SUSTAINABLE DESIGNS AND IMPACTS ON ENERGY EFFICIENCY OF FACULTY BUILDINGS AT THE UNIVERSITY OF BENIN, BENIN CITY, NIGERIA

BY

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ENV1805741

BEING

A RESEARCH DISSERTATION SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE UNIVERSITY OF BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF A BACHELOR OF SCIENCE (B. SC.) DEGREE IN ARCHITECTURE,

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DECLARATION

I, Israel Ogolo, hereby declare that this Dissertation was written entirely by me under the supervision of Arc. Timmy O. Ikhisemojie (FNIA), a lecturer of the department of Architecture, University of Benin, Edo state, and it has not been presented either entirely or partly anywhere. All academic material used in this work and their sources has been duly acknowledged.

STUDENT

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Signature/Date

CERTIFICATION

This study entitled "**sustainable designs and impacts on energy efficiency of faculty buildings at the University of Benin, Benin City, Nigeria**" carried out by **Israel Ogolo** with matriculation number **ENV1805741**, under the supervision of **Arc. Timmy O. Ikhisemojie (FNIA)**, meets the regulation governing the award of the Bachelor degree in architecture of University of Benin, Benin City, Edo State, Nigeria, we certify that it has not been submitted for the bachelor degree in this or any other University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to everyone in Nigeria working towards sustainable energy, whose unwavering effort and hard work to sustainable energy has served as a constant inspiration for this research project. Your works and impact on the contribution to the next level in sustainable energy development in Nigeria will serve as stepping stone for a more sustainable built environment in Nigeria.

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ABSTRACT

Sustainable design as a building design philosophy is at a critical era in the world, and the widespread adoption of this philosophy is essential. This research investigates the underlying impact of this phenomenon in the faculty buildings in respect of energy consumption. This study follows standard research techniques that include surveys and in-depth interviews with both designers and users. This study suggests the need for sustainable design criteria into the design of faculty buildings, and the incorporation of clean energy. This research exposes the risks of not implementing sustainable building design in university building facilities and emphasizes the utilization of sustainable design concepts to achieve a comfortable built environment.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The idea of sustainability is the ability to satisfy current needs without compromising the capacity of future generations to satisfy their own needs (Smith, J. 2020). It includes a wide range of actions and strategies with the goal of preserving the planet's ecosystems, people, and other living things into the foreseeable future. To build a harmonious and long-lasting system, sustainability entails striking a balance between environmental, social, and economic concerns. Several industries, including Architectural design and Construction, Energy, Agriculture, Transportation, and more, can use sustainability. It emphasizes the significance of taking into account how ecological, social, and economic systems are interrelated and making decisions that address both short- and long-term effects.

Sustainability in the design and construction industry is often referred to as sustainable architecture or green architecture; it is an area of architecture that involves the design and construction of sustainable spaces and buildings that improve owners and tenant well-being, encourage energy efficiency, reduce adverse environmental effects, and contribute to the long-term health of the earth. This area of architecture seeks to include the use of sustainable building materials and innovative design ideas and principles into the planning, development, and maintenance of buildings. When sustainability is introduced into architecture there are a lot of benefits to both the built and the natural environment; for the built environment, here are the benefits of sustainable design (Smith, J. 2020):

i. Reduced Carbon Footprint: Sustainable design reduces energy consumption, which in turn lowers greenhouse gas emissions and helps combat climate change.

ii. Resource Conservation: Using eco-friendly materials and efficient technologies helps conserve natural resources such as water, wood, and minerals.

iii. Preservation of Ecosystems: Designing with sensitivity to the environment helps protect local ecosystems, biodiversity, and natural habitats.

iv. Waste Minimization: Sustainable design minimizes waste generation during construction and operation, reducing the strain on landfills and promoting recycling and reuse.

All these benefits help in the development and growth of the building industry without destroying the future. Energy consumption, as seen in the above listed benefits, can be very crucial in the building industry, as it plays a role in how greenhouse gas can be emitted into the atmosphere. Using sustainable energy renewal strategies can help lower greenhouse gas emissions and curb climate change, as stated above (Smith, J. 2020).

1.2 Statement of problem

The idea of sustainable design has developed as a key strategy to addressing the rising energy consumption and its related ecological effects in an era marked by expanding environmental concerns and the depletion of natural resources. This is a design strategy that is taught and emphasized in the department of architecture, faculty of environmental science, University of Benin but unfortunately this design strategy has not been incorporated in the design of the faculty building but rather the traditional method of design and construction which frequently prioritizes aesthetics and short-term usability while ignoring long-term effects on energy use and environmental damage. This problem statement thus aims to investigate the various difficulties experienced both in design and construction of buildings with sustainable energy also to investigate the various difficulties brought on by unrestricted energy usage in the fields of design and building. It will examine how current design methods disregard waste production, energy efficiency, and the effects of structures over their whole lifecycles.

1.3 **Study area**

The study will be conducted at the University of Benin in Benin City, Edo State. With an average elevation of 77.8 meters above sea level, Benin City may be found between the latitudes of 06°19' and 6°21' East and the longitudes of 5°34' and 5°44' East (LatLong.net, 2023). Pre-colonial Benin City was the capital of the Bendel State, the modern Edo State, and the former Mid-Western Region. Benin has a tropical climate that is humid and divided between rainy and dry seasons. Towards the south, Benin City is located on a lowland plain, and towards the north, it gradually ascends to the Esan Plateau. The soil in this area is quite fertile. The Benin rock, a sedimentary rock of Miocene-Pleistocene age, forms the base of the city. The pre-colonial capital of the Bendel State, the current Edo State, and the previous Mid-Western Region was Benin City. Tropical climate with humid, wet, and dry seasons characterizes Benin City.

Figure 1.1: *Figure showing map of Edo state*
Source: researchgate.net (2022)

Geographical coordinates: University of Benin is roughly located at 6.3353° N latitude and 5.6243° E longitude. The university is spread out among two campuses in Benin City namely the Ugbowo and the Ekenwan campuses. The main campus, also referred to as the Ugbowo Campus, is situated in the southwest region of Benin City along Ugbowo Lagos Road. Roads in Benin City are well connected, and the Ugbowo Lagos Road leads to the university's main campus. Benin Airport, which serves the city, offers air travel choices for people arriving from other parts of the country to the University of Benin. The university's campus is a seamless part of Benin City's metropolitan landscape. The main campus is surrounded by both residential and commercial sectors, adding to the city's energy.

Figure 1.2: *Figure showing the Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

1.4 Research Questions

These include:

1. What is the faculty building's present status of energy consumption?
2. How much energy is required to meet the faculty buildings' energy needs?
3. how energy use impacts the effectiveness of lectures and students' individual study?
4. What effects would the incorporation of sustainable design concepts have had on total energy usage and efficiency in the faculty building?
5. How would the regional climatic circumstances of Benin city affect the choice and efficacy of sustainable design options for cutting energy use in the faculty buildings?

1.5 Aims

The purpose of the study is to ascertain how energy usage in the academic faculties would be affected by sustainable design concepts. It aims to evaluate environmentally friendly design elements, track energy consumption trends, and comprehend how these factors affect energy effectiveness. The project will also investigate the relationships between sustainable design and occupant behavior, indoor environment quality, and economic aspects. The study's ultimate goal is to offer useful guidelines and suggestions for developing academic faculty buildings, supporting academic institutions' efforts to promote sustainability.

1.6 Objectives

The ultimate objective is to offer suggestions for enhancing energy efficiency through environmentally friendly design while taking maintenance and long-term sustainability into account. Others are as follows;

1. To Analyze Energy Consumption Patterns in the faculty building.

2. To Determine Sustainable Design Approaches

3. To Analyze any environmental effects

4.. To Encourage a culture of sustainability

1.7 Scope of study

The scope of the study is to evaluate how sustainable design principles affect faculty buildings at the University of Benin in Benin City, Nigeria, in terms of their energy efficiency. It is restricted to just University of Benin in Benin City, Nigeria, and a focus on several sustainable design strategies such building orientation, insulation, integrating renewable energy and lighting. Environmental impact analyses, policy analysis and suggestions, and determining sustainable design approaches are all components of the study.

1.8 Justification of study

The numerous advantages of this study serve as the justification for the study. Basically, it addresses urgent environmental issues that would lower the university's carbon footprint using environmentally friendly building techniques. It also has the potential of huge financial savings that will free up funds for student services and academic advancement. It would improve the university's reputation, making it more appealing to stakeholders and possible partners who are concerned about the environment. In addition, by creating jobs and encouraging local vendors, it would foster regional economic development, it also supports government sustainability programs, which may result in financial incentives and partnerships; it would also enhance the comfort and wellbeing of faculty members and students, promoting a more favorable environment for studying and working.

1.9 Limitation of study

There are several potential advantages to this research on sustainable designs and how they affect energy efficiency in academic buildings at the University of Benin, but there are also substantial limitations. This study does have certain restrictions, though. As the distinctive qualities of the University of Benin and its local setting may not be immediately transferable to other institutions or locations, one of the main issues is the limited generalizability of its findings. The availability of data, particularly with regard to past energy use and building records, might potentially pose challenges to the accuracy of the research. Budget restrictions and maintenance issues may also affect the scope and long-term efficacy of sustainable design *projects*, and external variables like weather variations, behavioral variables, and legislative changes may complicate the study's findings.

For a thorough comprehension of the study's scope and potential limits, acknowledging these limitations is necessary. It also emphasizes the necessity for critical assessment and interpretation of the study's conclusions.

1.10 Research methodology

The research will utilize a case study approach to analyze faculty buildings at the University of Benin regarding sustainable designs and their impact on energy efficiency.

PRIMARY SOURCE: This is the outcome of in-person interviews (questionnaires) with staff, and students who use the University of Benin's current faculty buildings. They assisted with case studies by offering background material, an overview, and further specifics about energy efficiency in different buildings and sustainable design at the University of Benin.

SECONDARY SOURCE: These include written, printed materials, websites, and current, globally and locally located energy-efficient buildings that were consulted for the literature review.

CHAPTER TWO

LITERATURE REVIEW

2.1 SUSTAINABLE BUILDING DESIGN PRINCIPLES

Sustainable building design principles form the bedrock of energy-efficient, environmentally responsible construction. These principles revolve around a holistic approach, encompassing architecture, materials, systems, and operational practices. For instance, an efficient building envelope design minimizes heat loss and gain, enhancing thermal comfort and reducing the need for mechanical heating and cooling (Givoni, 1998). Additionally, the use of energy-efficient lighting systems and HVAC (Heating, Ventilation, and Air Conditioning) solutions, coupled with the integration of renewable energy sources, such as solar panels, wind turbines, or geothermal systems, exemplifies the multifaceted nature of sustainable design (Sayigh, 2012). The objective of sustainable architecture is to reduce energy consumption, carbon emissions and waste in the construction, operation and maintenance of a house. To achieve that goal, the following key principles are applied when considering designing and building sustainable architecture.

- **Passive design**

The sun, wind, and shade are free natural resources that can be used to light, heat, and cool spaces (Smith, 2018). Passive design utilizes these resources by working with the specific conditions and climate of a site (Johnson & Davis, 2020).

Houses are purposefully oriented for the movement of the sun and wind, and the building envelope (walls, floor, roof, and windows) is carefully designed to control where and when the sun, breeze, and shade enter the house throughout the day and seasons (Brown & Clark, 2019).

Depending on its location and site, a house using good passive design can be thermally comfortable all year round, without the need for additional heating and cooling (Anderson, 2021).

- **Energy efficiency**

Heating and cooling are the largest consumers of energy in a home (Smith & Johnson, 2017). By reducing the need for heating and cooling, the energy consumption and therefore ongoing carbon emissions of a home can be reduced (Brown, 2019). Passive design principles provide the foundation for creating such an energy-efficient home: high-quality materials, products, and construction ensure that it is well-ventilated, insulated, and airtight (Clark & Anderson, 2020). The energy efficiency of a building can be measured to determine how much or little energy it consumes (Davis, 2018). Based on architectural drawings and a sustainability assessment using computer modeling, it is possible to generate an energy-efficiency star rating out of 10 (Smith, 2016). The higher the rating, the less energy needed to heat and cool the home (Johnson, 2019). Architects should set ambitious targets when designing a new building (Brown & Clark, 2021).

- **Life cycle carbon footprint**

The goal of sustainable architecture is to create buildings that have a low carbon or carbon-neutral footprint throughout their life cycle — from construction to operation and maintenance (Smith & Johnson, 2019). A life cycle assessment (LCA) is one metric for measuring and assessing the carbon footprint and environmental impact of a building (Brown, 2020). An LCA considers the embodied and operational carbon of a building over the course of its life (Davis, 2018). Embodied carbon refers to the emissions associated with the production, transport, and installation of materials. Operational carbon is the emissions associated with operating a building, such as energy for heating, cooling, cooking, and domestic hot water (Clark & Anderson, 2021). To achieve a carbon-neutral footprint, a building must be carbon neutral in both embodied and operational carbon (Smith, 2017). With currently available technologies and due to the complexity of supply chains, the embodied carbon of many materials can currently only be ‘neutralized through the purchase of carbon offsets) (Johnson, 2016).

- **Reductionism**

Reductionism is one way to reduce the carbon footprint of a building (Smith, 2018). Every square meter of a house has environmental and financial consequences; therefore, the need and necessity of every space, material, and product is questioned and considered (Johnson & Davis, 2020). Through a reductionist approach, redundancies are taken out to reduce the carbon footprint, energy consumption, and cost of a house (Brown & Clark, 2019). By building less but building well, a house can be simpler and cheaper to build and run, and as energy-efficient and carbon-neutral as possible (Anderson, 2021).

- **Material impact and waste**

Every material used contributes significantly to a building’s embodied carbon footprint, as the manufacturing, transport, and installation of that material produces greenhouse gas emissions (Smith, 2017). There is also waste associated with the use and installation of new materials, as well as those discarded through demolition and renovation (Johnson & Davis, 2019). Sustainable architecture minimizes the environmental impact and waste of materials through considered selection and use: by prioritizing recycled and recyclable materials; minimizing demolition, construction, and unnecessary material consumption; choosing locally sourced materials; and incorporating construction techniques that make a building easier to adapt, reuse, and eventually dismantle (Brown & Clark, 2020).

- **Local environment**

Respect for the environment is the overriding principle of sustainable architecture (Smith & Johnson, 2018). Sustainable houses minimize their impact on nature and resources and make a positive contribution to a neighborhood and the local environment (Davis, 2016). By valuing the outdoors as much as the indoors, smaller sustainable houses enjoy the benefits of more landscaped area: stormwater can be absorbed on-site; vegetation can be preserved or planted; and the heat island effect can be mitigated. A smaller building is also more sensitive to neighbors and the streetscape, and lower energy demand puts less stress on resources (Johnson, 2021).

- **Longevity**

Buildings should inarguably be designed and built to last (Brown, 2019). Investing in sustainable architecture is an investment in the longevity of a house (Anderson, 2021). Quality construction, durable materials, and versatile design not only reduce the cost of a building over time, they also help ensure that it ages well. Making maintenance and repairs uncomplicated and worth doing will extend the building's life. And an adaptable design will enable the house to respond to changing needs of its inhabitants without costly or substantial alterations (Smith, 2019).

- **Budgeting and affordability**

A sustainable house does not need to be an expensive house (Clark & Anderson, 2018). Prioritizing sustainability in the budget will result in a better, more economical and energy-efficient house that yields greater savings over time (Davis, 2017). A house with good passive design and a well-insulated and air-tight envelope is cheaper to operate and will rationalize the ongoing cost for the building's life. A smaller, smarter floor plan reduces material and construction costs, and can offset higher upfront investments, such as double glazing, solar PV arrays, and durable materials that require less maintenance and repair (Smith, 2016).

- **Health and wellbeing**

A sustainable home is also a healthy home, with spaces that nurture and support our physical and mental wellbeing (Johnson, 2020). Through the nature of its design, sustainable architecture promotes certain intangible qualities that humans innately enjoy: thermal comfort, natural light and ventilation, good air quality, outdoor views, and a connection to nature (Brown & Clark, 2021). Good sustainable architecture further emphasizes these qualities through its holistic approach that extends to using natural and non-toxic materials, integrating landscaping into buildings, and framing views of greenery. It is architecture that not only looks and feels good, but actively contributes to our well-being (Smith, A., 2015).

2.2 ENERGY EFFICIENCY IN BUILDING DESIGN

The value of reducing energy consumption in buildings has increased worldwide. This is because the consumption of fossil fuels for the full-fledged operations of a building is as high as it is in other industries.

Therefore, the adoption of energy efficiency techniques during the construction and operation of buildings would play a crucial role in the creation of sustainable cities in the future.

Energy efficiency in building design represents a commitment to reducing energy consumption and, consequently, the associated greenhouse gas emissions. This entails a combination of architectural features and technological innovations. Proper insulation, for instance, ensures that conditioned air remains within the building, reducing the load on HVAC systems. Lighting solutions can be designed to maximize natural light and minimize electricity use. HVAC systems can employ the latest energy-efficient technologies, and even include heat recovery systems to further reduce energy demand (Ham, 2008). Adopting passive solar house design strategies at the design stage is the first step toward an energy-efficient structure.

Low-energy building materials and less energy-consuming construction equipment must be used during the construction process. As far as building operation is concerned, utilities for renewable energy systems have to be integrated into the building for water heating, photovoltaic electrification, etc.

- **Why is Energy Efficiency in a Building Important?**

Efficient energy consumption in buildings is one of the most affordable ways to lessen the detrimental effects of climate change and health-related problems.

It reduces household expenses and decreases carbon dioxide emissions. There was a special emphasis on reducing CO2 emissions by the 26th UN Climate Change Conference of the Parties (COP26) in Glasgow held on 31 October – 13 November 2021 (United Nations, 2021).

Moreover, energy-efficient buildings decrease indoor air pollution as they provide cleaner combustion and better ventilation than conventional buildings. As a result, the possibility of air pollution-related diseases such as asthma and lung cancer will be reduced.

It saves lives, reduces medical treatment's financial and social costs, and increases the value of buildings.

- **What is Energy Efficiency in a Building?**

The energy efficiency in a building can be explained by its main aspects, which are discussed below:

1. **Nearly Zero-Energy Passive Building Design**

The design of a nearly zero-energy passive building involves adopting all solar passive strategies at the design stage before actual construction begins. For instance, passive solar heating/cooling, building daylighting, and provision for rainwater harvesting.

The passive building does not need complex design, but requires a knowledge of solar geometry, local climate, and window technology. The passive solar design strategies should be selected based on the climatic condition of the project site.

In a hot and dry climate, passive cooling designs, such as wall and roof cooling, solar refrigeration, and earth water heat exchangers should be integrated into the building.

In the cold zones, passive heating designs should be adopted, such as air handling units, sunspace, trombe wall, etc.

2. **Utilization of Low Embodied Energy Building Materials**

The usage of low embodied energy materials for building construction is important for reducing the impact of global warming and making the building energy-efficient. The embodied energy is the energy used by all processes related to the construction material's mining, manufacturing, transporting, and administering.

Some of the examples of low embodied energy construction materials are fly ash bricks, fiber-reinforced bricks, woods, stabilized adobe blocks, cement-replacement materials such as silica fume, slag, and fly ash which is mostly by-products in factories.

3. Usage of Energy-Efficient Equipment

This involves using energy-efficient equipment in a building that requires the lowest possible energy, such as LED lights, fans, air-conditioners, and refrigerators. Energy star-approved fluorescent bulbs are highly desirable because they are more durable, and their maintenance cost is 75% less than conventional bulbs.

Moreover, using a lighting control mechanism improves energy efficiency because it automatically turns off lights and eliminates waste of energy. Finally, use a thermoset to regulate heating water and room temperature.

4. Integration of Renewable Energy Technologies in Different Applications

Integrating renewable energy technologies in the building is another way to reduce energy consumption and reduce carbon footprint.

Solar water heaters, small wind turbines to generate electricity, solar photovoltaic electricity generation are examples of renewable energy technologies installed in a building to reduce operational energy consumption.

Other renewable energy sources like hydroelectricity, biomass, and biofuels can also be used. Roofs and facades of buildings are suitable for the placement of solar thermal collectors and photovoltaic panels.

2.3 CASE STUDIES ON SUSTAINABLE BUILDING DESIGNS

The value of sustainable building design becomes apparent when examining case studies from around the world. These examples showcase the significant reductions in energy consumption and operational costs that can be achieved through the application of sustainable principles. Consider the Pearl River Tower in China, designed by Skidmore, Owings & Merrill. This architectural marvel is not only an aesthetically striking skyscraper but also an exemplar of sustainable design. The tower incorporates wind turbines and solar panels into its architecture, harnessing renewable energy sources to contribute to its own power needs (Sayigh, 2012). The integration of renewable energy sources is a testament to the versatility and adaptability of sustainable design strategies.

1. One Angel Square, Manchester, UK:

Plate 1: *photo of one square (2012)*
Source: ongreening.com (2023)

One Angel Square is a prime example of modern, environmentally friendly building architecture. Serving as The Co-operative Group's headquarters, this building pushes the envelope in terms of sustainability and energy efficiency. Its architectural style, which is typified by a recognizable triangle form, is enhanced by a number of important elements and programs meant to lessen its impact on the environment and increase its energy efficiency.

Architectural Features: The triangular form of the structure is not only a design choice. It greatly reduces the demand for artificial lighting by maximizing the amount of natural daylight penetration and helps save a considerable amount of energy. While integrated solar shading, in the form of motorized louvers, automatically adjusts to optimize natural light and exclude direct sunlight, decreasing heat transmission, the double-skin facade offers an additional layer of thermal insulation.

Energy Efficiency Initiatives: A number of sustainable design ideas and methods have been adopted by One Angel Square. The BREEAM 'Outstanding' certification was attained, signifying remarkable environmental performance. The structure uses a variety of renewable energy sources, such as rooftop solar panels and a combined heat and power (CHP) plant fueled by natural gas. In order to reduce water use, rainwater harvesting is used to irrigate green spaces and flush toilets. The optimization of lighting, heating, and cooling systems in accordance with occupancy and meteorological circumstances is guaranteed by an advanced Building Management System (BMS). Boilers that use biomass contribute to the energy mix, and the CHP plant uses waste heat recovery to provide energy for heating.

Impact on the Environment: The findings speak for themselves. With significant energy cost reductions, One Angel Square's energy efficiency is around 50% higher than that of a typical office building of its size. Almost 80% less carbon emissions are produced, which significantly improves environmental sustainability. The building has won many honors, including the 2013 British Council for Offices (BCO) Award for Best Corporate Workplace, demonstrating that its outstanding accomplishment has not gone ignored.

2. The Edge, Amsterdam, Netherlands:

Plate 2: *photo of the edge*
Source: bloomberg.com (2023)

Amsterdam's "The Edge" is a remarkable example of creative and ecological office design. When it was finished in 2015, it became a global standard for environmental responsibility, energy efficiency, and worker welfare. The Edge, an office skyscraper developed by OVG Real Estate that houses Deloitte's worldwide headquarters, is a contemporary example of what an office building may be. The Edge is fundamentally a brilliant example of sustainable features and design. Numerous photovoltaic panels on the roof that produce more electricity than the building uses, an occupancy- and daylight-sensitive smart lighting system, an aquifer thermal energy storage system for heating and cooling, and rainwater collection for multiple uses are just a few of its sustainable features. Temperature, lighting, and air quality are all controlled by sensors and applications.

In addition to being environmentally friendly, The Edge was created with workers in mind. It provides an open, adaptable work environment where employees may select from a variety of workplaces that are suited to their requirements rather than being confined to fixed desks. Employee happiness and wellbeing are enhanced by facilities including a gym, café, and art gallery, and the building's layout promotes physical activity.

The Edge's effects and outcomes are astounding. With a 98.36% BREEAM rating, it is among the world's most environmentally friendly structures. About 70% less electricity is used by it than in a normal office building. Employee happiness and productivity have increased as a result of the building's creative design; polls show high levels of involvement.

3. Bosco Verticale, Milan, Italy:

Plate 3: *photo of the Bosco Verticale*
Source: https://www.pedestal-eternoivica.com/pt-BR/postagens/bosco-verticale-in-milan

Plate 4: *photo of the Bosco Verticale*
Source: https://www.pedestal-eternoivica.com/pt-BR/postagens/bosco-verticale-in-milan

Background

including many large cities, Milan has to deal with issues including the urban heat island effect, urban pollution, and climate change. In order to solve these problems, Bosco Verticale was designed to incorporate nature into the city.

Design and Architecture

Bosco Verticale is made up of two residential buildings that are 112 and 80 meters tall, respectively. This development's signature feature is the lush vegetation that covers its façade, which includes 5,000 plants, 90 different varieties of shrubs, and over 700 trees. This vegetation performs vital ecological roles in addition to providing a beautiful visual display.

Environmental impact and sustainability

A representation of sustainable urban life is Bosco Verticale. The towers' greenery has the same environmental impact as a forest covering 30,000 square meters. It serves as a cooling agent in the city, filters pollutants, and reduces carbon emissions. The building's layout and the plants' thermal mass effect contribute to the building's energy efficiency by lowering the amount of energy needed for heating and cooling. A greywater recycling system and solar panels add even more sustainability to the project.

Quality of life and community benefits

Bosco Verticale significantly raises inhabitants' quality of life in addition to its ecological value. In the middle of the busy metropolis, the vertical forest offers shade, quietness, and peace. The microclimate that the vegetation creates improves both the general health of individuals who live there and the purity of the air.

Awards and recognitions

Bosco Verticale has received many honors, including as the International Highrise Award in 2014 and the Council on Tall Buildings and Urban Habitat's Best Tall Building Worldwide award in 2015.

4. The Bullitt Center, Seattle, USA:

Plate 5: *photo of the Bullitt center*
Source: bullittcenter.org

Background

Growing environmental concerns, such as resource depletion and climate change, led to the creation of the Bullitt Center. The project's goal was to show that it was possible to design and run an office building that produces more energy than it uses and offers a productive and healthy work environment.

Important Sustainable Design Elements:

- **Energy Efficiency**: The Bullitt Center places a high priority on energy efficiency by utilizing movable windows for natural circulation and wide windows that optimize natural sunshine. In order to use less energy, the building also has an innovative geothermal heat pump system and energy-efficient lighting.
- **Renewable Energy**: A photovoltaic array of 575 solar panels is installed on the top of the Bullitt Center. In addition to producing extra energy that is put back into the grid, this array provides all the electricity needed to operate the building.
- **Sustainable Materials**: Using FSC-certified timber, non-toxic paints, and low-VOC finishes are just a few examples of the sustainable building materials that were given top importance.
- **Water conservation**: The Bullitt Center uses a rainwater harvesting system to lessen its dependency on municipal water sources by collecting and storing rainwater for use in non-potable applications. Toilet composting is an additional water-saving measure.

Challenges

Developing a structure such as the Bullitt Center involved difficulties, such as securing licenses for avant-garde elements like composting latrines that did not comply with current codes. Purchasing sustainable resources, such as wood with an FSC certification, can be more expensive and time-consuming.

Outcomes and impacts

The Bullitt Center has obtained Living Building Challenge accreditation, one of the most demanding green building certifications in the world, and has come to represent sustainability in the construction sector. The structure welcomes a large number of tourists and advances sustainable construction techniques while acting as a research center and teaching resource.

2.4 CHALLENGES AND OPPORTUNITIES IN NIGERIA

While the principles of sustainable building design are universal, their application in Nigeria, and particularly in Benin City, presents unique challenges and opportunities. Nigeria's climate, with its distinct seasonal variations and high temperatures, necessitates tailored strategies for energy-efficient building design. Moreover, the availability of resources, materials, and skilled labor influences the feasibility of certain sustainable practices. Understanding and addressing these local challenges is pivotal in crafting effective, context-specific design solutions (Odusote & Ogunlana, 2018).

Challenges in Nigeria

i. Policy and regulatory challenges

Nigeria confronts difficulties in creating and enforcing building rules and comprehensive energy efficiency programs. Stricter rules and incentives are required to promote environmentally friendly architectural designs in academic buildings (Olotuah et al. 2016).

ii. Economic Constraints

Economic factors often hinder the adoption of sustainable designs because sustainable solutions need greater initial costs, economic reasons frequently impede their adoption. The incorporation of energy-efficient technologies and materials may be impeded by financial restrictions (Ogunjirin et al. 2018).

iii. Infrastructure Challenges

Inadequate infrastructure, such as erratic electrical supplies and a dearth of recycling facilities, can make it more difficult to install energy-efficient technologies and sustainable designs in Nigeria. (Ajayi, 2020).

Opportunities in Nigeria

i. Abundant Renewable Energy Resources:

Nigeria has a great deal of potential for using wind and solar energy. This offers chances to incorporate energy-efficient renewable energy technologies into buildings.

ii. Increasing Awareness and Green Building Initiatives:

As the value of sustainability becomes more widely recognized, organizations like the Green Building Council of Nigeria are working to promote environmentally friendly building designs and methods. (Olotuah et al, 2016).

iii. Research and Innovation:

Nigerian universities, including the University of Benin, can play a crucial role in research and innovation to develop cost-effective and context-specific solutions for sustainable buildings. (Odusami et al, 2017).

iv. International Cooperation:

Working with international organizations and specialists can open doors to financing, information sharing, and industry best practices for energy-efficient and sustainably designed buildings. (Ajayi, 2020)

2.5 SUSTAINABLE DESIGN TOOLS AND TECHNIQUES

Sustainable design is no longer an option but a necessity in the world of architecture. As stewards of the built environment, architects play a vital role in shaping a more sustainable future. In this comprehensive guide, I delve into the tools and techniques that architects can leverage to integrate sustainable design principles into their projects. By embracing energy efficiency and environmental responsibility, architects can create spaces that are not only visually striking but also contribute to a healthier planet. Sustainable design, also known as green design, prioritizes the well-being of people and the planet by minimizing the negative impact of buildings on the environment. It involves considering the entire lifecycle of a project, from construction to operation and eventual demolition.

The implementation of sustainable design principles often necessitates the utilization of specialized tools and techniques. Building Information Modeling (BIM), for instance, enables architects and engineers to simulate the environmental performance of a building before construction, helping in the identification of energy-saving opportunities (Yu et al, 2014). The choice of energy-efficient materials, the integration of green roofs, and advanced HVAC control systems are examples of techniques that can significantly contribute to energy efficiency.

2.5.1 TOOLS FOR SUSTAINABLE DESIGN

i. **Building Information Modeling (BIM)**

BIM technology allows architects to create detailed digital models of buildings, facilitating efficient design iteration and simulation. It enables energy analysis, daylighting studies, and material selection to align with sustainability goals.

ii. **Eco design tools**

Eco-design technologies facilitate the integration of environmental considerations into all phases of the design process, from concept generation through product production. Eco-design technologies are useful for ideation, impact analysis, solution optimization, and decision documentation. EcoDesign Canvas, EcoDesign Sprint, EcoDesign Checklist, and EcoDesign Toolkit are a few instances of eco-design tools.

iii. **Energy modeling software**

Energy modeling tools simulate the energy performance of a building, helping architects optimize insulation, HVAC systems, and lighting. Particularly for buildings and urban systems, energy modeling tools assist you in simulating and optimizing the energy performance of your design project. Energy modeling tools may be used to evaluate various scenarios and tactics to predict energy consumption, greenhouse gas emissions, and operational costs. Tools for energy modeling include DesignBuilder, TRNSYS, EnergyPlus, and OpenStudio.

iv. **Life Cycle Assessment (LCA)**

A product, service, or system's environmental effects are assessed at every stage of its life cycle, from raw material extraction to end-of-life care, using a technique called life cycle assessment (LCA). LCA software is a technology that facilitates the execution of LCA studies, data collection and management, and report and graph generation. You may analyze several design solutions, find potential for improvement and hotspots, and share your findings with stakeholders with the use of LCA software. Software for life cycle analysis (LCA) includes SimaPro, GaBi, OpenLCA, and Ecoinvent.

v. **Sustainability frameworks**

With the use of sustainability frameworks, you may better match your design project with the larger objectives and benchmarks of sustainability, such as the B Corp accreditation, the ISO 14000 series, or the Sustainable Development Goals (SDGs) of the United Nations. You may design your goals and objectives, create benchmarks and indicators, track and document your progress, and report on your effect with the aid of sustainability frameworks. The GRI Standards, B Impact Assessment, ISO 14001, and SDG Compass are a few instances of sustainability frameworks.

2.5.2 SUSTAINABLE DESIGN TECHNIQUES

Sustainable design techniques encompass a wide range of strategies and practices aimed at minimizing the environmental impact of buildings, infrastructure, and products while promoting long-term economic viability and social well-being. Here are some key sustainable design techniques:

vi. Passive Solar Design: Orienting buildings to maximize exposure to natural sunlight and heat during the winter while minimizing it during the summer, reducing the need for heating and cooling.

vii. Energy-Efficient Building Envelopes: Using high-performance insulation, energy-efficient windows, and well-sealed building envelopes to reduce heat loss and gain.

viii. Daylighting: Incorporating natural daylight through well-placed windows and sky lights to reduce the need for artificial lighting and enhance occupant well-being.

ix. Natural Ventilation: Designing for cross-ventilation and the stack effect to enhance indoor air quality and reduce reliance on mechanical ventilation systems.

x. High-Efficiency HVAC Systems: Utilizing energy-efficient heating, ventilation, and air conditioning systems to reduce energy consumption.

xi. Renewable Energy Integration: Installing solar panels, wind turbines, or other renewable energy sources to generate on-site power and reduce reliance on non-renewable energy.

xii. Rainwater Harvesting: Collecting and storing rainwater for non-potable uses like irrigation, flushing toilets, and cooling systems.

xiii. Graywater Recycling: Treating and reusing graywater (wastewater from sinks, showers, and laundry) for non-potable purposes.

xiv. Sustainable Materials: Choosing environmentally friendly building materials like recycled, rapidly renewable, and locally sourced materials, as well as those with low volatile organic compounds (VOCs).

xv. Low-Impact Site Development: Minimizing site disturbance, preserving natural features, and promoting permeable surfaces to reduce stormwater runoff and erosion.

xvi. Green Roofs and Walls: Installing green roofs with vegetation and living walls to provide insulation, reduce heat island effects, and enhance urban biodiversity.

xvii. Waste Reduction and Recycling: Implementing construction and demolition waste management plans to reduce landfill waste and promote recycling.

xviii. Smart Building Technologies: Using advanced sensors and building management systems to optimize energy use, lighting, and HVAC systems based on real-time occupancy and environmental conditions.

xix. Adaptive Reuse: Repurposing existing buildings and structures for new uses, reducing the need for new construction and preserving cultural heritage.

xx. LEED and Other Certification Programs: Seeking certifications such as LEED (Leadership in Energy and Environmental Design) to ensure adherence to sustainable design principles and best practices.

xxi. Biophilic Design: Incorporating elements of nature, such as greenery and natural materials, into interior spaces to enhance occupant well-being and productivity.

xxii. Resilient Design: Designing structures to withstand extreme weather events and other environmental challenges, ensuring long-term functionality and safety.

xxiii. Cradle-to-Cradle Design: Focusing on the entire life cycle of a product, from material sourcing to disposal, to ensure minimal environmental impact.

xxiv. Collaborative Design and Integrated Project Delivery: Involving all stakeholders, including architects, engineers, contractors, and building owners, from the project's inception to encourage interdisciplinary collaboration and holistic problem-solving.

xxv. Community Engagement: Engaging with local communities to ensure that the design meets the needs and preferences of its users and benefits the broader community.

2.5.3 ENVIRONMENTAL RESPONSIBILITY AND AESTHETICS

i. **Harmonizing sustainability and aesthetics**

Sustainable design does not mean compromising aesthetics. In fact, sustainable principles can enhance architectural beauty. Incorporating natural materials, maximizing natural light, and creating biophilic connections enrich the visual appeal of spaces.

ii. **Adaptive reuse and historic preservation**

Preserving existing structures through adaptive reuse minimizes resource consumption associated with new construction. This approach honors history while promoting sustainability.

2.5.4 THE IMPACT OF SUSTAINABLE DESIGN

i. Energy efficiency

Sustainable design reduces energy consumption, resulting in lower operational costs and a smaller carbon footprint.

i. Improved indoor air quality

Careful material selection and ventilation strategies contribute to healthier indoor environments, enhancing occupant well-being.

ii. Long-term cost savings

While sustainable materials and technologies may have higher upfront costs, they often lead to long-term savings through reduced energy and maintenance expenses.

2.6 POLICY AND REGULATIONS

National and local policies and regulations significantly influence the adoption of sustainable building design and energy efficiency practices. In Nigeria, the National Building Code, established by the Federal Ministry of Works and Housing, delineates standards and guidelines for sustainable construction practices (Federal Ministry of Works and Housing, 2011).

Compliance with such regulations is integral in promoting sustainable design and fostering a culture of energy efficiency.

2.7 COMMUNITY AND STAKEHOLDER INVOLVEMENT

Sustainable design is not solely about architectural innovations; it is also about fostering a sense of collective responsibility and engagement within the campus community. The active participation of stakeholders and the community, including faculty, staff, and students, can be instrumental in ensuring that sustainable practices are embraced and effectively implemented. Community engagement strategies, like sustainability awareness campaigns and educational programs, are essential for promoting the adoption of sustainable design principles (Seyedian & Singh, 2017).

CHAPTER THREE

DATA COLLECTION

3.1 OVERVIEW OF THE UNIVERSITY OF BENIN

Founded in 1970, the University of Benin (UNIBEN) is a leading university in Nigeria. It is renowned for its dedication to community involvement, research, and academic success. With a organized campus located in Ugbowo, Benin City, UNIBEN maintains a strong research culture and provides a diverse array of academic programs. Notable graduates who have achieved success in a variety of disciplines and a varied student body characterize the university. Despite certain difficulties, UNIBEN also actively engages with the community and is often ranked among Nigeria's best institutions.

3.2 SELECTION CRITERIA FOR CASE STUDY PROJECTS

Sustainable and energy efficient buildings are recognized as a new innovation in building technology in Nigeria and has not been widely adopted. This is a limitation to the selection of relevant case studies as existing sustainable buildings in the University of Benin main campus is very limited. Within the Ugbowo campus of the University of Benin, there are a couple of buildings that incorporate sustainable building but none of which meet the full requirements to be considered sustainable at the time of this study; the Faculty of Environmental Science building, Faculty of Engineering building, Computer science department and the University of Benin information communication and technology building.

3.3 CASE STUDY ONE: FACULTY OF ENVIRONMENTAL SCIENCE

3.3.1 BUILDING OVERVIEW

***Plate 6**: photo of Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

***Plate 7:** photo of Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

The faculty of environmental science building is the faculty building for 5 departments namely Architecture, Quantity Surveying, Estate Management, Fine and Applied arts and Geomatics. The contractors of this project could not be accessed for adequate construction details, hence limited information was gathered.

3.3.2 DESIGN AND SUSTAINBLE AND ENERGY EFFICIENT FEATURES

The faculty building perimeter has a dimension of 187ft (56m) by 218 (66m) including the landscaping. It's a two (2) story building (3 floors) which contains four (4) studios two (2) extra lecture rooms and multiple offices as well as public and private toilets for both staff and students. The building has a very distinct look from the front as it has a sharp pointy front elevation that captures passers-byes and on lookers. The building has some sustainable features such as:

- **COURTYARD FOR NATURAL LIGHTING**

The presences of a courtyard at the middle of the faculty building provides natural lighting throughout all the offices, studios and lecture rooms.

Plate 8: *photo of Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

- **CROSS VENTILATON IN ALL STUDIOS AND LECTURE ROOMS**

Each classroom and lecture room were designed to accommodate natural ventilation through long vertical window openings on both sides of the studio, one to the exterior of the building and the other to the courtyard, this is known as cross ventilation.

Plate 9: *photo of Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

- **NATURAL LIGHTING THROUGH OPENINGS**

Just like with the ventilation, the building provides natural lighting for both studios, lecture rooms and offices.

- **SOLAR PANELS FOR SOME OFFICES**

The visual presence of solar panels that provide clean energy for the dean's office.

Plate 10: *photo of Faculty of Environmental science (2023)*
Source: Researcher field work (2023)

3.3.3 MERITS OF SUSTAINABLE FEATURES

- Enhanced Aesthetics: glass curtain walls for natural lighting enhances the aesthetics of the building.
- Health and Well-Being: proper ventilation and lighting during class hours helps students focus and make them more productive.

3.3.4 DEMERITS OF SUSTAINABLE FEATURES

- Maintenance Complexity: Certain features of the building have been poorly maintained.
- Extreme glare caused by lack of proper shading devices for office spaces

Plate 11: *photo showing direct sun light hitting the building.*
Source: Researcher field work (2023)

CHAPTER FOUR

DATA ANALYSIS

4.1 INTRODUCTION

Sixty-six percent (66%) of the fifty (50) questionnaires that were provided were filled out and returned. This study's response rate is similar to those of previous surveys (Danity, 2008; Sutrisna, 2009). Sutrisna (2009) defends such a response rate as normal, while Danity (2008) mentions it as suitable, arguing that if the total number of responses is fewer than 30, a questionnaire would be viewed as subjective or irrelevant. As a result, the survey's 66% response rate provides reliable data for study. Using the Likert Scale, some qualitative responses were translated into quantitative data analysis. Then, simple descriptive statistics like median, mean, frequency, and percentages were used in the data processing process. The question, for instance, listed and emphasized on the features of sustainability and energy efficiency in respondents affiliated faculties.

4.2 GENERAL INFORMATION

RESPONDENT ROLE AT THE UNIVERSITY

The role of respondents in data presentation is crucial for successful research. They supply the information that serves as the basis for study findings. To guarantee the quality of the data, respondents provided truthful and precise information. Their comments elucidated interpretations and confirmed findings. In the end, respondents play a crucial role in the research process, adding to its legitimacy and success.

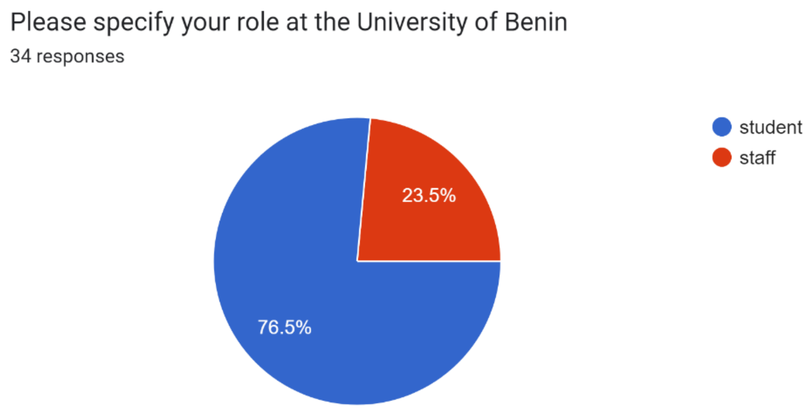

Figure 4.1*: pie chart showing role of respondents at the University of Benin.*
Source: Researcher field work (2023)

Out of the 34 total respondents, 26 which makes up for 76.5% were student while the remaining 8 which makes up 23.5% were staff respondents. It is important to get feedbacks from both staff and student perspective.

RESPONDENT SCALE OF EXPERIENCE IN UNIVERSITY OF BENIN

The duration of an individual's affiliation with the University of Benin is a pertinent question for the research project on this research because it sheds light on the institutional knowledge, cultural dynamics, historical background, and decision-making processes surrounding sustainability initiatives. Comprehending an individual's tenure can facilitate a more thorough examination of the social and organizational elements impacting the efficacy of sustainable practices at the University of

Benin.

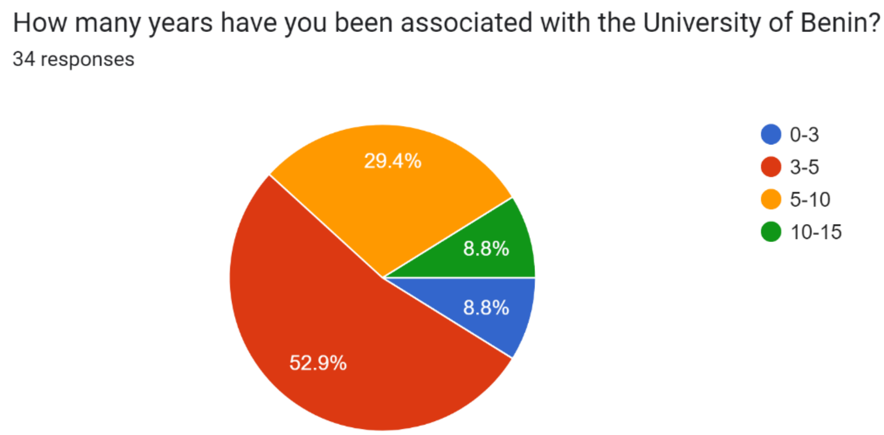

Figure 3: *pie chart showing years of experience of respondents at the University of Benin. Source: Researcher field work (2023)*

Respondent with 0-3 years of experience: 3 persons which make 8.8%

Respondent with 3-5 years of experience: 18 persons which make 52.9%

Respondent with 5-10 years of experience: 10 persons which make 29.4%

Respondent with 10-15 years of experience: 3 persons which make 8.8%

This result shows that out of the 34 respondents, majority (52.9%) have spent average time of 3-5 years in the University of Benin and have sufficient experience and information.

RESPONDENT FACULTY OF AFFILIATION

The question "*Which faculty are you affiliated with*?" is essential since it establishes the academic or professional background of the audience. To customize the presentation to the audience' interests and degree of competence, it is necessary to know which faculty members will be present.

Which faculty are you affiliated with

34 responses

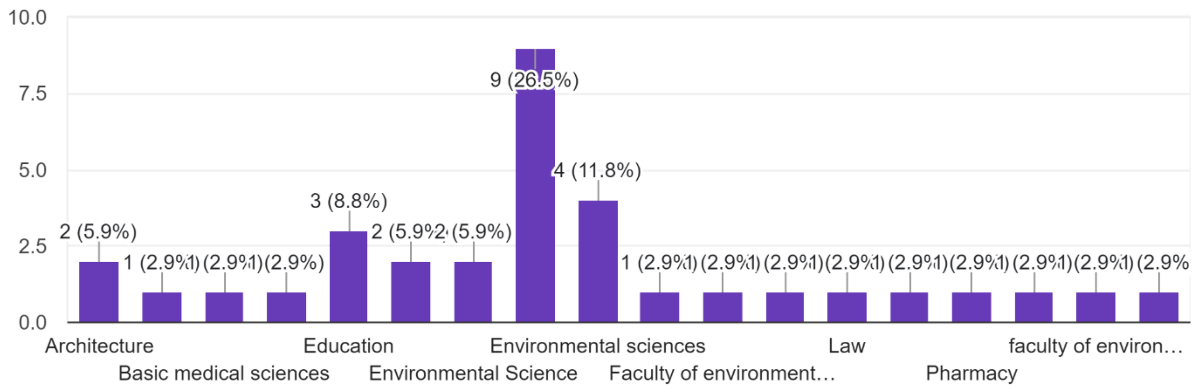

Figure 3: *bar chart showing years of experience of respondents at the University Of Benin.*
Source: Researcher field work (2023)

the data above shows the distribution of respondent with their affiliated faculties in the University of Benin.

	Environmental Science	Engineering	Law	Pharmacy	Arts	Education	Basic Medical Sciences	Life science
NOS	21	2	1	1	2	4	1	1
%	63%	6%	3%	3%	6%	12%	3%	3%

TOTAL: 33 RESPONDENTS

4.3 AWARENESS AND PERCEPTION

RESPONDENT FARMILIARITY WITH SUSTAINABLE DESIGN AND ENERGY EFFICIENCY

To determine the present knowledge levels of stakeholders involved in the construction and maintenance of academic buildings at the University of Benin, the study question "*Are you aware of sustainable design principles in building construction and energy efficiency*?" is essential. This question aids in establishing a baseline knowledge, identifying needs for education, involving stakeholders, revealing implementation difficulties, influencing the creation of policy, and assessing user awareness. In the end, policies and activities targeted at advancing sustainable design principles and improving energy efficiency in the university's academic buildings are informed by the answers to this question**.**

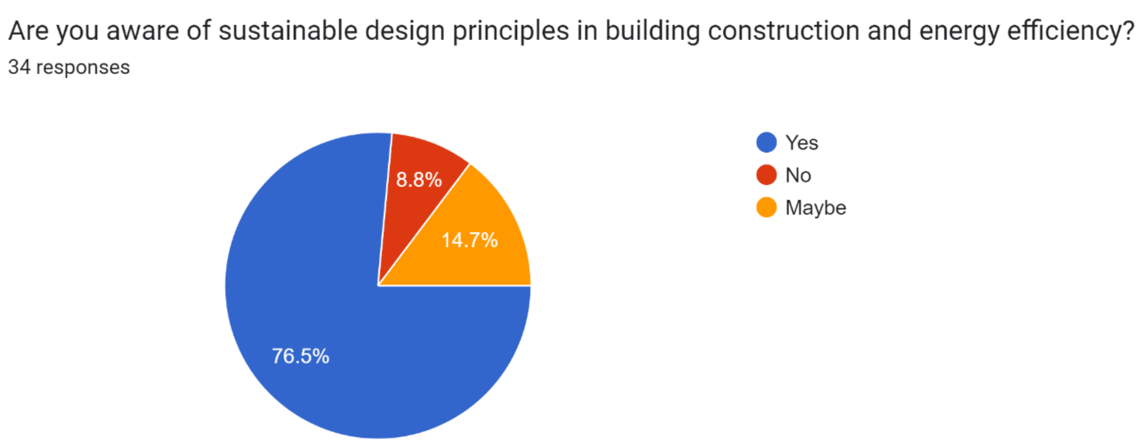

Figure 4.2.1*: pie chart showing years of experience of respondents at the University of Benin.*
Source: Researcher field work (2023)

From the responses, 26 (76.5%) are familiar with sustainable design and energy efficiency while 3(8.8%) have no idea what the concept it and the rest which make a percentage of 5(14.7%) have little knowledge but cannot be considered as professional opinions.

RESPONDENTS OPINIONS ON UNIVERSITY OF BENINS EFFORTS TOWARDS SUSTAINABLE DESIGN.

For this research study, the research question evaluating the University of Benin's sustainability initiatives in academic buildings is essential. It creates a starting point, points out advantages and disadvantages, compiles viewpoints from a variety of stakeholders, permits comparison analysis, makes suggestions for development, and provides quantitative data for statistical analysis. Adding qualitative information to it will help provide a more thorough assessment of sustainability programs.

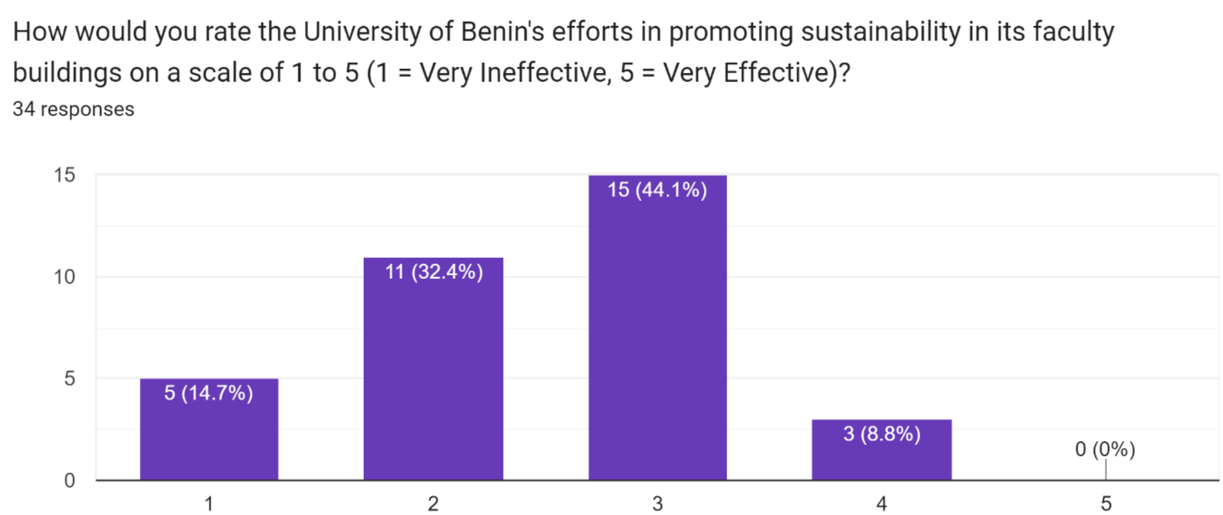

***Figure 4.2.2**: bar chart showing years of experience of respondents at the University of Benin.*
Source: Researcher field work (2023)

Student and staff of the university affiliated to various faculties stated their opinions on the university's efforts to the contribution of sustainability and energy efficiency. Using the Likert scale ranging from 1 to 5 (1=very ineffective, 5= very effective) 3 was the most picked option suggesting that respondents believe that the university is at best making average effort towards energy efficiency.

4.4 SUSTAINABLE DESIGN FEATURES

For this research study on sustainable designs in academic buildings at the University of Benin, the research question, "*Are there any sustainable design features (e.g., solar panels, energy-efficient lighting) implemented in your faculty building?*" is essential. It helps to determine which technologies have been put into use, analyze how they affect energy efficiency, pinpoint problem areas, guide the development of new regulations, and provide benchmark comparisons. To plan for increased energy efficiency and to comprehend the current state of sustainability, this question is fundamental.

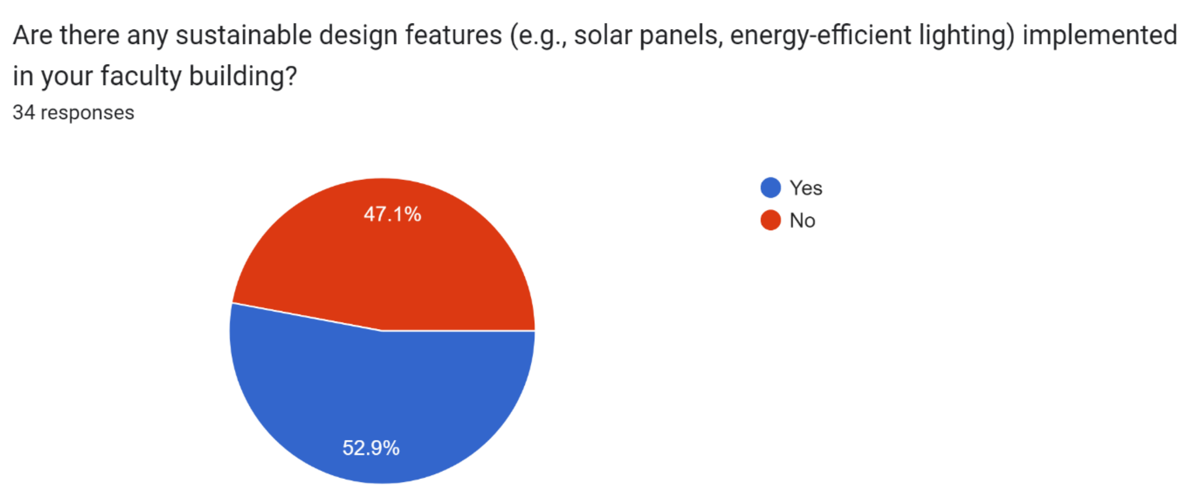

Figure 4.3.1: pie chart showing availability of sustainable features at the University of Benin. Source: Researcher field work (2023)

18 (52.9%) respondents claim that faculty buildings their affiliated to have sustainable design features while 16 (47.1%) respondents claim that faculty buildings their affiliated too don't have sustainable design features.

If yes, please describe these features and their impact on energy efficiency.

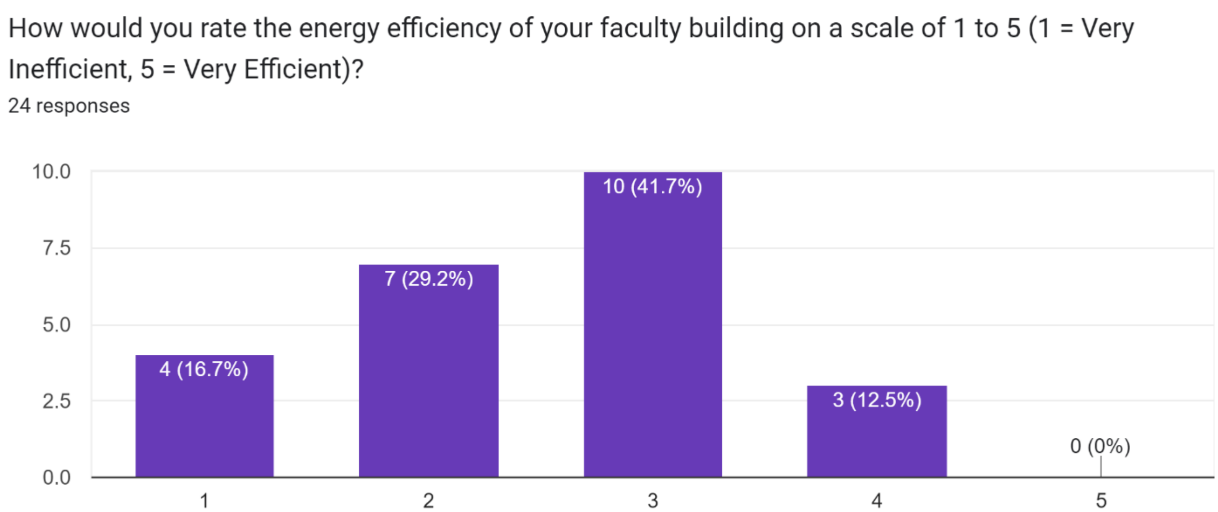

***Figure 4.3.2**: bar chart showing energy efficiency in respondents' faculty of affiliation.*
Source: Researcher field work (2023)

4.5 ENERGY USAGE

The question, "*How would you rate the energy efficiency of your faculty building on a scale of 1 to 5 (1 = Very Inefficient, 5 = Very Efficient)?*" is crucial to getting a subjective understanding of how residents see energy efficiency. It can offer data on sustainability-related awareness, satisfaction, and behavioral elements.

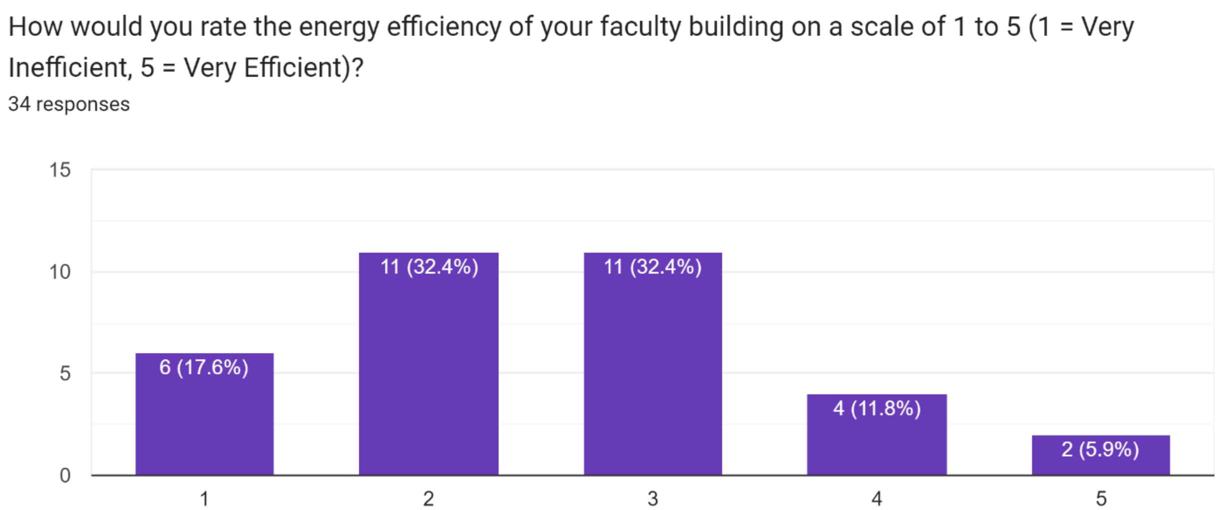

Figure 4.4.1*: bar chart showing energy efficiency in respondents' faculty of affiliation.*
Source: Researcher field work (2023)

Based on the understanding of respondents, energy efficiency in academic buildings in university of Benin using a scale of (1-5) is at "2" which is 34.4% of the total responds from my survey.

To comprehend the present status of energy usage in academic buildings of the University of Benin, it is imperative to ask the research question, "*Have you observed any energy consumption patterns, trends, or fluctuations in your faculty building*?" By providing a baseline, this data makes it easier to spot inefficiencies, evaluate the building's energy efficiency, and develop focused sustainable design plans. Through the examination of consumption patterns, the study may tackle particular problems, take into account user conduct, and eventually direct actions that advance environmental sustainability and energy efficiency.

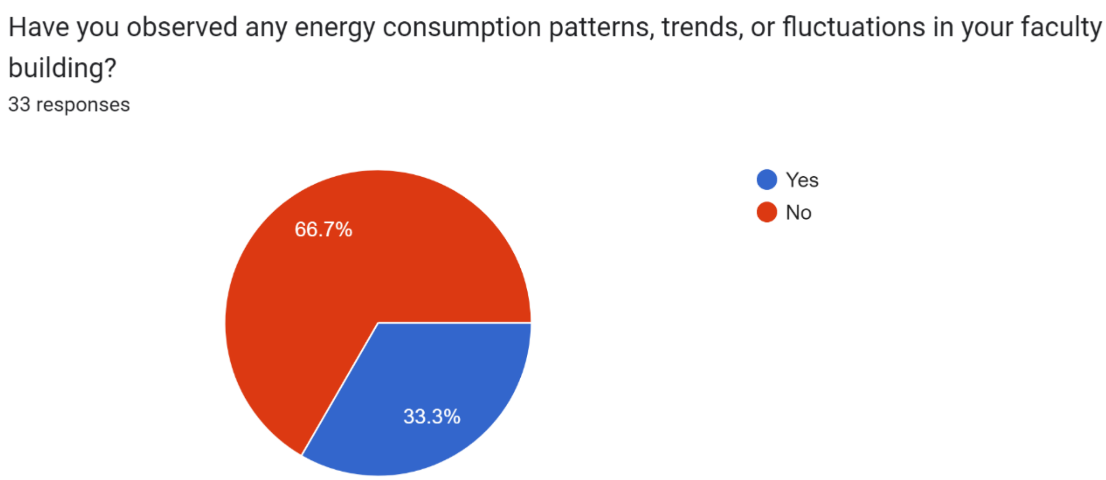

Figure 4.4.2*: pie chart showing energy consumption patterns.*
Source: Researcher field work (2023)

22 (66.7%) respondents have observed energy consumption patterns in their faculty of affiliation while 11 (33.3%) respondents have not observed energy consumption patterns.

The question, "*Do you believe that investments in sustainable designs are a viable long-term solution for reducing energy consumption in academic buildings?*" is relevant to this research project at the University of Benin. Stakeholder views are addressed, policy choices are influenced, implementation difficulties are investigated, cost-benefit analysis is aided, community engagement is fostered, and the need of awareness-raising and education is emphasized. All things considered, it offers a thorough grasp of the social and human dimensions of sustainable design, directing tactics for boosting energy efficiency in academic buildings.

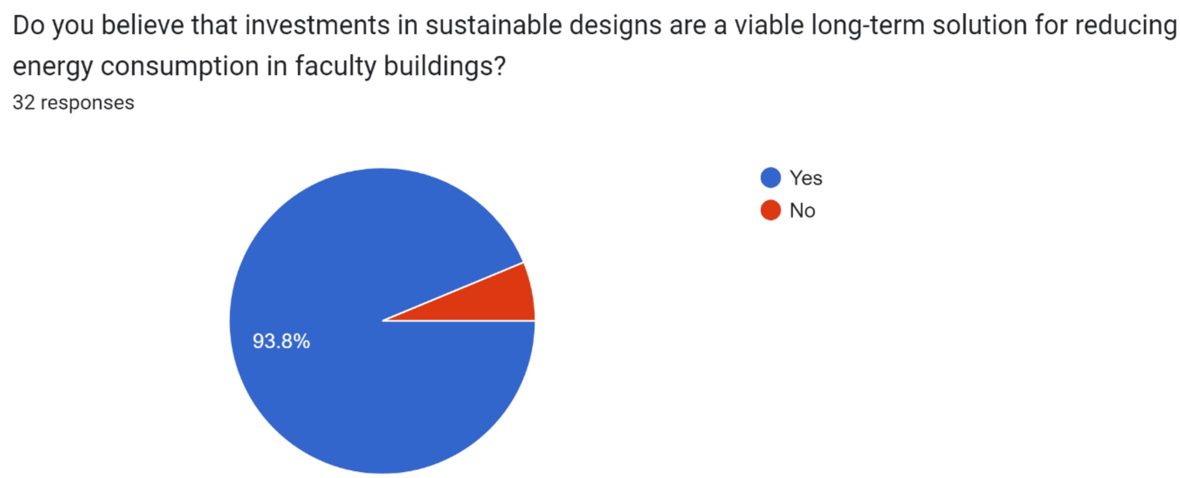

Figure 4.4.3*: pie chart showing believe in investment opportunities*
Source: Researcher field work (2023)

30 (93.8%) respondents believe that investment in sustainable design is a good long-term solution for reducing energy consumption while 2 (6.3%) disagree with this.

CHAPTER FIVE

FINDINGS AND CONCLUSION

5.1 FINDINGS

The results of my research into sustainable designs and their effects on energy efficiency in academic buildings at the University of Benin, Benin City, Nigeria, are summarized in this chapter, which serves as the capstone of my research efforts. I start by going over the research questions that served as our study's main focus and providing a quick rundown of the methods used. I then painstakingly lay out and explain the key conclusions, highlighting trends, patterns, and important results. Although I have received some insights, I am open about the limits of my study.

Regarding perception and awareness, our study showed that a sizable portion of participants, or around 76.5%, showed a clear understanding of sustainable design principles in building construction and how they affect energy efficiency. Furthermore, more than eighty percent (80%) of the participants acknowledged the importance of sustainability in buildings, highlighting the necessity of energy-efficient and ecologically conscious constructions. This indicates that stakeholders at the University of Benin are beginning to recognize and comprehend the importance of sustainable design concepts.

As for the use of sustainable design elements, we discovered that the University has implemented them in a few of its faculty buildings. These frequently included the use of solar panels, and energy efficient design. Importantly, those whose dwellings included these sustainable design components reported a significant improvement in energy efficiency for a couple of offices within the faculty building as most of the components were only allocated to certain portions of the building. This effect demonstrated the useful advantages of such features by resulting in lower power usage and increased interior comfort for building occupants.

Nonetheless, there are notable differences in the energy efficiency of the University of Benin academic buildings that my study also uncovered. Some buildings scored better (four or five on a five-point grading system) than others (one to three), indicating that there is still potential for development in terms of design and upkeep. Patterns of energy usage seemed to be influenced by a number of variables, such as student behavior, building age, and maintenance frequency. This variation emphasizes how crucial it is to take a customized strategy to solving energy efficiency issues in various types of buildings.

The suggestions provided by the respondents were rather helpful in improving the sustainability and energy efficiency of university facilities. Among them was the significance of educating and raising awareness of sustainability principles among stakeholders and building users. The respondents also stressed the need of allocating specific budgeted funds for energy-efficient retrofits and solar panel installations, among other sustainable construction projects. To further achieve long-term gains in energy efficiency and sustainability, it was recommended that rules and incentives be put in place to encourage building occuoants to behave in an energy-efficient manner.

5.2 RECOMMENDATION

This study project recommends that the University of Benin should include sustainable design concepts into the planning and construction of future academic buildings, with a focus on the use of environmentally friendly materials and energy-efficient technology. In order to emphasize the long-term advantages of sustainable designs, it promotes education and awareness campaigns among stakeholders. It's also advised to set up monitoring and assessment systems for currently operational sustainable buildings in order to collect information for ongoing development. All things considered, putting these recommendations into practice is thought to be essential for improving energy efficiency on campus as well as serving as a possible template for other academic institutions seeking to be resource- and environmentally-conscious.

5.3 CONCLUSIONS

In summary, the substantial potential for improvement is shown by this study of sustainable designs and their effects on energy efficiency in University of Benin academic buildings. I have seen the real advantages of adopting sustainable design principles via a thorough investigation of findings, not just in terms of energy efficiency but also in cultivating an environmental responsibility culture.

It is advised that sustainable building methods be used in future projects to encourage resource efficiency and lower ongoing operating expenses. It is impossible to overestimate the significance of stakeholder education and awareness since educated participants are essential to the acceptance and success of sustainable projects.

Furthermore, observation and assessment of current sustainable buildings will offer insightful information for continued development. This flexible strategy makes sure that, in the ever-changing landscape of building technology and environmental concerns, the applied sustainable solutions continue to be applicable and efficient.

This conclusion essentially highlights the practicality of sustainable design as a means of lowering energy use in academic buildings as well as its wider potential for favorable effects on the environment and the economy. The study's recommendations act as a guide for the University of Benin and other academic institutions hoping to build energy-efficient and ecologically sensitive campuses.

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