



**NATURAL LIGHTING AND VENTILATION IN A LIBRARY FOR GODFREY OKOYE
UNIVERSITY, MAIN CAMPUS UGWUOMU NIKE, ENUGU**

BY

**OKONKWO SOMADINA FAVOUR
U20/NAS/ARC/272**

**DEPARTMENT OF ARCHITECTURE,
FACULTY OF NATURAL SCIENCES AND ENVIRONMENTAL STUDIES GODFREY
OKOYE UNIVERSITY, UGWUOMIKE, ENUGU.**

JULY, 2026



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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE,
FACULTY OF NATURAL SCIENCES AND ENVIRONMENTAL STUDIES, GODFREY
OKOYE UNIVERSITY, ENUGU**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE
DEGREE OF BACHELOR OF SCIENCE (B.Sc.) IN ARCHITECTURE.**

SUPERVISOR: PROF C.B CHUKWUALI.

JULY, 2026

APPROVAL

Okonkwo Somadina Favour, Registration number U20/NAS/ARC/272, 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.

PROF C.B Chukwuali

(Project Supervisor)

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Signature

.....

Date

.....

External Examiner

.....

Signature

.....

Date

Arc. Chukwu Chinaechetam

(Head of Department)

.....

Signature

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Date

CERTIFICATION

I certify that this project entitled "**Natural Lighting and Ventilation in a Library for Godfrey Okoye University, Main Campus Ugwuomu Nike, Enugu**" was carried out by **Okonkwo Somadina Favour (U20/NAS/ARC/272)** under my supervision in the Department of Architecture, Faculty of Natural and Environmental Sciences, Godfrey Okoye University, Enugu. The work presented in this report is original and has not been submitted, either wholly or partly, for the award of any degree or diploma in this or any other institution.

Okonkwo Somadina Favour
(Student)

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Signature

.....
Date

Prof. C. B. Chukwuali
.....
(Project Supervisor)

.....
Signature

Date

DEDICATION

This project is dedicated to God Almighty for His guidance, protection, and grace throughout this work. It is also dedicated to my family and all who supported me morally and academically.

ACKNOWLEDGEMENT

I express my sincere gratitude to God Almighty for the strength, wisdom, and endurance He gave me to complete this project successfully. I am deeply indebted to my supervisor Prof. C. B Chukwali for the guidance, corrections, and encouragement offered throughout the work.

I also appreciate the lecturers and staff of the Department of Architecture for their contributions to my academic development. My heartfelt thanks go to my family and friends for their support, prayers, and understanding throughout this study. I also acknowledge the authors and researchers whose works were consulted in preparing this project.

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ABSTRACT.

The design of public libraries is an important aspect in creating a comfortable, functional, sustainable space which facilitates learning, research and community engagement. This research looks at the effect of natural light and ventilation in the design of a public library in Ugwuomu, Enugu State. With the growing demand for buildings that respond to the environment, using less energy and improving the comfort, health and productivity of occupants, the research was born. The study is designed to explore the benefits of the effective integration of natural lighting and air movement in library architecture, and its potential to support sustainable architecture.

The research method used was a mixed method which consisted of literature review, case study analysis, site survey and field observation. The data gathered were analysed to determine the climatic factors, the environmental factors and the passive strategies that will be applicable in the design of the Ugwuomu climatic environment. Special focus was placed on orientation of the building, the positioning of the windows, shading devices, cross ventilation, landscaping, and the selection of materials appropriate for climate conditions.

The results suggest the significant role of proper integration of natural lighting and ventilation in achieving visual and thermal comfort, improving indoor air quality, minimising reliance on artificial lighting and mechanical cooling systems, and achieving energy efficiency. The study also shows that passive design can greatly enhance the usability and environmental performance of public library buildings, while also creating comfortable and productive environments for people.

The proposed library design incorporates these principles by maximizing daylight penetration, effective natural air flow and by following sustainable design principles responsive to climatic conditions of the study area. The conclusion is that the natural lighting and ventilation conditions are the essential factors in the design of modern public libraries, which influences the satisfaction of users, environmental sustainability and reducing the cost of the library operation. It suggests that for planning and designing future public library projects, and for the design of other educational facilities in similar climatic zones, passive environmental design principles should be used.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Libraries are the cradle of knowledge, learning and intellectual growth and are the bedrock of academic and research work. Libraries are more than information centres; they offer a physical space for reading, critical thinking, co-operation and lifelong learning. Therefore, the architectural design of library buildings has an important influence on the academic achievement, productivity and health of the users. A well-designed library should provide a space conducive to learning, promote social interaction and make the user feel at ease and comfortable, while a poorly designed library should make it difficult for users to concentrate, reduce their productivity, and negatively impact their experience.

A proper library environment is essential that it has adequate natural lighting and natural ventilation. The light coming through the natural light brings richness to the user and creates a better spatial quality and perception of the space for the user. Likewise, proper natural ventilation provides good indoor air quality, thermal comfort and generates healthier indoor environments. The indoor environment is important because library users spend long hours reading and studying and doing research work. The quality of the indoor environment has a great impact on the process of reading and studying, and therefore it affects the comfort, health and performance of users in the library.

Studies have indicated that natural light exposure helps regulate the human circadian rhythm, which regulates various physiological processes including body temperature, mood, sleep and wake cycles. Lack of natural light and poor ventilation, on the other hand, can interfere with these biological processes and cause a loss of focus, fatigue, discomfort and general poor health. In

addition, by delivering healthier and more comfortable indoor environment, natural lighting and ventilation benefits the body's immune system, metabolic health and psychological well-being.

The increase in natural lighting and ventilation also contributes to the sustainability of library buildings by minimizing the use of artificial lighting and mechanical cooling systems, resulting in reduced energy consumption and operational costs. Therefore, implementing successful natural lighting and ventilation design is a vital consideration in developing healthy, comfortable, energy-efficient and environmentally sustainable learning spaces that meet the academic requirements of school users, researchers, library users and the community, Pniewska (2012); Wijesundara & Gamage (2021); Hauge (2015).

The use of daylight and ventilation is one of the important factors to improve the visual comfort in a library. The natural light is a moving light, which varies over the course of a day, so that the occupants have a visual indicator of natural day and night. This dynamic quality contributes to the mood, comfort and overall well being of users of the Library in a positive way. The most effective integration of natural light with appropriate artificial lighting systems is to ensure that there is enough light to do a range of visual activities in various environments such as reading, studying and similar activities. This will help in making the learning environment more comfortable and productive, and will assist in reducing energy use and carbon emissions due to artificial light.

Natural lighting and ventilation are essential in sustainable library designs as they contribute to both healthy and happy library users and environmental sustainability. Where artificial lighting and mechanical ventilation are necessary, it should be connected with natural environmental systems, rather than in place of them, under certain circumstances. Natural light is a part of visual comfort, circadian control and helps to achieve psychological comfort, natural ventilation helps to

control indoor air quality, thermal comfort and prevents indoor pollution. All of these factors contribute to better healthier learning, concentration and study environments indoors.

The main function of libraries is to provide space for visual activity, such as reading, writing, research etc., and the appropriate amount of daylight and good natural ventilation become important for good visual performance and good thermal comfort, respectively. Library users' attitude to study can be enhanced and their motivation to study well maintained through the provision of an effective library with good light and air circulation and the users' interaction with each other in the library learning areas. In addition, research has demonstrated a beneficial effect of natural light on the mood, cognitive function and social behaviour of the users, making the inclusion of natural light an important consideration in the design of a library. Similarly, the natural ventilation is effective for improving the people's comfort and health, and the library environment is better, and supports sustainable architectural practice, Pniewska (2012); De Carli *et al.* (2008); Ridzwan Othman & Mohd. Mazli (2012).

1.2 Statement of the Problem

Libraries are no longer just a repository of books but are now becoming spaces of learning, socialization, and innovation. Learning areas in these institutions continue to be necessary for students who need to acquire knowledge, think critically, explore and be creative in a conducive environment. Lighting, natural or man-made, has visual and non-visual effects on human behaviour, including productivity, mood, attention and circadian entrainment. It is therefore a key factor in the regulation of sleep patterns and immune function. However, the current situation in library design and management does not consistently prioritize natural light, although its positive effects on the comfort, health and academic performance of students have been proven. Despite the positive effects that have been reported from previous studies of natural light on the wellbeing

and productivity of students, there are currently no formal guidelines on the integration of natural lighting within library design (Bellia *et al.*, 2013; Sternheim, 2016; Ridzwan Othman & Mohd Mazli, 2012; Pniewska, 2012; De Carli *et al.*, 2008).

1.3 Aim and Objectives of Research

1.3.1 Aim

The aim of this research is to evaluate natural day lighting and ventilation strategies for improving impact on visual comfort, energy efficiency and satisfaction levels of library users, specifically focusing on the university library setting.

1.3.2 Objective

1. To examine the principles and strategies of lighting and ventilation in library design.
2. To identify environmental and architectural factors that affect daylight and airflow in library spaces.
3. To review literature and case studies related to library environmental design.
4. To develop a design guidelines that provides effective comfort, functionality, and energy efficiency in the proposed Godfrey Okoye University main campus library.

1.4 Research Question

1. What principles guide effective lighting and ventilation in library buildings?
2. How can daylight and airflow be improved through architectural design?
3. How can the findings of the study be applied to produce a suitable public library design?

1.5 Significance of the Study

The importance of this study is the proof of the effect of lighting and ventilation on the performance of public library buildings. Sufficient environmental design (room layout, lighting, acoustics) promotes reading comfort and concentration, energy efficiency and building sustainability. It also offers valuable advice to architects, planners, university administrators and students in educational facility design.

The study should also be relevant to Enugu state since careful consideration has to be taken of the sun, heat and airflow being experienced in the state. It is possible to design a library that better meets the needs of the university and local community if it is designed with daylight and ventilation in mind. It can also be used as a reference for future public buildings in similar environments.

1.6 Scope and Delimitation

1.6.1 Scope

This study is based on the design of a new public library at Godfrey Okoye University, Uguwuomu Enugu State. This deals with light, daylighting, ventilation, thermal comfort, shade, orientation and other architectural solutions. The work will only consider architectural issues, and will not involve full structural or mechanical engineering analysis.

1.6.2 Delimitation

1. These research will focus only on university library, not public library.
2. These research will only focus on library with floor-to-ceiling windows, and some areas smaller windows.
3. These will also focus on a certain number of library users, at least 80,000 users in a week.

1.7 Organisation

1.7.1 Chapter One: Deals with the introduction of the study.

1.0 Introduction

1.1 Background to the study

1.2 Statement of the problem

1.3 Aim and objectives of the study

1.4 Research questions

1.5 Significance of the study

1.6 Scope and delimitation

1.7 Organization of the thesis

1.8 Definition of special terms of a library.

1.7.2 Chapter Two: In this study draws upon relevant and authoritative sources of information, including expert opinions and research findings, which are mentioned throughout the work as appropriate to support and substantiate the arguments presented.

2.0 Literature Review and Case Studies.

2.1 Conceptual Framework.

2.2 Theoretical Framework.

2.3 Review of related literature

2.4 Summary of literature review and case studies.

1.7.3 Chapter Three:

This section provides the background information on the study.

3.0 The Study of Ugwuamu Nike.

3.1 Geographical location and setting.

3.2 Site selection criteria.

3.3 Brief history of the study area.

3.4 Physiography, climate and vegetation.

3.5 Population, culture and economic development.

1.7.4 Chapter Four: Present the results of the research on the effects of natural lighting and ventilation on library users.

4.0 Research Methodology.

4.1 Research Design – review, survey, case studies, quasi-experimental, experimental research.

4.2 Data needs and sources

4.3 Population of study and sampling procedure (if applicable)

4.4 Methods and instruments for data collection (“)

4.5 Methods of data analysis and analysis (“).

1.7.5 Chapter Five: Analyze the results and discuss the implications for library design and library management.

5.0 Design Synthesis and development.

5.1 The design brief.

5.2 Design requirements for activities/planning data (Standards, anthropocentric, etc.)

5.2 Schedule of accommodation.

5.3 Special consideration.

5.4 Site inventory and analysis.

5.5 Data analysis and presentation.

5.6 Design concept and design proposal.

5.7 Presentation Drawings with 3D.

5.8 Detailed Drawings and Physical Model (as appropriate)

1.7.6 Chapter VI: Summarize and Conclusion.

6.0 Conclusion and Recommendations.

6.1 Summary of findings or main issues.

6.2 Conclusion.

6.3 Recommendations.

6.4 Contribution to knowledge.

1.8 Definition of Special Terms

1.8.1 Terms

Some terms used in a library include:

Definition of Special Terms

1. The Public Library: An institution that is open to the public and offers free access to books and information resources and learning facilities for the purposes of education, research, and learning throughout life.
2. Natural Lighting: The use of natural light (sunlight) in the interior of a building using windows, skylights and other building openings, with a smaller need for artificial light.
3. Natural Ventilation: A technology that uses natural forces like wind and the thermal buoyancy of air to improve indoor air quality and thermal comfort within a building.
4. Daylight: Natural light from the sun and sky to lighten the interior of a building during the day.
5. Visual Comfort: The state of maintaining light to perform visual work without eye strain, glare or discomfort.
6. Thermal comfort: Condition of satisfaction of the occupants with the temperature and air flow of indoor environment in a building.
7. Indoor Air Quality (IAQ): Quality of air in a building as affected by the ventilation, temperature, humidity and levels of pollutants.
8. Passive Design: Designing a building using passive elements from nature to enhance the comfort and minimise energy use.
9. Building orientation: Orientation of a building that is designed to promote good daylight and air movement and reduce unwanted heat gain.

10. Cross Ventilation: A natural ventilation approach that uses openings on opposite sides of a building to allow air to flow through the building.
11. Glare: Direct or reflected bright light that causes visual discomfort or lowers visual acuity.
12. Shading Devices: Overhangs, louvers and fins used for architectural purposes to control sunlight, glare and heat gain.
13. Sustainable Architecture: The design of buildings that are energy efficient, use fewer resources and resources more efficiently, and are designed to benefit their occupants' health.
14. Energy Efficiency: Application of design techniques and technologies to minimize energy use within a building and use while not compromising its performance.
15. Reading Space: A specific space in a library that is designed to be a place of peace, comfort and light for a person to read and study.

CHAPTER TWO

LITERATURE REVIEW

Artificial lighting has always complemented natural lighting. With the advent of industrial and technological revolution, the significance of artificial and natural light in a building has also changed and the development of many artificial light sources like fluorescent lamps and electric bulbs has made it possible to use a variety of lighting systems to produce light. In modern architecture and construction, natural light and ventilation have taken center stage due to the increasing focus on sustainability and green building design.

Light and air are integral part of library space and have been found to have positive impact on library environment, student's learning and comprehension, library's aesthetic value, library's job satisfaction, student's mood, absenteeism and improved productivity. Moreover, natural lighting and ventilation contribute to aesthetically pleasing environments and enhances user comfort, interaction, and engagement. Sufficient natural lighting and ventilation also helps staff operate at their best as it creates a comfortable work environment for them which improves visual comfort and overall staff health. For library buildings, large windows are used to allow natural light and fresh air to enter interior spaces. If not designed and controlled properly, however, the large glazed openings can cause the building to gain or lose more heat than it should, causing discomfort in the building and a higher energy use.

The theoretical framework of this study is presented in this chapter which is supported by reviewing related literature in the field of University Library. The emphasis of the review is the conceptual understanding of university libraries, particularly the key factors in using library facilities for university studies. In particular the chapter reviews literature on the following aspects:

- i. History of library.
- ii. Review of some historical views on natural light and ventilation within a library. Some historical views on natural light and ventilation in a library.
- iii. University libraries and academic performance

A. History of Library

A library is a collection of books and possibly other materials and media that is available for use by its members and members of related institutions. Libraries provide physical (hard copies) or digital (soft copies) materials, and may be a physical location, a virtual space, or both. Libraries are classified based on the type of services it offers.

A university library is a library set up to provide service to the students and staff of the university, irrespective of age, social standing and profession of the users. Academic library's role is to meet the needs of students, teachers, professors and others. By providing reference and other materials which is relevant to their academic courses. Academic category is that of all the School, College or University libraries. Libraries can range in size and could be operated and managed by a government, an institution (schools, museums etc), a corporation or an individual.

Library buildings frequently offer study spaces, room for group studies and collaboration, and may offer public facilities for accessing their electronic resources, including computers and Internet access.

B. Historical Background on Natural Light and Ventilation inside the Library

The significance of natural lighting and ventilation in library spaces has changed over the years. Sunlight was the initial lighting source and natural ventilation was the first method of ventilation used in a library, but as technology has evolved, libraries increasingly rely on artificial light and mechanical ventilation.

An important part of this literature review is to find a historical background of the use of natural light and natural ventilation in different forms in the built environment. It examines the symbolic meaning of natural light and how architects have manipulated the natural light and ventilation in a building to produce various spatial experiences. The history of windows and natural lighting is closely related to the history of architecture, as the design and arrangement of windows have always had an impact on the appearance and function of buildings.

In the Middle Ages, windows were designed mostly for a purpose—they provide interior areas with natural lighting and ventilation—and the shape, size and position of windows depended on their purpose. This altered during the Renaissance when windows became formal architectural features and became part of building elevations, and lost their direct relationship with the interior space. This allowed architects to create more flexible designs for interior spaces in the center of buildings, where natural light and ventilation could be achieved from a number of different roof openings like clerestory windows and skylights.

By the 1930s, the Modern Movement in England had embraced the use of large glass facades and wrap-around corner windows which were part of the first large-scale architectural attempts to connect the interior and exterior spaces. The design features innovative solutions that optimised the penetration of natural light and improved natural ventilation whilst also fostering greater visual connection with the surrounding context.

It is generally believed that natural light has symbolic significance, beyond its role of providing light to the interior spaces, this association with the symbols of cleanliness, purity, knowledge and spirituality has a historical origin. Likewise, natural ventilation has been known for a long time to enhance the quality of indoor space, thermal comfort and the health of the occupants. Natural light

and ventilation have also been integral parts of the built environment since then and are vital to the comfort, health and productivity of users, especially in learning environments like libraries.

Phillips (2004); Moore (1985).

C. The relationship between University Libraries and Academic Performance.

A university library is a library which is a part of someone's higher education institution, generally a college or university. These libraries deliver many resources, services and facilities to assist the Institution's academic programs and research efforts. It provides access to an extensive range of resources, such as books, journals, research papers, and multimedia materials. They also offer a variety of study areas, research and technology support, and access to computer, printer and scanner. It also boasts unique and rare collections, spaces for collaboration and creativity, and community outreach and engagement. In general, university libraries are an important tool for university students and faculty members' academic success by providing the necessary resources and support to help them learn, research and innovate.

A modern university library interacts with different information networks to give more users easy access to e-resources/data so that they can access the desired information even from their workplace. In India, for instance, the facility of INFLIBNET is being utilised in University libraries for the same purpose. Ashikuzzaman, 2013.

2.1 Conceptual Framework

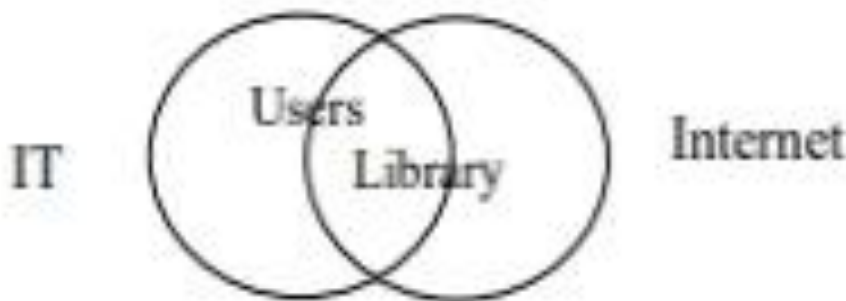


Figure 1: Two-way connections between users and library.

A library is created to provide services for users. The effect of digital and networked environment change has transformed a lot in library service features. The internet is used extensively in library and has a profound effect on library users. In every stage library users have always wanted to have access to library resources and it is important to know that libraries were there to be used when required, although it is not really important to visit them very often. The questions facing today's research is whether the work libraries performed in the past is still necessary in today's design.

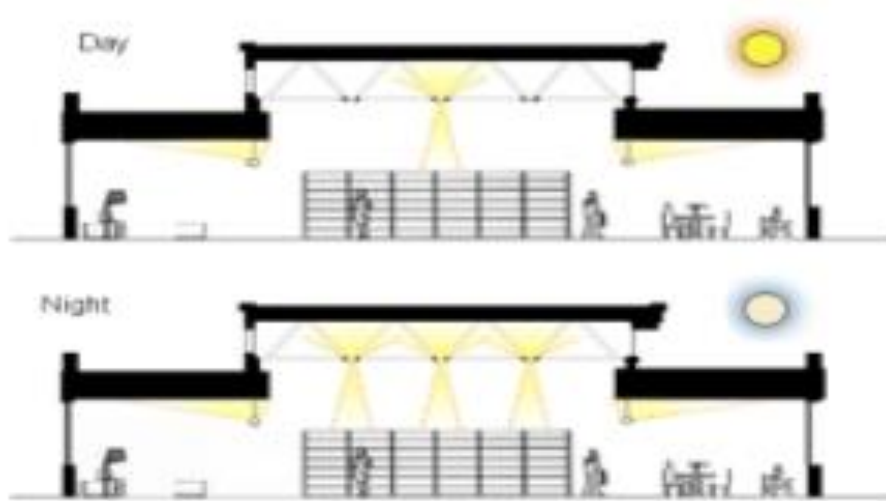


Figure 2: By day, the outer luminaries are switched off in response to day lighting levels. As evening approaches and day lighting diminishes, outer luminaries switch back on.

The use of natural lighting and ventilation in modern libraries has significantly improved the quality and functionality of various spaces, particularly reading areas. As universities strive to provide an environment that supports students' academic success and overall well-being, library management must ensure that library facilities are comfortable, healthy, and conducive to learning. Integrating natural lighting and ventilation into library design enhances visual comfort, indoor air quality, and thermal comfort, thereby creating an environment that encourages reading, studying, and research.

A university library serves as an essential academic resource where students, lecturers, and researchers access a wide range of information materials, including books, magazines, journals, newsletters, dictionaries, encyclopedias, atlases, almanacs, periodicals, pamphlets, and other reference resources. To borrow library materials, students are typically required to obtain a library card containing relevant identification details such as their full name, registration number, faculty, and photograph. During the borrowing process, students present their library card together with the call number of the required book, while the loan transaction is recorded with the corresponding borrowing and return dates.

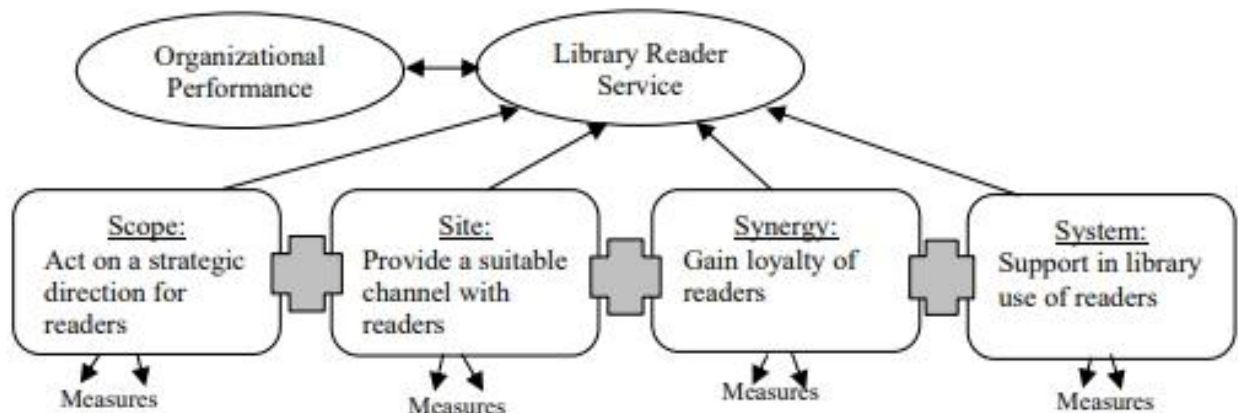


Figure 3. The conceptual framework of 4S in library reader service.

2.2 Theoretical Framework

The theoretical framework provides an understanding of how natural lighting and ventilation influence the comfort, health, and productivity of library users. It also helps to identify potential challenges and limitations associated with the provision of natural lighting and ventilation, thereby informing strategies for improving the quality of indoor library environments. By understanding this framework, architects and designers can make informed decisions when designing library spaces that optimize natural lighting and ventilation to enhance user satisfaction and building performance.

The framework encompasses theories explaining how the human visual system responds to natural light, how exposure to light influences circadian rhythms, and how different lighting conditions affect mood, concentration, and productivity. It also incorporates principles of natural ventilation, including airflow patterns, thermal comfort, and indoor air quality, all of which contribute to occupants' health and well-being. Furthermore, the framework considers how natural light is distributed within interior spaces, how it interacts with building materials and surfaces, and how users perceive and evaluate the quality of indoor environments. Collectively, these concepts provide a comprehensive foundation for understanding and enhancing natural lighting and ventilation in library buildings, thereby promoting comfortable, healthy, and energy-efficient learning environments.

2.2.1 Hypothesis One: The Lighting and ventilation Quality

The lighting quality, developed by the Illuminating Engineering Society of North America (IESNA), is a framework for assessing the quality of lighting. It's based on four main factors: Visual Comfort, Visual Performance, Non-Visual Effects, and Energy Efficiency.

2.2.1.1 Visual comfort

This refers to the extent to which people find a lighting environment to be comfortable. It can be affected by a number of factors, including glare, flicker, color, and intensity. Glare is a visual discomfort caused by excessive brightness, and it can be reduced by using adjustable lighting controls and diffuses. Flicker is a rapid, rhythmic change in lighting intensity, and it can cause headaches, eyestrain, and fatigue. The color of light can also affect visual comfort, with warmer colors generally being more comfortable than cooler colors. Finally, lighting intensity can be adjusted to find the right balance between bright and dim light.

2.2.1.2 Visual performance

This refers to how well people can see and perform tasks under a given lighting environment. For example, reading requires a higher level of visual performance than simply moving around a space. The level of contrast between light and dark areas is also important, as it affects how easily people can distinguish between different objects.

2.2.1.3 Non-visual effects

These refer to the ways in which light affects people's circadian rhythms and mood. Circadian rhythms are the body's natural cycles of sleep and wakefulness, which are regulated by exposure to light. Exposure to light during the day helps to keep the circadian rhythm in sync, while exposure to light at night can disrupt it. Lighting that is too bright or too dim can also affect people's moods, with bright light often being associated with positive emotions and dim light with negative emotions.

2.2.1.4 Energy efficiency

This refers to the amount of energy used to provide a given level of lighting. Energy efficient lighting can help to reduce costs and environmental impact. There are a number of ways to improve the energy efficiency of lighting, including using LED bulbs, daylight harvesting, and dimming controls. LED bulbs use less energy than traditional incandescent bulbs, and they also last longer.

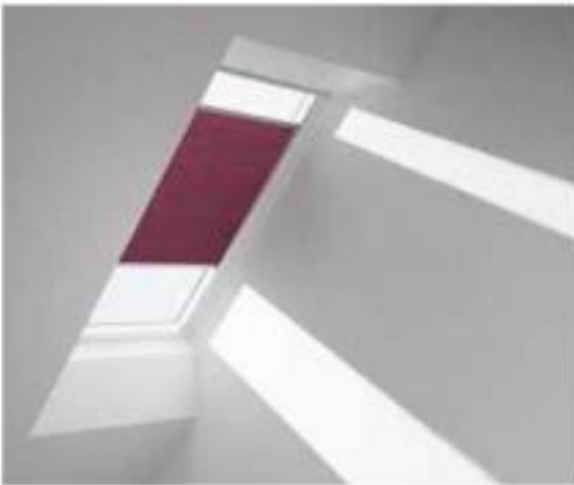
2.2.2 Hypothesis Two: natural lighting and ventilation Strategies



Interior Shading, Venetian blind



Exterior Shading, roller shutter



Interior shading, pleated blind



Exterior Shading, Awning blind

Fig. 4: Samples of Internal and External Shading Strategies

2.2.2.1 Glazing and Windows

Glazing, as a material used for windows and facades, serves several important purposes in architecture. Not only does it provide an avenue for natural light to illuminate indoor spaces, but it also establishes a visual connection between the interior and the surrounding environment. In essence, glazing is classified into three main types, as follows:

- I. Clear Glazing.
- II. Tinted Glass.
- III. Miscellaneous Glazing, includes:
 - i. Patterned Glass,
 - ii. Wired Glass,
 - iii. Laminated Glass,
 - iv. Glass Blocks.

2.2.2.2 Side Window

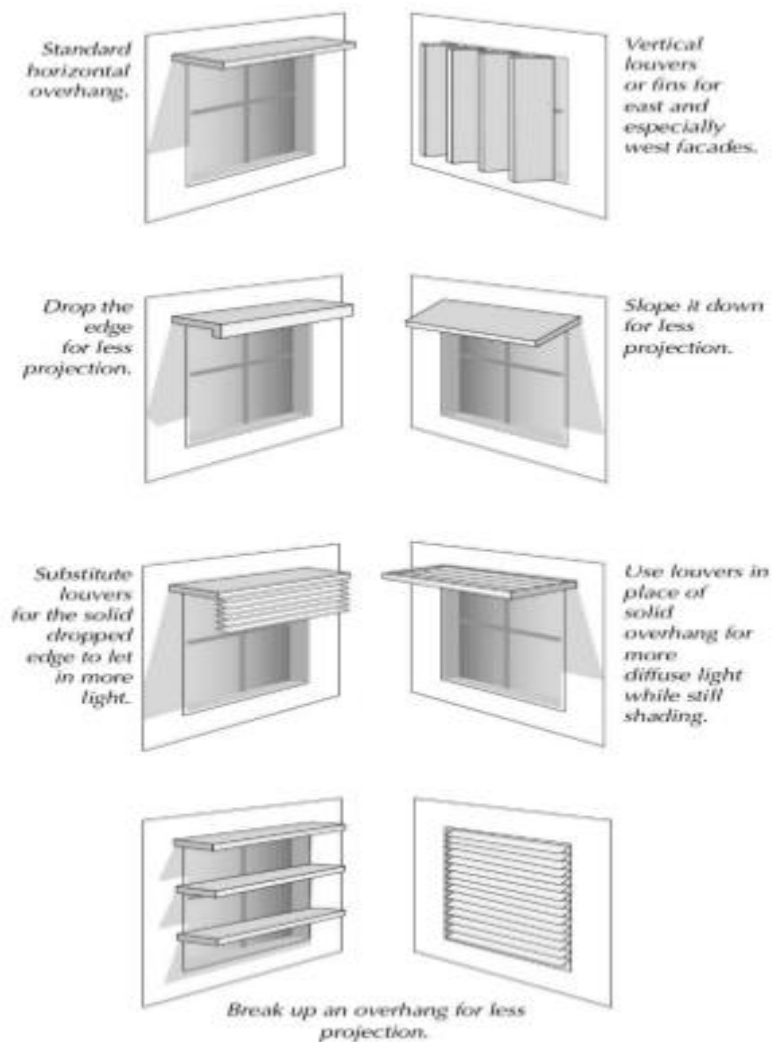


Figure 5: Samples of Basic External Shading Strategies for Side Windows.

Side windows, when positioned strategically, can effectively regulate the amount of sunlight that enters the library. Various factors come into play, such as the proportion of the window to the wall, its orientation, and the state of the sky. If natural light and ventilation is only entering from a single side window, it can create an uncomfortable visual environment due to the stark contrast between the bright light at the window, (*fig 6* and *fig 7*) and the darkness in the depths of the space.

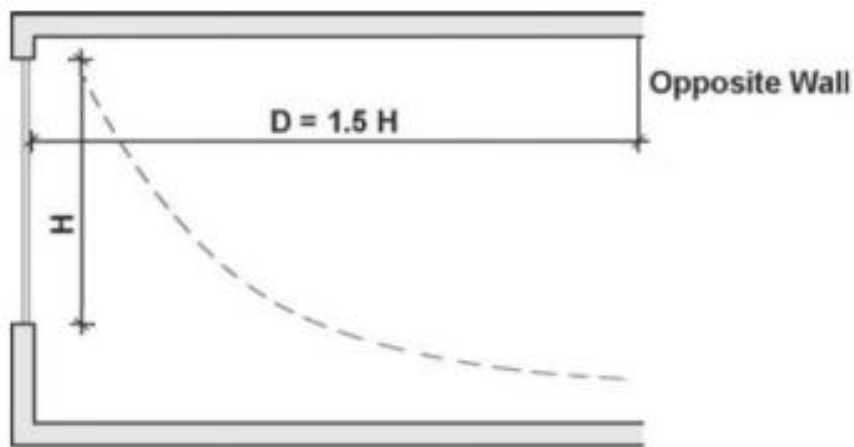


Figure 6: Daylight Effective Depth (D) when Penetrate through Side Window with (H) Height.

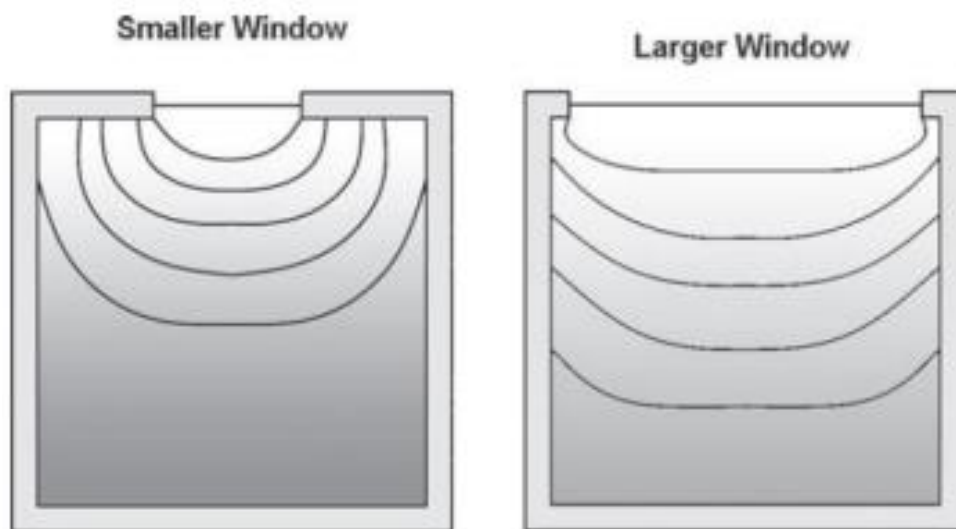


Figure 7: Iso-contour Curves of Daylight Pattern through Small and Large Windows.



Figure 8: Balanced lighting Distribution by Two Adjacent Side Windows.

2.3 Review of Related Literature

However, recent studies have shown the importance of the role of natural lighting and ventilation in improving the experience and satisfaction of library users. It has been proven that provision of natural light combined with a good ventilation will enhance the perceived spatial quality, indoor environmental quality, and users' well-being. The natural lighting and ventilation of library spaces are associated with increased comfort and satisfaction among library users compared to those mainly using artificial lighting and mechanical ventilation. Additionally, natural lighting, thermal comfort, and IAQ plays a significant role on users' concentration, reading efficiency and academic productivity. This results indicates that in the university libraries, the provision of natural lighting and ventilation makes a significant contribution to creating comfortable and effective learning environments.

The effects of natural light & air on energy efficiency and environmental sustainability of buildings has also been studied recently to evaluate the contribution of natural light & ventilation to library buildings. Energy efficient buildings can utilize natural light to help cut down on the need for

artificial lighting in the daytime, and can also take advantage of natural ventilation to help reduce the need for mechanical cooling systems, which in turn decreases energy use and operational costs. Architectural elements that help to improve natural lighting, enhance airflow and keep the temperature comfortable have been identified, including skylights, clerestory windows, light shelves, operable windows, courtyards, shading devices and thermal mass. Thus, the inclusion of natural light and ventilation in library design not only improves the health, comfort and satisfaction of the people who use it, but also helps to improve building performance and to help the library in its conservation of the environment.

Edwards, L., & Torcellini, P. (2002); Lechner (2015); Szokolay (2014); Olgyay (2015); Givoni (1998); Fanger (1970); Wong and Huang (2004); CIBSE (2015).

2.4 Case Study

These deals with Case Studies of the building type. The merits and demerits of the design would be analyzed to play a role in the final design.

2.4.1 Nnamdi Azikiwe Library, UNN, Enugu State

Location: UNN University of Nigeria, Nsukka.

Date of Commissioning: Library began in 1960, then relocated to a bigger building on 9th March, 2009.

Capacity: 735,157 collection of books and 99,760 bound volume of journals.

Structure: It is a four floors building, which includes a basement or ground floor, a first floor and two other upper floors.



Figure 9: Nnamdi Azikiwe library, UNN Nsukka, Enugu state..

Facilities: Basement – Acquisition section, cataloging section, exhibition center, bindery section, Bibliography, conveniences.

First floor – Reference section, circulation, reading halls, administration, conveniences.

Second floor - Serial section to the left, social science libraries/ humanity to the right.

Third floor – CBT center to the right, Africana/Nigerian section, United Nations and Government document archives to the left.



Figure 10: Nnamdi azikiwe library, UNN, Enugu state.

Merits

1. The structure gives an attractive and inviting appearance.
2. The library Central location offers convenient accessibility for the users.
3. There's an extensive parking lot that accommodates a large number of visitors and staff.
4. A Dual entrance design to Separate access points for both staff and users.

Demerits

1. Incomplete construction, like the lift areas, have been left unfinished.
2. Insufficient ventilation in basements.
3. Inadequate basement lighting.

2.4.2 Kenneth Dike Library , Oyo State, Nigeria

Location: University Of Ibadan, Ibadan, Oyo State (South-West Region).

Date of Commissioning: 17th November, 1954

Capacity: Collection of over 700,000 items and volumes.

Structure: The library is a four storey building.



Figure 11: Kenneth Dike Library , Oyo State, Nigeria

Facilities: a general reading room, a 24-hour reading space, a postgraduate research library, individual study carrels, a sound-proofed group discussion room, an e-research library, a multimedia e-classroom, a digitization chamber, an IT systems unit, a secure Africana section, an Arabic books and manuscripts collection, a serials stack and microfilm area, an exhibition gallery, a mandatory cloakroom, catalogue and collection development divisions, and a basement bindery and repro-graphic studio.



Figure 12: Interior Of Kenneth Dike Library , Oyo State, Nigeria

Merits

1. There are wide windows that allow adequate natural lighting.
2. Proper use of sun shading devices.
3. The security unit is centrally located.
4. The provision of a garage for delivery of books in case of rainy seasons.

Demerits

1. The site is located in a noisy area.
2. Very little parking lot for both the staff and library users.
3. Not enough reading halls.
4. No outdoor reading spaces.

2.4.3 Kashim Ibrahim Library, Kaduna State.

Location: Ahmadu Bello University (ABU), Zaria, Kaduna State (North West Region).

Date of Commissioning: 10th December 1976.

Capacity: Collection of above 500,000 items.

Structure: The A massive three story monolithic building covering 13,000 square meters.



Figure 13: Kashim Ibrahim Library, Kaduna State.

Facilities: Ground Floor – Right wing – Contains the main reference section, general exhibition hall, a casual reading parlor, central card catalogue, periodicals/serials unit, and the main book bindery and repro-graphs darkroom.

First Floor – Houses the University Librarian administrative wing, main staff lounge, an audio-visual media room, a corporate conference hall, and two large general reading wings.

Second Floor – Reserved for the Postgraduate reading section, the Rare Books archives, and special thesis/dissertation collections.



Figure 14: Interior of Kashim Ibrahim Library, Kaduna State.

Merits

1. Acoustic Design where considered in flooring and handrail.
2. High Headroom where considered to improve air Circulation.
3. There's good functional Layout for space Utilization.
4. Elaborate Glazed Windows for improved Lighting.

Demerits

1. Absence of enough conveniences.
2. Limited ICT Capacity, Resulting in an overflow of Users.
3. Absence of bindery section for worn out Books.
4. Inadequate Parking Facilities.
5. Poor Roof Construction.

CHAPTER THREE

THE STUDY AREA

Enugu State (Igbo: Òra Enugu) is situated between the South East geopolitical zone of Nigeria to the north are the states of Benue and Kogi, east and Southeast are Ebonyi, South is Abia, and West is Anambra State. The state is named after its capital and biggest city, Enugu. The city became a township in 1917 and was named Enugwu-Ngwo. Due to the rapid expansion towards areas owned by other indigenous communities, it was renamed Enugu in 1928.



Figure 8: Location of Enugu in Nigeria, Coordinates: 6°30'N 7°30'E



Figure 15: Enugu map

The modern Enugu State has been populated by different ethnic groups, the Igbo people and minority of the Idoma, Igala people in the Etteh Uno community in the Igbo Eze North Local Government Area of Enugu State for a number of years. Prior to the coming of Europeans, the present Enugu State was part of the medieval Kingdom of Nri and the Arochukwu based Aro Confederacy which was defeated by the British troops in the early 1900s in the Anglo-Aro War. Post-war, the British administration made the territory part of the Southern Nigeria Protectorate and in 1914 this was incorporated into British Nigeria, and after the 1949 massacre of striking coal miners in the Iva Valley, Enugu became a symbol of anti-colonial resistance. Economically, Enugu State is based around trading, manufacturing mainly plastic manufacturing (but recently, China opened a factory called Dongfeng) and services along with agriculture, mainly of yams, rice, cocoyam, oil palm, and cassava.

3.1 Geographical Location and Setting

The proposed location of the library building is within an educational environment in an academic and semi urban setting where there are educational functions and public access. The site is suitable for a library due to its connection to an educational institution, and as it can be used by both the university and local community.

3.2 Site Selection Criteria

The site was selected based on the following considerations:

1. Accessibility to students, staff, and visitors.
2. Suitability for public and academic use.
3. Adequate land area for library development.
4. Potential for good daylight and natural ventilation.
5. Security and institutional support.
6. Availability of infrastructural services.

3.3 Brief History of the Study Area

Brief history of the Study Area.

Ugwuomu is a rapidly growing community in Enugu State, Nigeria and closely related to the growth and expansion of Godfrey Okoye University. The university's history has had a major impact on the physical, social and educational development of the area, bringing people, education and business to the area.

The capital of Enugu State, Enugu, has been known for so long as one of the important educational, administrative and commercial centres in the south eastern region of Nigeria. Its abundance of higher education and research institutions, as well as its public facilities, has bolstered its status as a hub for education and intellectual growth. In view of this, the academic and research activities

of the University at Ugwuomu have grown into vital areas and this has resulted in the University environment having a higher demand for ready information resources and up-to-date library facilities.

The choice of the study area is thus appropriate because of its emerging educational value and the desire to have a good design of a modern public library featuring an efficient natural lighting and ventilation. A facility of this sort would offer a supportive, healthy and comfortable learning environment, allow the students, staff and community to continue to learn and research from the facility and meet their information needs.

3.4 Physiography, Climatic, and Vegetation.

The climate in Enugu state is tropical with two seasons of wetness and dryness. The region has fairly warm weather all year long, coupled with moderate to high humidity and ample sunshine. The rainy season is from April to October and dry season from November to March. Such climatic conditions offer ample possibilities for good use of natural light and air in architectural design. However, they can also cause problems like high solar heat gain, glare and varying indoor thermal environment if suitable design strategies are not applied.

The physiography of the area of study includes gently rolling terrain, well-drained soils, and moderate elevations which allow air movement to flow across the study area. These natural features can be beneficially applied to improve the cross- ventilation and quality of the indoor environment of buildings.

Vegetation within the study area includes a mixture of urban and semi-urban, ornamental trees, shrubs, grasses and landscaped open space areas around institutional and residential development. Vegetation helps to create a better microclimate in the area by offering shade, cooling ambient temperatures, filtering dust and improving air quality. If used in a proper manner in the

architectural design, landscaping can help in achieving good ventilation and minimizing upheaval caused by direct solar radiation on buildings.

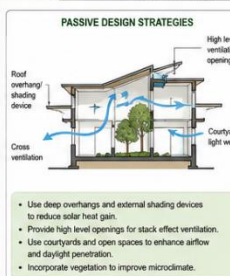
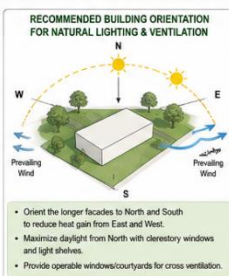
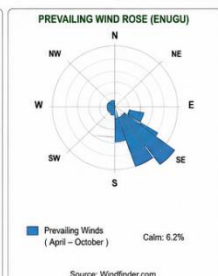
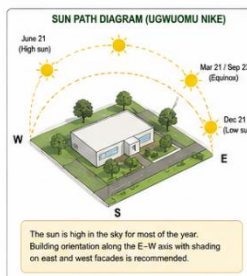
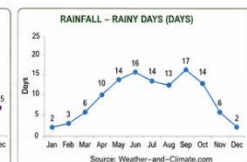
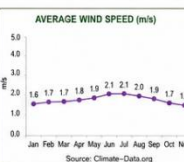
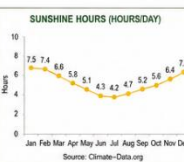
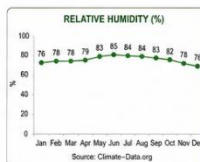
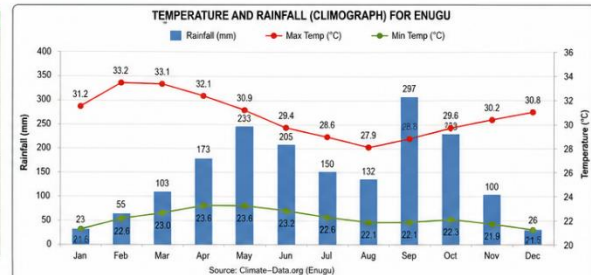
Considering these environmental features, passive design features which optimize natural lighting and ventilation are very appropriate for Enugu. The elements of architecture including appropriate building orientation, shading components, operable windows, courtyards, light shelves and landscape buffers can all be used to enhance the comfort of the occupants, to lower energy use and to provide sustainable library spaces.

CLIMATE ANALYSIS OF UGWUOMU NIKE, ENUGU STATE, NIGERIA

Ugwuomu Nike is located within Enugu Urban in Enugu East Local Government Area of Enugu State, Nigeria. The area experiences tropical savanna climate (Köppen Aw) characterized by high temperatures throughout the year and a distinct wet and dry season. This analysis is based on climate data for Enugu City, the nearest meteorological station to Ugwuomu Nike.



CLIMATE SUMMARY (ENUGU)	
Climate Type	Tropical Savannah (Aw)
Mean Annual Temperature	26.4 °C
Annual Rainfall	~1,720 mm
Relative Humidity	70 – 85 %
Wettest Month	September
Driest Month	January
Hottest Months	February – March
Coollest Month	August
Sunshine Hours	5 – 7 hours/day (avg.)



IMPLICATION FOR DESIGN: The warm humid climate of Ugwuomu Nike calls for a library design that maximizes natural daylight, enhances cross ventilation, provides effective shading, and integrates landscaping to create a comfortable, healthy and energy-efficient environment.

Figure 16: Climatic Analysis of Ugwuomu Nike, Enugu State Showing Temperature, Rainfall, Relative Humidity, Wind Pattern and Sun Path.

3.5 Population, Culture, and Economic Development

The population of the study area consists of students, academic, non-academic staff of Godfrey Okoye University, residents of Ugwuomu and people coming from the neighbouring communities for educational, commercial and social activities. The ongoing development of the university has helped to sustain the growth of population, which has led to a rising demand for educational facilities, information resources and other public services.

Culturally, the study area is an area of rich tradition and heritage of the Igbo people who form the bulk of the ethnic population of Enugu State. The community has values in education, hard work, communal living and preservation of cultural identity. Such cultural characteristics have created a learning, research and intellectual development environment.

Godfrey Okoye University, along with commerce, transportation and hospitality and other service businesses serving the students, staff and residents of the area, drive the economy of the area. The impact of the University campus has been seen in the infrastructural development and job creation it has brought to Ugwuomu and the various communities involved, which has played its role significantly in the socio-economic development of the area.

The creation of a public library in this setting would enhance the educational base of the area by making information resources, study spaces and research facilities available to students, researchers and the public. Furthermore, the inclusion of natural light and ventilation would provide a pleasant, healthy and sustainable learning environment, and could play a role in the physical, educational and socio-economic development of the university community and the broader Enugu metropolis.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.0 Introduction

The research methodology used for the study is discussed in this chapter. It refers to the scientific techniques used to gather, analyze, and interpret data that pertain to the research problems. Specifically, the chapter discusses the research design, data requirements, study population, sampling techniques, methods of data collection, and methods of data analysis.

The methodology offers a systematic approach to the study of the effects of natural lighting and natural ventilation in the design of a public library. It aims to provide accurate data to assist the architectural design process and to produce a functional, comfortable, energy-saving and environmentally friendly public library that meets the needs of its users.

4.1 Research Design

The study used a mixed methods research design which combines the qualitative and quantitative methods to collect full data required to accomplish the study objectives. The mixed-method approach is deemed suitable due to the nature of the research that involves the study of the current knowledge and the creation of architectural design proposal. It is a balance of theory and empirical data gathering to give good grounding for design decisions.

The research method used in the study includes extensive literature review, case study analysis, site survey and observation on the field. The literature review serves as the basis of the theory in the study of principles of natural lighting and ventilation in library design. Selected case studies of university libraries provide knowledge and lessons learnt about the architectural strategies, design features and environmental performance. Site surveys and field observations supply primary data on physical, environmental and socio-economic features of the study area and

interviews and consultations with relevant stakeholders can be used to gain further data on the needs and functional requirements of users.

These methods are integrated, so that reliable data will be collected for informing the planning and design of an optimal public library where natural lighting and ventilation will be optimized, functionality, comfort, environmental sustainability and energy efficiency will be met.

The following methods were used in this study:

1. Literature review
2. Case study analysis
3. Site survey
4. Field observation.

4.2 Data Needs and Sources

Primary Sources

1. Site observation.
2. There was a need for field measurements.
3. Informal meetings with design practitioners.

Secondary Sources

1. Library design: books and journals.
2. Natural lighting and ventilation articles.
3. Online research publications.
4. Design principles and construction advice.

4.3 Population of the Study and Sampling Procedure

The population of the study is made up of:

- 1.Students.
- 2.Academic staff.
- 3.Non-academic staff.
- 4.Library users.
- 5.Architects.

The respondents were sampled purposively since it was necessary for the study to have people that had knowledge of the library use or library building design. This approach enabled the researcher to concentrate on individuals who might be able to offer valuable feedback for the design proposal.

4.4 Methods and Instruments for Data Collection.

The data collection methods and instruments include some of the following:

The following instruments were used:

- 1.Questionnaire to gather user feedback on comfort and space quality.
- 2.Interviews to collect user and professional feedback.
- 3.Assessment by site using an observation checklist.
- 4.Documentation photographs of the setting.
- 5.Literature review to obtain background information and design standards.

4.5 Method of Data Analysis

The data were analysed using descriptive and research methods.. The case studies were compared to determine which design strategies were effective with regard to lighting and ventilation. Site conditions were also analysed to aid in design proposal.

CHAPTER FIVE

DESIGN SYNTHESIS AND DEVELOPMENT

5.0 Introduction

The design synthesis and development of the proposed public library are presented in this chapter. The design is based on the result of the literature review, case study, site study and methodology. It is designed to create a functional, comfortable and climate responsive library.

5.1 Design Brief

The proposed library building is a university library that will be situated at Godfrey Okoye University, Ugwuomu, Enugu State. The library must cater for the needs of students, staff, researchers and public users. It must be designed to ensure effective light, good ventilation, reading comfort and a relaxing environment.

Design Objectives

- 1.To allow adequate natural light.
- 2.To use artificial light which complements the natural light.
- 3.To provide natural ventilation and thermal comfort.
- 4.To reduce glare and heat gain.
- 5.To provide areas conducive for study, research and quiet reading.

Examine the processes used in the design of a product or service to create requirements and planning data.

Reading Areas

- 1.Balanced daylight.
- 2.Low glare.
- 3.Comfortable seating.

4. Quiet atmosphere.

Stacks

1. Controlled lighting.

2. Good air circulation.

3. Protection from heat and humidity.

Reference Section

1. Uniform artificial lighting.

2. Clear circulation.

3. Accessibility of resources.

Administration

1. Good daylight.

2. Privacy.

3. Comfortable working conditions.

ICT and Study Areas

1. Controlled light levels.

2. Ventilation support.

3. Flexible layout.

5.3 Schedule of Accommodation

Space/Quantity.

Main reading room 4

Reference section 1

General book stacks 2

ICT/computer room 1

Administration offices 3

Librarian's office 1

Conference room1

Seminar hall 1

Store/record room 1

Reception/lobby 1

Toilets Multiple

Security post 1

Outdoor shaded area

5.4 Special Considerations

Several special considerations have been kept in mind in the design of the proposed public library that would provide a functional, comfortable, sustainable and user-centred learning environment. The incorporation of natural light and ventilation, sustainability and energy efficiency are especially emphasized and play a vital role in the functioning of the building and in the well being of its occupants.

The lighting design aims to optimise the use of natural light and reduce glare and unwanted solar heat gain. The building envelope is integrated with the correct sized windows and external shading devices, allowing control of the amount of sunlight in the interior spaces. Reading rooms, study areas and other areas where people go a lot are well placed to get good natural light during the day and minimise the need for artificial light and thus reduce energy usage. Furthermore, energy saving artificial lighting systems are installed to assure sufficient lighting during the night and when natural light is limited. Light coloured and reflective interior finishes further promote daylighting within the building, providing for an improved visual comfort and good learning environments.

One of the key design considerations is natural ventilation in order to achieve thermal comfort and healthy indoor environmental conditions. The wind direction of the site is considered in the orientation of the building, which offers natural ventilation to the internal spaces. Windows, doors and ventilation openings are strategically positioned to allow for effective cross-ventilation, and high ceiling spaces allow for a better flow of air and heat to be better dispersed. The use of courtyards and shaded openings also supports natural ventilation through the creation of pressure differentials to facilitate continuous ventilation while providing protection from unwanted solar gain.

The design also takes into account the sustainability of the environment. Integrating elements of landscaping with trees, shrubs and green open spaces into the site will provide shade, improve the microclimate, lower the surrounding temperatures and increase the visual quality of the environment. The building's orientation, sun shading, daylighting and natural ventilation are all passive design features used to minimise the needs for mechanical lighting and cooling and enhance energy performance. In addition, building materials that are durable, locally available and climate sensitive are used to reduce maintenance needs, promote sustainable construction and ensure the building is functioning optimally in the climate of Ugwuomu, Enugu State.

These design factors help create a public library that is environmentally responsive, energy-efficient and can create a comfortable and productive learning, research and community environment.

5.5 Site Inventory and Analysis

The site proposed for the university library is in the proximity of Godfrey Okoye University, Ugwuomu, in Enugu State. The strategic location of the site within a rapidly expanding academic environment and the access for students, academic staff, researchers, physically challenged and

visually impaired students and members of the surrounding community was the reason for the site's selection. The existence of the university and other educational institutions is a great foundation that encourages the formation of a university library as a place for learning, research and community.

A comprehensive site inventory and analysis were carried out to evaluate the physical, environmental and context characteristics of the site. The assessment analyzed topography, access, existing land use, vegetation, existing drainage, climate, adjacent developments, and existing infrastructure. The above factors are important to consider when planning and designing a proposed library and should be taken into account when responding to the physical and environmental context.

There are a number of opportunities on the site which are favourable to the proposed development. It's embedded in an academic setting which makes its user population easily accessible and adds to its importance as an institution. Moreover, the sun shines copiously throughout the year, providing great opportunities to use natural light optimally in the library. Open spaces also offer opportunities for landscaping that can buffer against environmental impacts, alter the site's

microclimate, and enhance the site's visual quality.

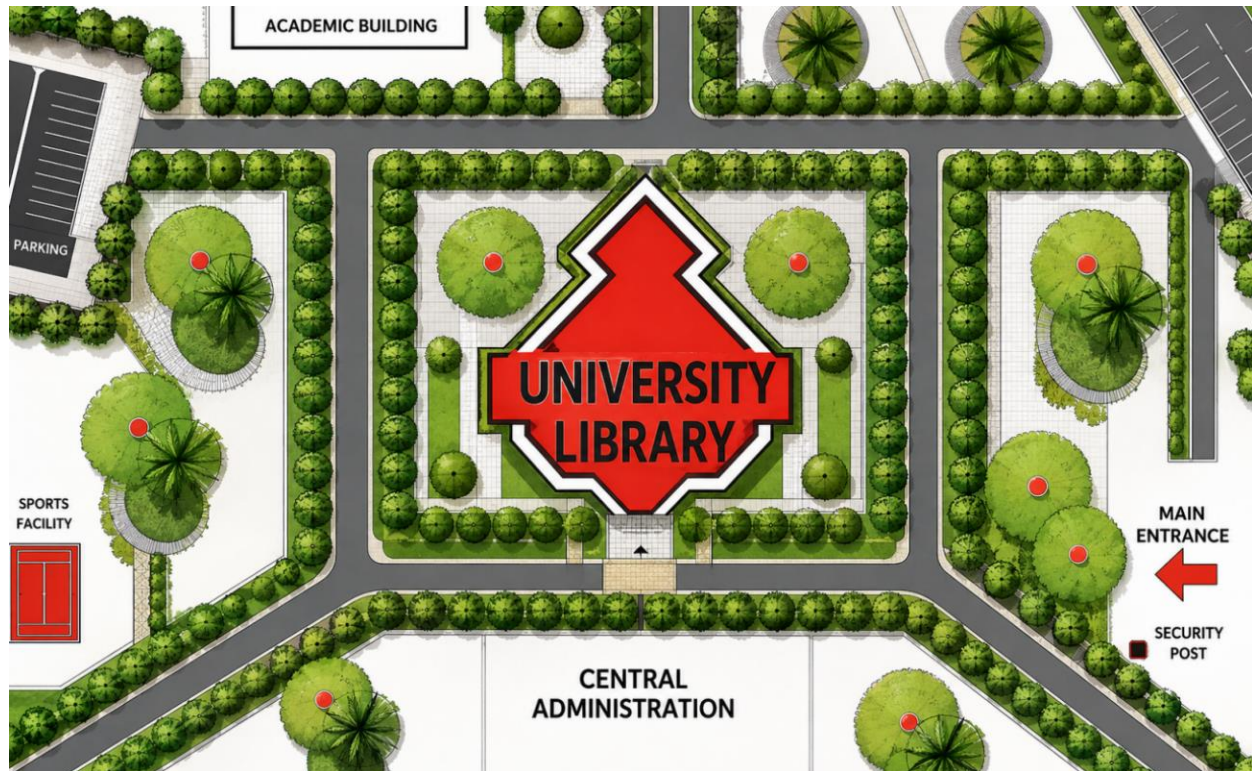


Figure 17: Proposed site plan.

Despite these advantages, the site also presents certain constraints that require careful consideration during the design process. The high intensity of solar radiation, particularly during the dry season, may result in excessive heat gain and visual discomfort if appropriate control measures are not incorporated. Seasonal rainfall also necessitates the provision of adequate drainage systems and protective architectural features to prevent water penetration and maintain user comfort. Furthermore, the abundance of natural light increases the potential for glare within reading and study areas, making it essential to incorporate shading devices, appropriate window orientation, and other daylight control strategies.

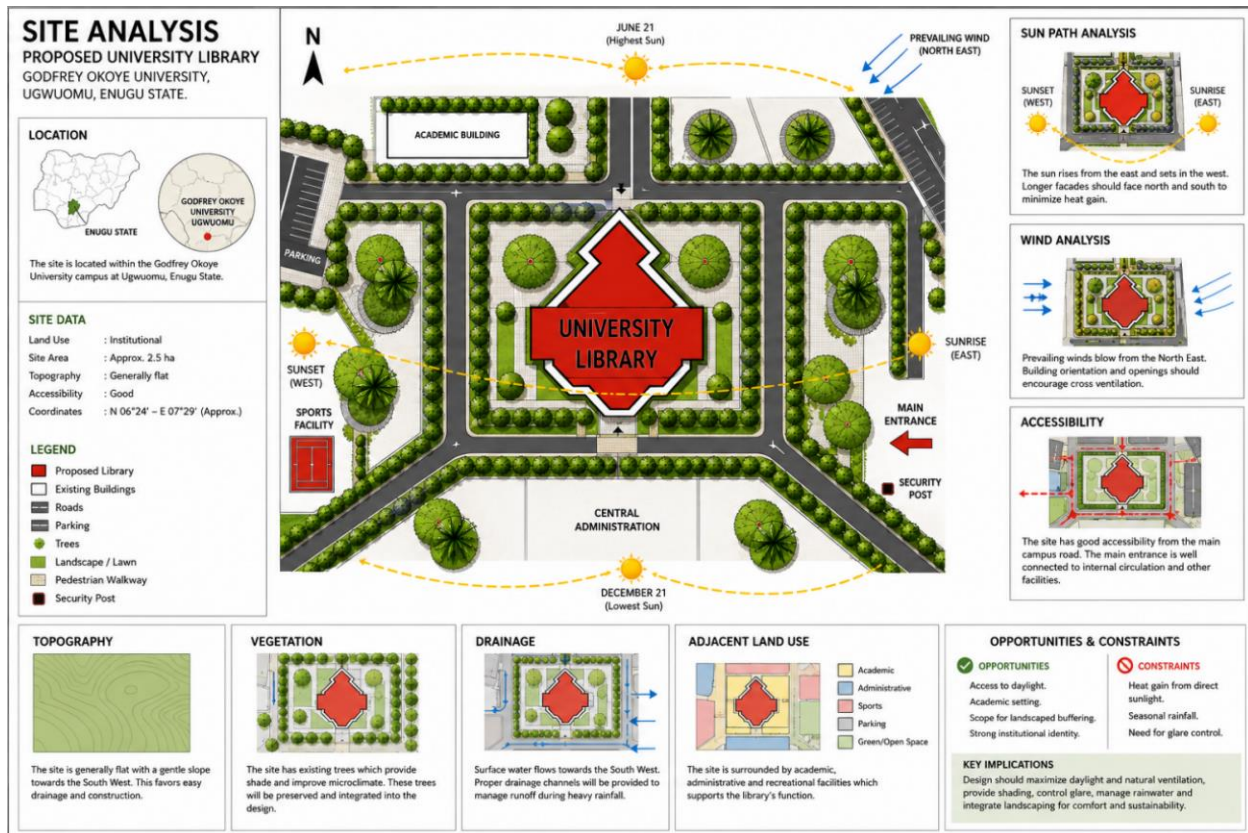


Figure 18: Proposed site plan analysis.

The conditions in the study area are especially conducive for the use of passive environmental design principles. The prevailing wind patterns lead to good natural ventilation, and constant availability of daylight allows for the use of natural lighting as the main source of lighting during the day. Thus, passive design features like building orientation, external shading elements, operable windows, landscaping and more are included in the proposed design to reduce the heat gain, thermal comfort, indoor environmental quality and also to reduce the dependence on mechanical lighting and cooling system. The measures will help to create a friendly, energy efficient and environmentally friendly public library which is conducive to the climatic conditions of Uguwuomu, Enugu State.

5.6 Design Concept

The design concept is climate responsive library. The building should also allow for some daylight to enter in a controlled manner, promote airflow and offer a tranquil environment for reading and learning. The form can be designed around a courtyard or linear circulation system that will allow for illumination and ventilation.

The façade needs to be open and at the same time protected. Some areas may be given more day lighting in the public areas and more control in sensitive areas like the stacks and reference rooms. The building must convey a sense of quiet, discipline and educational importance.

5.7 Design Development

The building is designed to have different functional spaces, such as public areas, semi-public areas, and service areas. Public areas are the entrance lobby, reading rooms and discussion areas. Semi-public areas are the reference section and the ICT room, and service areas are administration, storage and support areas.

Windows, shading devices and internal openings should be positioned to effectively distribute light and facilitate air flow. Interior finishes should reflect soft daylighting, exterior landscaping should minimise heat and enhance site environment. The design should be simple, functional and be suitable for an academic community.

5.8 End of the Design Process

Design synthesis illustrates that the natural light and ventilation are the basic components of the successful design of a university library. In addition to addressing functional needs, the environment of a well-designed library is comfortable, healthy, and conducive to reading, learning, research, and social interaction. The natural lighting and ventilation greatly enhance the user experience contributing to visual comfort, thermal comfort, IEQ, and energy efficiency.

During the design process, it was found that the various conditions of the site, climate conditions, and user needs, as well as sustainable design principles, must be carefully considered during the development of the proposed library. The design incorporates various passive elements and strategies, such as building orientation, shading devices, window placement, landscaping, and natural ventilation systems, to optimize the use of natural resources and reduce reliance on artificial lighting and mechanical cooling systems.

In the proposed university library in Ugwuomu, Enugu State, a combination of natural lighting, solar control and effective air circulation strategies respond to these requirements, making the project a functional, environmentally responsive and energy efficient building. As a result, the design offers a sustainable architecture that will create comfort for the users, allow for learning activities, and will benefit the learning and physical growth of the community.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The lighting and ventilation are very important in the design of a university library, as this study has demonstrated. They impact on user comfort, reading performance, indoor air quality and energy consumption. The literature review and case studies presented here support the notion that libraries are best when environmental concerns are addressed at the pre-design stage.

Godfrey Okoye University, Uguwuomu, Enugu is therefore envisaging a university library building with a climate responsive design to facilitate learning and research activities. The design can create a comfortable and functional environment for users by utilizing the sun's lighting, shading, and natural ventilation effectively.

6.2 Recommendations

The following recommendations are made:

1. Daylighting should be planned in a controlled manner within the university library.
2. The proper window orientation and location of windows should be combined with natural ventilation.
3. In all reading areas, artificial lighting should be in harmony with natural light.
4. Shading devices should be used to minimize glare and heat gain.

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