heart of the campus. Each wing runs roughly east-west so that its long facades face north and south, in line with the bioclimatic orientation requirement. The admin sits at the apex, connecting the two wings and completing the spine of the open book. Covered walkways run the full length of both wings on the south side, providing shaded and rain-protected

routes between classrooms and labs. The central courtyard between the wings is landscaped with grass, trees, and planted beds.

3. **Assembly and Social Zone (Mouth of the Y):** The assembly hall and labs are positioned at the open south end of the V, between the academic zone and the admin zone. This placement makes both buildings equally accessible from either classroom wing and creates a natural transition between the academic and recreational parts of the campus.

4. **Sports and Recreation Zone (Located south-east of the Campus):** The football field, occupy the large open eastern portion of the University Farm. Positioning the sports area at the opposite end of the campus keeps the noise of physical activity well away from classrooms during lesson time.

5. **Service Zone (Located south-east of the Campus):** The generator house, maintenance workshop, caretaker flat, and service access road are tucked into a discreet corner at the rear of the campus, away from the main pedestrian areas.

5.6.3 Bioclimatic Design Strategies in the Proposal

The following passive design strategies are applied consistently across all buildings in the proposed school. Each strategy is directly traceable to findings from the literature review, the case study analysis, or the site analysis.

Building Orientation: All classroom blocks are oriented with their long axis running east-west, so that the large classroom wall surfaces face north and south. This is the single most important passive design decision in the entire project. It minimizes the solar heat gain on the walls students sit against, and it makes horizontal window overhangs or fins far more effective.

Natural Cross Ventilation: Every classroom has louvred windows on both the north and south walls. The south windows are the inlets, placed at 0.6 to 1.0 meters above floor level to bring cool air directly into the zone where students are seated. The north windows are positioned higher, to allow hot air that has risen to the ceiling to escape. The Y-shape of the campus concentrates and speeds up the prevailing south-westerly breeze before it reaches the classroom openings, making the cross ventilation more effective than it would be in a straight building arrangement.

Stack Effect Ventilation: The 3.5-metre ceiling height in every classroom, combined with a raised roof ridge and a continuous ventilation gap between the roof structure and the ceiling below, creates a passive stack effect. Hot air rises naturally above head level and escapes through the roof gap by convection, even on calm days when there is no wind to drive cross ventilation. This strategy was directly inspired by the raised roof system at the Gando Primary School in Burkina Faso, which was observed to work extremely effectively in a West African climate very similar to Enugu's.

Solar Shading: vertical fins of between 0.6 and 0.9meters projection are provided above every north and south-facing window. The depth was calculated based on the solar angles for latitude 6.47°N, breaking up direct sunlight before it reaches the window surface while still allowing diffuse daylight and airflow through the louvres behind them. Deep verandas of 2.0 to 2.5 meters run along the full length of both classroom wings on the north sides, shading the walls, the windows, and the covered walkways simultaneously.

Daylighting: Windows are sized to achieve an average daylight factor of at least 2% across the full depth of each classroom. All interior wall and ceiling surfaces are painted in off-white or cream to maximize the reflection of daylight into the corners and back of each room.

Landscape Integration: Large canopy trees: neem, mango, and African locust bean are planted at regular intervals on the east and west sides of both classroom wings. These trees shade the short-end facades of the buildings during the vulnerable low-sun morning and afternoon hours when fins are less effective. The courtyard at the centre of the campus is planted with grass and shade trees to create a cool, pleasant outdoor social space. The cooling effect of the courtyard vegetation also reduces the temperature of the air entering the classrooms through the south windows.

Roof Design: All classroom and laboratory blocks have a pitched roof with a raised central ridge. A continuous ventilation gap runs the full length of the ridge between the top of the roof and the underside of the ceiling, allowing hot air to escape by convection at all times. The roof is finished in light-coloured aluminium sheeting with a reflective surface that bounces solar radiation away rather than absorbing it as heat.

5.6.4 Materials

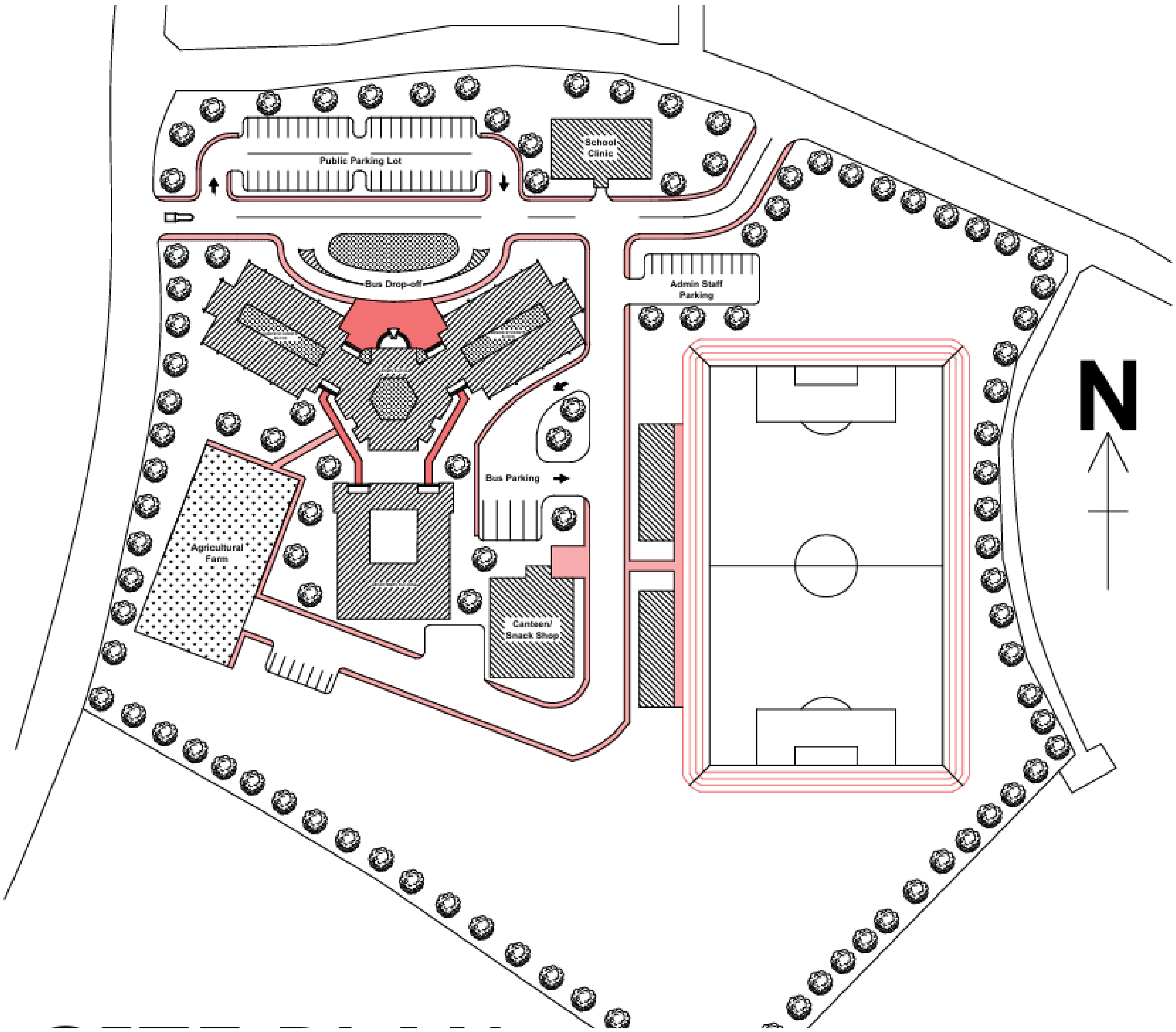
The materials used in the proposed school have been chosen for their local availability, their thermal performance in the Enugu climate, their durability, and their cost-effectiveness in a public-school building context.

1. **Walls:** 225mm thick sandcrete block walls throughout. The thickness provides useful thermal mass that absorbs heat during the day and slows its transmission to the interior. External and internal surfaces are plastered and painted in light colors.
2. **Roofing:** Long-span aluminium roofing sheets with a reflective finish on all buildings. The raised roof design with ventilation gap is used on all classroom and laboratory blocks.
3. **Floors:** Smooth cement screed base with ceramic tiles in classrooms, laboratories, and circulation areas, for durability and ease of cleaning.
4. **Windows:** Aluminium-framed louvered windows throughout all occupied spaces. Fixed glass windows are deliberately avoided in classrooms and staff areas to ensure natural ventilation is always available and adjustable.

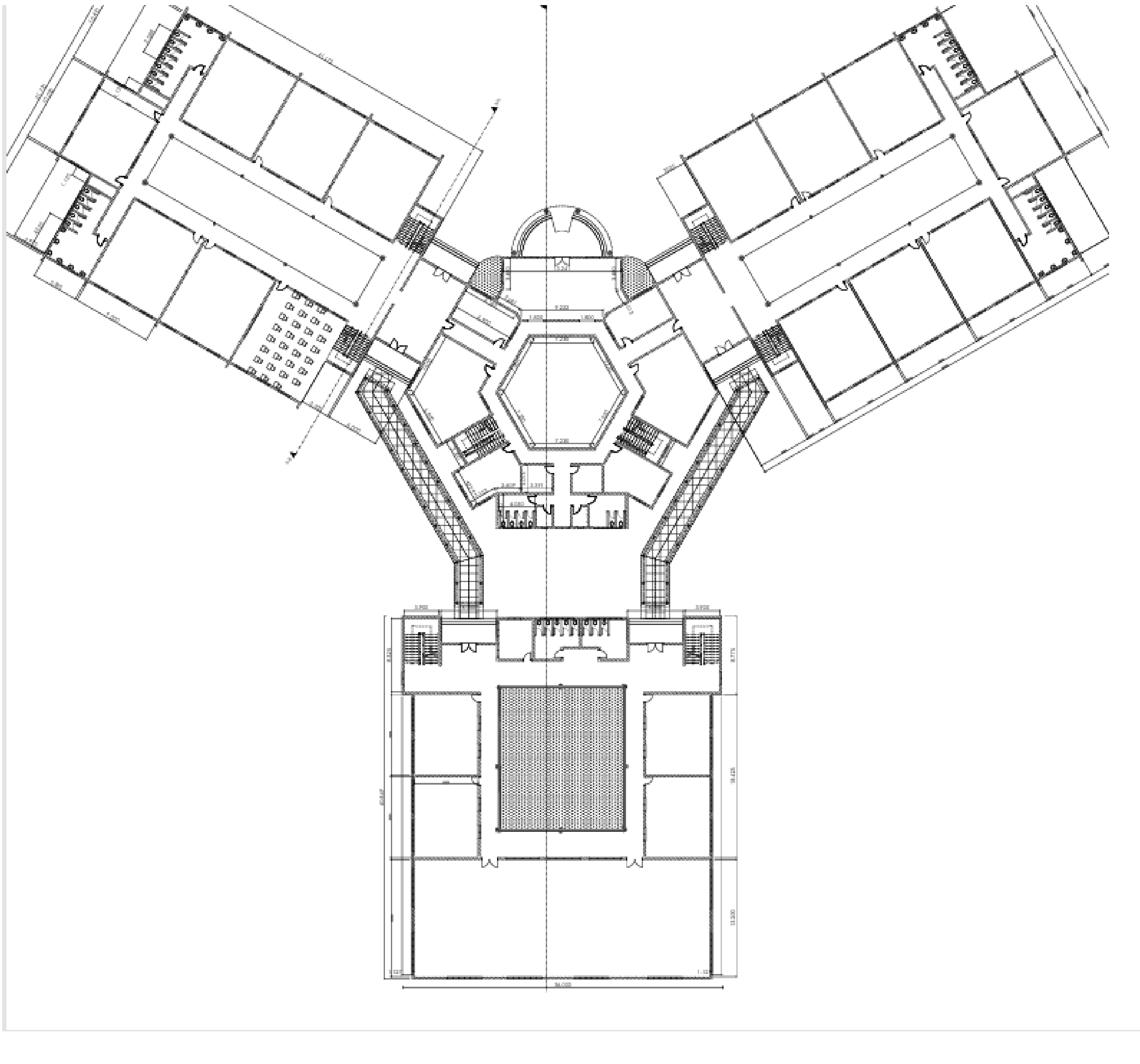
5. **Verandas and Covered Walkways**: Reinforced concrete slab roofs on concrete columns. The underside of all veranda and walkway slabs is painted white to reflect daylight back up into the adjacent classroom windows.

6. **Landscape:** Locally available grass species for all ground surfaces. Neem, mango, and African locust bean trees for canopy shade, chosen for their fast growth, large canopy spread, and availability in the Enugu area.

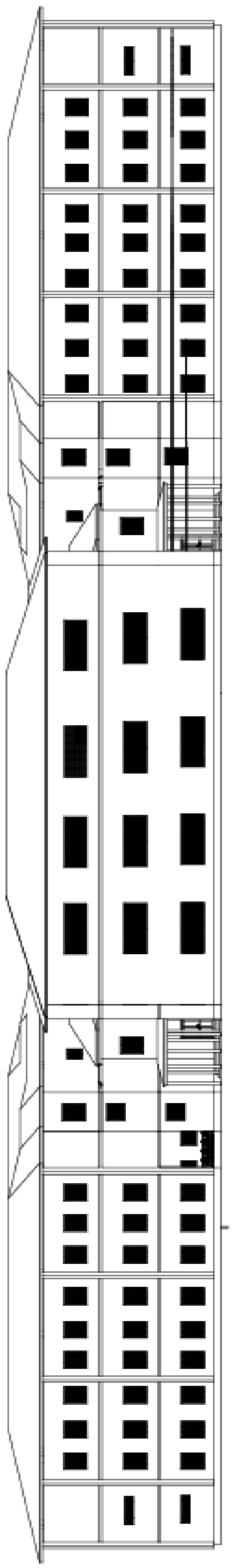
5.7 Presentation drawings with 3d



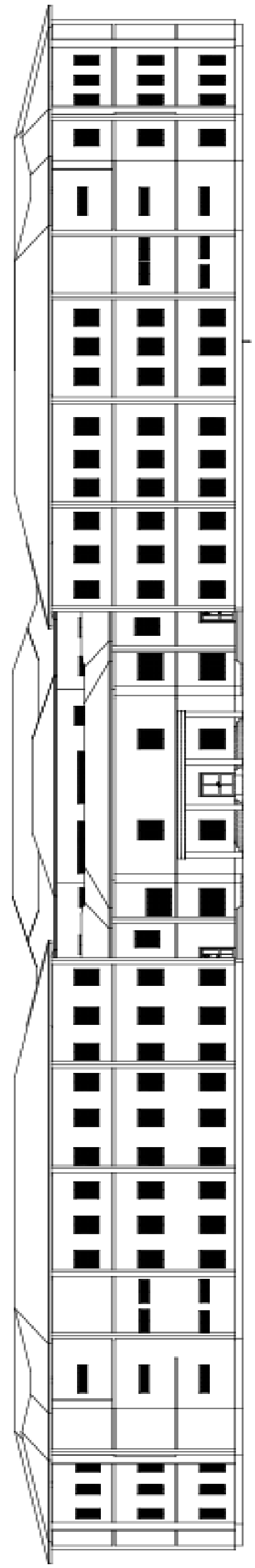
SITE PLAN



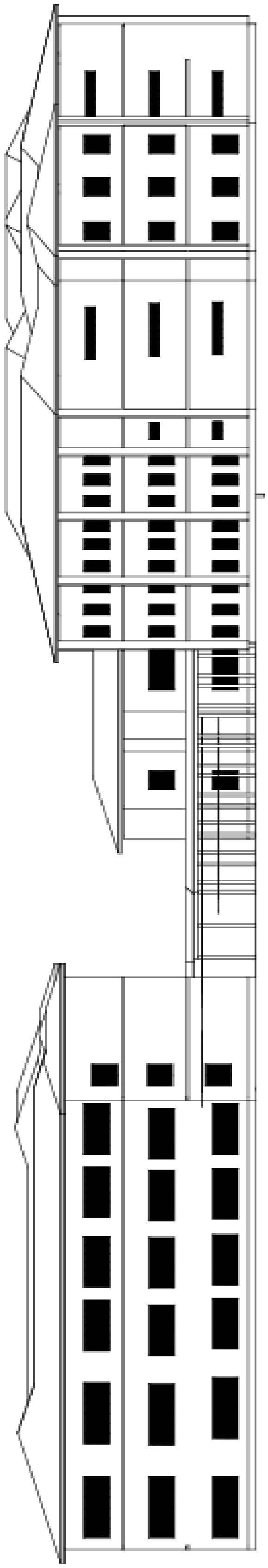
FLOOR PLAN



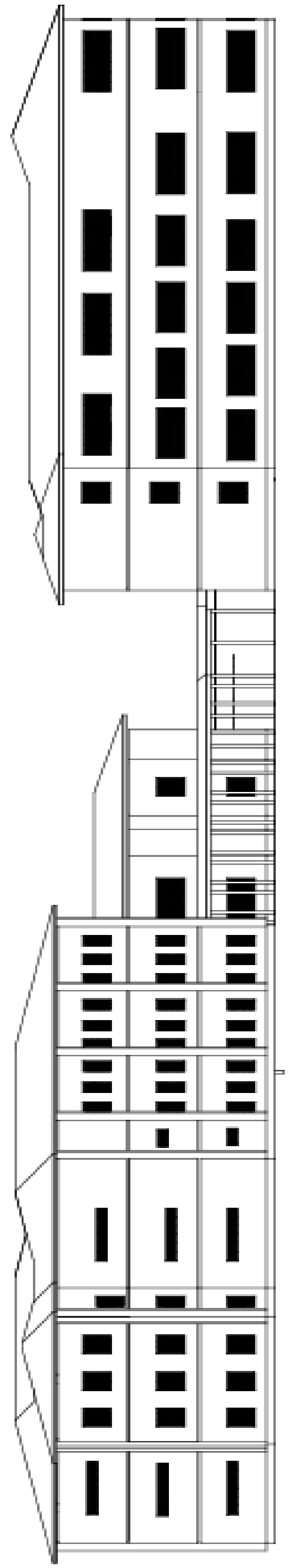
SOUTH ELEVATION



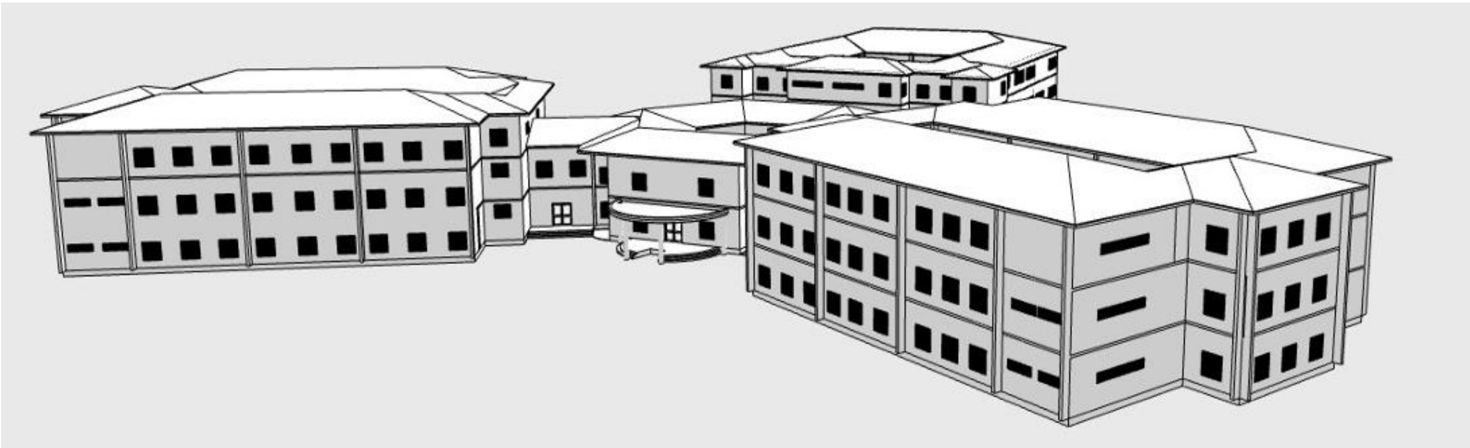
NORTH ELEVATION



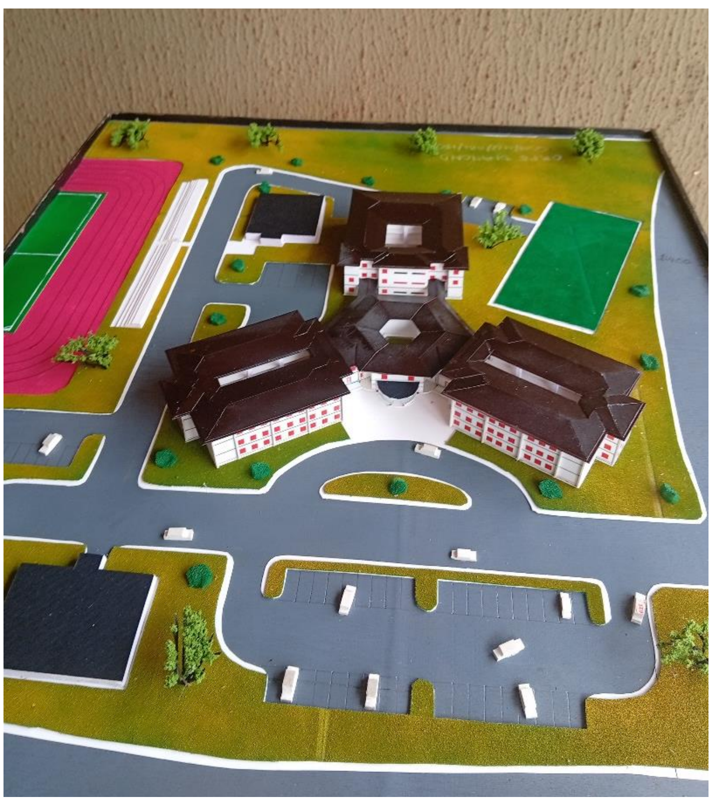
EAST ELEVATION



WEST ELEVATION



3D VIEW




MODEL

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0. Introduction

This final chapter brings the project to a close. It looks back at what the research set out to do and what was actually achieved, draws conclusions from the findings, and offers recommendations that could be useful to architects, policymakers, school administrators, and future researchers. It also reflects on what this project contributes to knowledge in the field of architecture and environmental design in Nigeria

6.1. Summary of Main Findings

On Bioclimatic Architecture and Passive Design: The literature review made it clear that bioclimatic architecture is not a new or experimental idea. It is a well-established, evidence-based approach with decades of research behind it, and it works. In the hot and humid climate of Enugu State, the most powerful tools available to the designer are correct building orientation, natural cross ventilation, solar shading, good daylighting, and landscape integration. None of these strategies requires expensive technology or imported materials. They simply require careful thinking at the design stage about how the building will relate to the sun, the wind, and the landscape around it.

On Indoor Environmental Quality and Learning: Perhaps the most compelling finding from the literature was the direct link between the quality of the school environment and how well students learn. Research consistently shows that students in thermally comfortable, well-ventilated, and well-lit classrooms perform better academically, are healthier, and attend school more regularly than those in uncomfortable buildings. This makes bioclimatic design not just an environmental or energy issue but a genuine educational issue, one that directly affects the life chances of the students who use the building.

On the Case Studies: Visiting two out of three local case study schools in person was one of the most instructive parts of this research. At Federal Government College Enugu, it was possible to feel directly the difference between a well-shaded, tree-lined outdoor corridor and a poorly ventilated lower-floor classroom. At Queen's School Enugu, the old colonial buildings with their wide verandas, high-pitched roofs, and louvred windows demonstrated that climate-responsive design does not need to be complicated or expensive it just needs to be thoughtful. At the University of Nigeria Secondary School Nsukka, the campus' comfortable environment showed how much a well-planted, low-density site can do for thermal comfort, even without any deliberate bioclimatic design strategy in the buildings themselves.

On the Study Area: The site analysis confirmed that the University Farm is an excellent choice for the proposed school. It is large enough, flat enough, open enough, and well-positioned enough to support a full bioclimatic school campus without major earthworks or infrastructure investment. The prevailing south-westerly winds blow directly across the open southern face of the site throughout most of the school year, making natural ventilation both practical and powerful at this location.

On the Design Proposal: The Open Book design concept brought together the symbolic and the functional in a way that felt genuinely satisfying. The V-shaped campus layout communicates the school's educational purpose through its form, while simultaneously acting as a wind-channeling device that improves the natural ventilation of every classroom in the building. Every design decision from the orientation of the classroom wings to the depth of the overhangs to the placement of trees was made for a clear reason rooted in the research.

6.2. Conclusion

This project began with a question: is it possible to design a secondary school in Ugwuomu Nike that is genuinely comfortable for the students and teachers who use it, without depending on air conditioning or electric fans, and without spending more money than a typical Nigerian public school construction budg*et al*lows? The answer, based on all the research and design work carried out, is yes.

The proposed bioclimatic secondary school demonstrates that passive design strategies: orientation, ventilation, shading, daylighting, and landscape can fully address the thermal challenges of the Enugu State climate when they are applied together as an integrated system from the very beginning of the design process. The building does not fight its climate. It works with it. And in doing so, it creates a school that will be comfortable to learn in, affordable to run, and built to last.

The Open Book concept gives the school a clear architectural identity that connects the building's form to its purpose. It is a school that looks like what it is: a place of learning, open to knowledge, and open to the world. It is hoped that this project will be of use not only to the Ugwuomu Nike community but to anyone in Nigeria who is looking for evidence that better, more thoughtful school design is both possible and necessary.

6.3. Recommendations

6.3.1 For the Design and Construction of the Proposed School

1. The bioclimatic strategies that define this design particularly the east-west orientation of classroom blocks, the raised roof ventilation gap, the depth of the window fins or overhangs, and the landscape strategy must be protected during the detailed design and construction process. These are not decorative features that can be cut for cost savings. They are the reason the building will be comfortable, and removing or compromising them would undermine the entire purpose of the project.

2. A soil bearing capacity test should be carried out on the University Farm site before structural foundation design begins, to confirm the appropriate foundation type for the local lateritic soil conditions.

3. Tree planting on the east and west sides of all buildings should start as early in the construction programme as possible. Trees take time to grow, and the sooner they are planted, the sooner they will begin to provide the shade they are designed to deliver.

4. Rainwater harvesting gutters, downpipes, and storage tanks should be included in the initial construction budget and not deferred to a later phase. The wet season provides abundant free water that should be captured and used from day one of the school's operation.

5. The school administration should prepare a simple maintenance plan specifically for the bioclimatic elements of the building: cleaning louvres regularly, checking roof vents for blockages, maintaining the landscape, and replacing any trees that do not establish successfully.

6.3.2 For Policy and Practice

1. The Enugu State Ministry of Education should consider incorporating bioclimatic design criteria particularly minimum ceiling heights, window-to-floor area ratios, mandatory cross ventilation, and solar shading requirements into the standard technical specifications for all publicly funded secondary school construction in the state. This would ensure that future school's benefit from the same passive design thinking applied in this project, without requiring individual architects to rediscover these principles from scratch each time.

2. Architecture schools and professional bodies in Nigeria should give more attention to the rich tradition of vernacular bioclimatic design in Nigerian building culture. The

wide verandas, high roofs, and courtyard typologies of traditional Igbo and other Nigerian building types are not outdated or irrelevant. They are locally proven solutions to locally specific climate challenges that contemporary architects should be drawing on more actively.

3. School boards and management committees across Enugu State should be encouraged to invest in landscape development as a priority. Planting large canopy trees around existing school buildings is one of the cheapest and most effective ways to improve thermal comfort on a school campus, and the benefits grow every year as the trees mature.

6.3.3 For Future Research

1. After this school is built and has been in operation for at least a year, a post-occupancy evaluation should be conducted to measure the actual indoor temperatures, air quality levels, and thermal comfort of students and teachers across different seasons. This kind of real-world measurement would provide valuable data on whether the predicted performance of the bioclimatic design strategies was achieved in practice, and what adjustments might improve performance further.
2. Future research should explore the potential for combining the passive strategies used in this project with small-scale active renewable energy systems, particularly rooftop photovoltaic solar panels. A school that is already designed to minimize its energy demand through passive design requires a much smaller solar installation to meet its remaining needs, making the combination highly cost-effective.
3. The Open Book design concept developed in this study could be a productive starting point for design explorations in other community building types in Nigeria; public libraries,

health centres, community halls where both symbolic clarity and bioclimatic performance are equally important.

6.4. Contribution to Knowledge

1. This study provides a fully documented, evidence-based bioclimatic school design for the specific hot and humid climate of Enugu State, Nigeria. It can serve as a practical reference for architects, students, and public agencies responsible for designing and procuring secondary school buildings in the region.
2. It develops and demonstrates the Open Book design concept, an original idea that unifies symbolic educational meaning and functional bioclimatic performance in a single architectural form. This demonstrates that meaning and climate responsiveness are not competing values in architecture; they can reinforce each other when the design process is approached thoughtfully.
3. It adds to the growing body of literature on bioclimatic architecture in the Nigerian and West African context by providing a specific, site-grounded case study of these principles applied to a complete secondary school programme in Enugu State.
4. It illustrates a clear and replicable design research methodology combining literature review, case study observation, and site survey that architecture students at Godfrey Okoye University and elsewhere can follow to produce design proposals that are genuinely evidence-based rather than intuitive or stylistically driven.

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