DESIGN OF AN ECO-FRIENDLY MIXED-USE BUILDING WITH EMPHASIS ON THE SUSTAINABLE DEVELOPMENT GOALS IN LAGOS STATE

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JANUARY, 2023

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN ARCHITECTURE

JANUARY, 2022

ABSTRACT

Lagos state faces an urbanization problem characterised as urbanisation without infrastructural development, the fast-paced growing city is approaching mega city status. This high rate of urbanization will result in two-third of the world's population living in cities by 2050 and would pose a threat to habitation in the cities should cities lack the capacity to accommodate their rising population effectively, this trend warrants the incorporation of sustainable features in the approach to designing buildings in megacities, thus a fusion of multi-functional buildings and sustainable design. The aim of this research is to ensure sustainability in the design of a mixed-use building through the adoption of eco-friendly features. Data was collected from relevant literature with a focus on sustainable design in high-rise mixed-use buildings, this data produced the variables that were used in the research. Data was further collected through the use of observation schedules and a checklist on a sample size of 6 mixed-use high-rise buildings that were carefully selected through purposeful sampling. The data was analysed through content analysis and the findings of the research show that all 6 case studies observed had an average rating of sustainable measures incorporated, also the introduction of high-rise buildings with mixed-use criteria resulted in a more balanced home and work life that can easily be adopted in high population areas. The findings yielded in the development of a, "Design framework for Eco-friendly mixed-use buildings" that outlines the major spatial functions for a seamless work-shop-home relationship in urban cities and also suggests that Urban planning policies should be drafted from studies like this on infrastructural development, as a foundational base for planning in developing countries.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Most governments around the world face certain challenges common to them, Urbanization as a common challenge to developing countries and in often cases urbanization without infrastructural development, the rate of urbanization in Nigeria is at an alarming increase, Lagos state leading in urbanization, growing four times the national average and urban areas like Onitsha and Kano experiencing rapid increase as well (Eco city, 2019). The kind of urbanization experienced in Nigeria has been defined as a rapid rate of urbanization marked by economic expansion without development, with major neglect of rural areas and little infrastructural development in metropolitan areas. As more of the population now in the cities it provides a lot of opportunity for social and economic development but creates a lot of pressure on infrastructure, limited resources and thus potentially open doors to escalating social inequality.

Developing countries indicates a high projection of increase in urban areas by nearly 2 billion people, Asia will account for the majority of the growth, but Africa will account for the largest proportionate rise, East Africa currently is experiencing the highest population increase in the world and in terms of infrastructure. Venables (2017), asserts that in the next two decades, the continent will need to develop at least twice as much urban capital as it has in its whole history. In line with these Bouteligier (2012), has projected that cities in the developing world will absorb 95% of urban growth, others are however opined that some of the statistics provided are misleading and exaggerated, stating that all censuses since 1952 have been highly contested due to political and economic reasons, in a country like Nigeria politics is a game of numbers and also federal

allocation to states is influenced by numbers, and also politically to win elections controlling a high population is more advantageous than low numbers. Having observed the dramatic increase of the population in Lagos Nigeria the available data on Lagos and in fact on the population data increase in Nigeria is conflicting as observed by Gould, (1995), represented in Table 1.1. Urbanization is major reason for the development and growth of megacities such as Lagos.

Table 1.1: Lagos state population data

Year	Population	Growth Rate (%)	Growth
2035	24,418,768	3.46%	3,818,612
2030	20,600,156	3.73%	3,443,763
2025	17,156,393	3.61%	2,788,061
2020	14,368,332	3.26%	2,129,126
2015	12,239,206	3.23%	1,798,024
2010	10,441,182	3.34%	1,581,783
2005	8,859,399	4.00%	1,578,693
2000	7,280,706	4.01%	1,298,026
1995	5,982,680	4.66%	1,218,587
1990	4,764,093	6.36%	1,263,629
1985	3,500,464	6.36%	928,246
1980	2,572,218	6.36%	682,416
1975	1,889,802	5.98%	476,274
1970	1,413,528	4.48%	278,089
1965	1,135,439	8.29%	373,021
1960	762,418	10.23%	293,958
1955	468,460	7.57%	143,242
1950	325,218	0.00%	

Source: Gould (1995)

According to the World Bank, the West African metropolis is the fastest-growing city in the world from 2017 to 2030 (Euro monitor, 2018). This coincides with the United Nations Development Programme's (UNDP) deadline for the Sustainable Development Goals (SDGs).

1.2 Statement of the Research Problem

Cities will house more than half of the world's population. According to UN estimates, two-thirds of humanity (6.5 billion people) will live in cities by 2050 (Basu *et al.,* 2021). With the increase in urban activities, it would be good to synergize specific spatial functions together in building design in order to achieve sustainable development. Global warming has been acknowledged as a threat to humanity by the SDGs, which have called for action to make cities more inclusive, safe, resilient, and sustainable. Euro monitor, (2018), has identified the fast-paced growing city of Lagos to approaching mega city status by the year 2050, the climatic and population factors raised in already established literature suggests that the city planning needs to adopt the use of mixed-use buildings if the climatic crisis is to be remedied. As such there has to be a dynamic and sustainable approach to how we live and indeed construct these mixed-use buildings.

1.3 Aim and Objective of the Study

1.3.1 Aim

The aim of this study is to ensure sustainability in the design of a mixed-use building through the adoption of eco-friendly features.

1.3.2 Objectives

The objectives are to: -

i. Evaluate buildings and their primary function across the corridors of Lagos state.
ii. Evaluate the use of sustainable features in buildings observed in Lagos state.
iii. Design an eco-friendly mixed-use building.

1.4 Research Justification

Mixed-use structures aren't exactly a novel notion. Humans have traditionally settled in mixed-use patterns, concentrating all of their resources in a single location. The industrial revolution, on the other hand, introduced new zoning restrictions and a clearer distinction between dwelling and working areas. The invention of the automobile accelerated this tendency, allowing people to commute great distances between home, office, and shopping, as well as a shift from city to suburban lifestyle (Niemira, 2007).

Developers, on the other hand, are once again embracing mixed-use developments. People are moving back to cities, and high-density building is becoming more popular. Furthermore, during the 1990s, a loosening of mixed-use zoning restrictions has aided architects and city planners in developing innovative concepts that meet a variety of city dwellers' demands in a single site. In a city like Lagos, where cars and people are trapped in traffic for lengthy periods of time, continuously spewing carbon into the atmosphere, the need to lessen this burden on the planet while simultaneously getting people to their destinations on time is critical (Eco city, 2019).

Eco-friendly or green design is a construction method that uses careful material selection and sustainable construction procedures to reduce harmful effects on human health and the environment. Mixed-use developments are available in a variety of sizes and shapes. Mixed-use developments, mixed-use zones, and mixed-use structures all have varied scales. They range from the fashion designer who works out of her living room (mixed-use spaces) to the shopkeeper who lives on the first floor and operates a shop on the ground floor (mixed-use buildings) to massive mixed-use developments spanning several acres of land, due to recent calls for nations to take a Global climatic action to arrest

certain global issues such as global warming, the United Nations has established sustainable development goals so that countries can take steps to protect the environment (United States Environmental Protection Agency, USEPA, 2019). As a result, in order to come up with a comprehensive and applicable conclusion, this research is undertaken on facilities of varied scales and type.

1.5 Scope of Work

The physical scope of this work is Lagos state however the study scope of this work is to integrate activities in a sustainable mixed-used building. The design would integrate:

i. Residential

ii. Commercial and

iii. Institutional buildings

1.6 Study Area

Lagos state is Nigeria's most populous state, with a metropolitan population estimated to reach 24.7 million by 2021 (UN-Habitat, 2015). It is located on the equator at 6°27′11″N 3°23′45″E, in the country's south-western area, with the smallest land mass comprising islands and main lands. The republic of Benin is on the east, Ogun state is on the north and west, and the Atlantic Ocean is on the south, this can be seen in Figure 1.1 (Eco city, 2019).

Figure 1.1: The location of Lagos state on the Nigerian map

Source: Eco city (2019)

Historically Lagos state was divided into 5 major areas; Ikeja, Epe, Badagry, Ikorodu and Lagos islands (colloquially known as IBILE), under which Eko Atlantic is a reclaimed region of formerly known Lagos bar beach on Victoria Island, it consists of 102 high-rise buildings, of which 9.5% are mixed-use buildings, its location is shown in Figure 1.2. Some existing high-rise buildings in that area are also represented in Table 1.2.

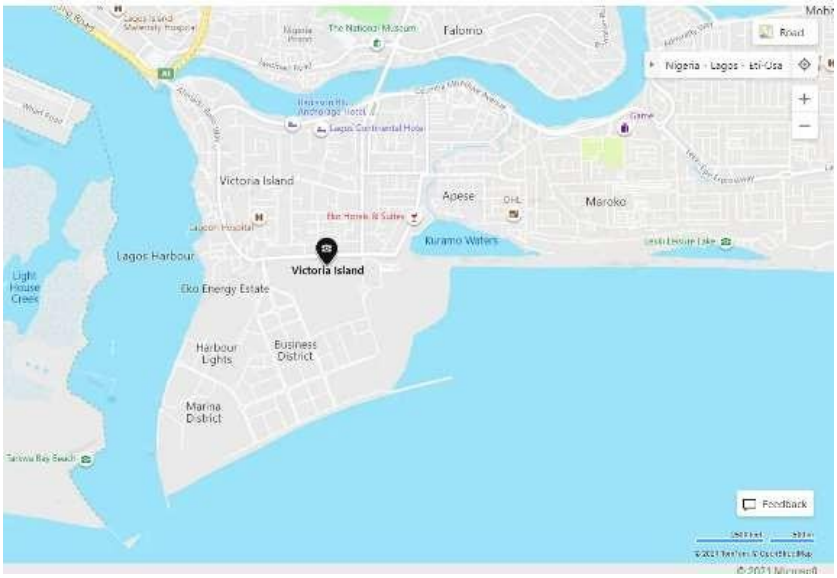

Figure 1.2: Victoria Island and Eko Atlantic, Lagos

Source: Author's Work (2020)

Table 1.2: Some high-rise mixed-use buildings in Victoria Island

S/N	Building	Height	Floors	Building type
1	Inter-Continental Hotel Lagos	101 m	17	high-rise building
2	Eko Court Block C	99 m	24	high-rise building
3	Eko Court Block B	99 m	24	high-rise building
4	Eko Court Block A	99 m	24	high-rise building
5	Wema Towers	82 m	20	high-rise building
6	CASI Towers III	66 m	16	high-rise building
7	CASI Towers II	66 m	16	high-rise building
8	CASI Towers I	66 m	16	high-rise building
9	Black Diamond Suites & Apartments	62 m	15	high-rise building
10	Federal Palace Hotel	57 m	14	high-rise building
11	Zenon House	53 m	13	high-rise building
12	Sapetro Tower	53 m	13	high-rise building
13	Atlantic Royal Gardens	53 m	13	high-rise building
14	Octagon House	49 m	12	high-rise building
15	Africa Re Building	49 m	12	high-rise building
16	Churchgate Tower I	49 m	12	high-rise building
17	Eko Hotel	49 m	12	high-rise building
18	AIB Plaza	41 m	10	low-rise building
19	Total House	25 m	6	low-rise building
20	Nestoil building	62 m	15	high-rise building
21	Cornerstone	53m	13	high-rise building

Source: Eco city (2019)

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 General Overview on the Historical Development of Mixed-Use Development

Going back in time, history has it that majority of human settlements were mixed-use and that a man's home of residence had everything to do with his source of livelihood, these two functions were however attached to each other. The distance from work to home was very little. Majority of walking as a resulting of transferring goods from one place to another; people used their homes as workshops, or sale shops or even places where certain services can be rendered like the earlier physicians or engineers, people basically walked from home. As a result of increase in population the development of markets as an urban development came into being so there was the introduction of markets and market towns. It wasn't as if each building was divided into discrete functions on a room-to-room basis, most districts contained a diversity of use and overtime a certain neighbourhood tend to become predominantly known for certain services such as metal workers or textile workers, this can be seen in Figure 2.1 and Figure 2.2. Population increase led to high density areas leading to the rise of in towns and cities, leading to certain modification between the relationship between people's place of work and residence (Niemira, 2007).

Figure 2.1 The proximity of work to residence in a fishing community

Source: Udomiaye *et al*, (2018)

Figure 2.2 A Fishing Community

Source: Udomiaye *et al*, (2018)

2.2 The Emergence of Zoning and Decline in Mixed-Use Living

The industrial age brought about a decline in mixed-use pattern of human living this was in favour of early capitalist-style manufacturing on a big scale in single-purpose buildings (Florida, 2002). This era saw massive migration to urban city areas from the rural areas most of the people who had local business where now attracted by factory jobs and this migrants upon moving needed a place for residence, hence the rise of many new urban districts with the purpose of domestic housing as a primary function (Stern *et. al.*, 2013).

This led to the creation of the land use with areas designated for specific activities. Also, the pollution and toxic wastes of factories, for the hygiene of people distances was required to minimize adverse effects on the health of individuals from either noise or toxicants. These considerations were crucial in the movement for Euclidian zoning, which is based on the division of land uses into similar functions and their spatial separation.

Garden city proponents in Europe proposed better techniques to zone city functions during the design stage in order to avoid conflicts between land uses. In his ideas like the "Plan Voisin," "Ville Contemporaine," and "Ville Radieuse," Le Corbusier, a pioneer modernist architect, envisioned similar city designs for Paris. This necessitated the deconstruction of huge towns and their replacement towers (Bigon and Katz, 2014).

The Euclidian zoning ushered in the emergence of skyscrapers in the United States, but the concern of structures shutting out the sun prompted many to ask for zoning rules, particularly in New York City. Building height limits were first proposed in 1916, followed by a proposal for the separation of land uses. Keeping people away from heavily intoxicated regions, then with time the separation was extended to commercial areas; these land use acts set the stage for the suburban lifestyle known in the United States today and also ushered in the mass transit systems which would see private automobile, bus and rail systems transport people from a distant residential area through commercial, industrial and institutional areas.

2.3 The Return of Mixed-Use Development as an Urban Design Concept

The 20th century brought about a rapid increase in urban population, it so a high rise in urbanization patterns, just like what is currently being experienced in Nigeria. During the 1960s and 1970s, the phrase "mixed-use" became popular in urban planning circles as a

tool for urban revitalization, especially in large-scale initiatives (Miller and Miller, 2003). The Brundtland report, which was submitted to the World Commission on Environment and Development in 1987, sparked a renewed interest in mixed-use complexes. Europe was experiencing a high urbanization growth rate with little infrastructural development. This sort of development led to many urban issues such as congestion, slums, pollution and a whole lot of pressure on the already existing infrastructure, a reasonable duration of time can be spent on just commuting to work from home. The lack of service layout for proper city development were not available and thus cities developed without the necessary infrastructure in place. Individuals either used a considerable amount on fuelling vehicles to commute or were used to transport themselves, a significant number of individual incomes was used for transportation, and the environment was under constant pressure of environmental pollution due to carbon emissions from the vehicles (Walker, 2005).

Individuals began to hunt for jobs close to where they live in order to alleviate some of these urban concerns, and large residential areas also acted as a market for commercial activity. These two types of land use became more linked as information and telecommunications technologies made it easier and more feasible for people to work from home. As a modern urban planning idea, mixed-use is rapidly gaining traction in growing cities around the world. “A mixed-use development is a real estate project that combines retail, office, residential, hotel, recreation, and other purposes in a planned manner” (Ayeyemi, 2012). It's designed for pedestrians and includes features of a live-work-play environment. It makes the most of available space, provides amenities and architectural expression, and helps to reduce traffic and sprawl.” (Niemira, 2007).

Grant (2002), lets us understand that the mixed-use development does not introduce anything new from what the typical land uses contain (e.g., residential, office, retail, restaurants, entertainment), however (Rabianski *et al*., 2009) expanded the mixed-use development to contain activities (live, work, play, learn) and to cater for the contained demography and also zoned accordingly (income, wealth, gender, age, education, skill levels) within such developments.

2.4 The Challenges of Mixed-Use Development as An Urban Design Concept

During the twentieth century, most towns and cities experienced tremendous population growth and urbanization tendencies. The rate of population and urbanization growth outpaced that of infrastructure development. This resulted in serious urban difficulties such as traffic and people congestion, urban sprawl, slums, pollution, and a strain on existing infrastructure and services. Commuting to and from work could take up a significant amount of time. Because towns and cities grew without the requisite infrastructure and services, there were environmental and sanitary difficulties. Commuters need a large amount of gasoline for their vehicles; therefore, they spent a large portion of their earnings on transportation. Individuals' health has been impacted as a result of the stress associated with traveling to and from work. Automobile emissions contaminated the environment as well (Niemira, 2007).

People began looking for work near their homes in order to address these urban difficulties and obstacles. In addition, big residential neighbourhoods served as a commercial marketplace. As a result, activities shifted from residential to commercial and vice versa. People could also live and work in the same place because to advances in information and telecommunication technology. Not only is the mixed-use building type

resurfacing in our cities around the world as high-density, urban in-fill mixed-use structures, but it's also resurfacing as a key component of large commercial complexes (Rabianski *et al*., 2009).

2.5 Related Theories on Mixed-use Buildings

Some comparable theories and concepts are advocated by promoters of mixed-use developments as a form of urban planning method, These beliefs stem from efficient studies of old and new cities.

They are:

i. Transit-oriented development (TOD)
ii. Smart growth
iii. New Urbanism
iv. Intelligent Urbanism.

2.5.1 Transit Oriented Development (TOD)

A transit-oriented development (TOD) is a mixed-use development of residential or commercial use that is built to accommodate public transportation accessibility and most times contains aspects that encourage people to use public transportation. A TOD neighbourhood often consists of a core location with a train station, metro station, train stop, or bus stop that is surrounded by relatively high-density construction, with lower-density development radiating outwards from the centre (Rettenwender and Spitz, 2009). TODs are often found within a quarter-mile to half-mile (0.4 to 0.8 km) radius of a transit station, as this scale is considered suitable for walkers.

TODs have the following characteristics:

i. Public transportation is available at all hours of the day in a mixed-use complex.

ii. a high-quality pedestrian crossing is present.

iii. Streets that are narrow

iv. Building's taper as they get further away from the public transportation hub.

v. A reduction in the amount of parking available for personal vehicles.

2.5.2 Smart growth

In order to reduce urban sprawl, smart growth promotes compact, transit-oriented, walkable, and bicycle-friendly land use, as well as neighbourhood schooling, accessible roadways, and mixed-use development with a choice of housing options.

Smart Growth places a greater emphasis on long-term regional sustainability rather than a focus on the near term. Its objectives are to establish a sense of place and community, provide transportation, job, and housing options, equally divide development costs and benefits, protect and preserve natural and cultural resources, and promote public health (Pozdena, 2002).

2.5.2.1 Rational for smart growth

Sprawl, traffic congestion, disconnected neighbourhoods, and urban decay can all be avoided with smart expansion. Long-held urban planning assumptions, such as the importance of detached homes and the use of automobiles, are called into question by its notions. By placing people close to one another, near jobs, and near shops, travel time and transportation infrastructure costs are decreased. In the past, policymakers have attempted to offer financial incentives to developers in order to induce them to build them to use a variety of property kinds, often in concert with shifting legal constraints. Smart growth evaluates the entire long-term economic repercussions of development initiatives

rather than focusing exclusively on short-term profits. Life cycle cost analysis is widely used by engineers to analyse trade-offs, while investors and business owners may be more concerned with the "bottom line" of profit (Grant, 2009).

Cities must undertake structural adjustments and regulations to preserve and reduce climatic and environmental impacts in this age of global warming. Green belts, or urban-development borders, are advocated by environmentalists as a means of promoting smart growth. By supporting a healthier, pollution-free pedestrian lifestyle, transit-oriented development can improve people's quality of life (Grant, 2009).

2.5.2.2 Elements of smart growth

People and businesses flock to compact, liveable urban neighbourhoods. Creating such communities is an important part of decreasing urban sprawl and conserving the environment. One example of such a strategy is to use redevelopment methods and zoning restrictions to direct housing and job growth into urban centres and neighbourhood business districts, resulting in compact, walkable, bike- and transit-friendly hubs. As in Accra and Kumasi, where efforts are being made to boost density in the CBD by introducing a sequence of mid-rise structures, local governing organizations may be required to make code revisions that allow for increased height and density downtown. The majority of the ancient buildings in the CBD have been removed and replaced with four to eight-story mid-rise buildings. When this technique is well-coordinated, it will result in the CBDs gradually becoming denser (Pozdena, 2002).

This is an urban design principle in and of itself, but it's also found in related theories like Smart Growth. TOD is a residential or commercial neighbourhood designed to enhance

public transportation accessibility, and mixed-use/compact communities are more likely to use public transportation at all hours of the day. Because they offer a range of public transportation choices, places like UTC and Kantamanto in Accra, and Kejetia, Asafo, and Adum in Kumasi, for example, might be created as highly efficient transit-oriented projects (railway stations and bus stations). These transportation infrastructures, as well as the residential and business districts that surround them, can be used to form TODs (Rabianski *et al*., 2009).

Walking or using a bike instead of driving can help individuals live better lives by reducing pollution, saving capital on gas and maintenance, and helping them live healthier lives. Pedestrian and bicycle-friendly modifications include bike lanes on major routes, an urban bike-trail system, bicycle parking, pedestrian crossing and related master plans.

2.5.3 New urbanism

In the early 1980s, new urbanism became a popular urban planning trend in the United States. From urban retrofits to suburban infill, its mission is to transform every element of real estate development and urban planning. New urbanist neighbourhoods are meant to be walkable and to offer a variety of housing and job options (Rabianski *et al*., 2009).

2.5.3.1 Brief historical background of new urbanism

Throughout the first part of the twentieth century, cities in the United States were created in the shape of compact, mixed-use towns, comparable to European cities. This trend began to shift as cheap rapid transit enabled the spread of streetcar suburbs, contemporary design, zoning laws, and the rise of the automobile.

Following WWII, a new development system known as suburban development emerged, with a rigorous separation of purposes. As a result, rapid urbanization occurred. The majority of people in the United States now live-in suburbs that were built in the last fifty years. Suburban growth consumes large quantities of land for a very small population, and automobile use per capita has climbed considerably. The working poor in the suburbs must spend a considerable percentage of their income on cars, and those who cannot drive are severely restricted in places where public transportation is inadequate (Sackey, 2009).

2.5.3.2 Defining elements of new urbanism

New urbanist neighbourhoods, according to the Charter of New Urbanism, share the following features represented in Table 2.1.

Table 2.1 The characteristics of new urbanist movement

S/N	Characteristics of New Urbanist Movement
1	The neighbourhood has a discerning centre i.e., a green area, square or memorable street corner.
2	An average of 0.5km from every dwelling to the centre
3	Dwellings may consist of row houses, apartments houses, apartments so every member of society would find where to live.
4	Sufficient shops and offices at the corners to supply weekly needs of the neighbourhood.
5	Buildings have ancillary units like garages that can be used for small offices or workshops.
6	An elementary school is close to most of the students from their home.
7	Playing grounds accessible for all dwellers
8	Streets that disperse pedestrians
9	Trees that provide shading within the streets.
10	Building oriented to create a well-defined outdoor space
11	Parking lots are provided in front of the streets
12	Presence of a neighbourhood civic building or centre.

Source: Sackey (2009)

These defining elements can be used to create new neighbourhoods as well as re-plan or restructure existing ones. These defining qualities, when followed, contribute to establish high-quality, pedestrian-friendly neighbourhoods.

However the concept of mixed structures remains the traditional sustainable relationship between users of the built industry and their environments, this is represented in Figure 2.3.

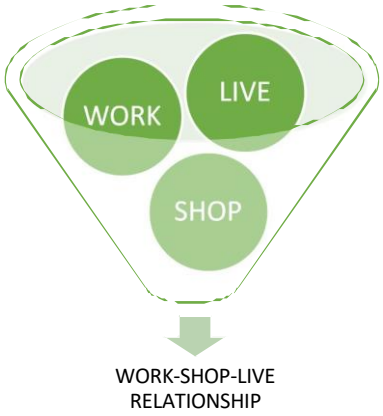

Figure 2.3 Traditional sustainable relationship between people and the environment

Source: Author's work (2020)

2.6 Ecology and Building Design

The term ecology is derived from the Greek root oikos, which means "home," and "logy," which means "science of" or "study of" — As a result, ecology refers to the discipline of studying the house, household, and environment, which includes plants, animals, and microorganisms that coexist on land, in the oceans, in the air, and in fresh water. Ecology is also defined as the study of living systems and their interactions. As a result, ecological design can be defined as "the construction and responsible maintenance of a healthy constructed environment, based on resource efficiency and ecological principles" (Darwish, 2014). It is suggested, is the use of natural symbolism to develop connections

between architecture and its cultural setting — by fusing architecture and landscape. It can also be thought of as environmental design and construction practices that aid in the adoption of new green architecture and the interpretation of items in context, resulting in environmentally responsible and sustainable architecture.

Eco-friendly design, according to Jashari-Kajtazi, (2009), is long-term architectural and urban planning ideas that provide a vision of the future, based on broad social and political changes that may influence construction and environmental policies. Because sustainability is a broad concept, it is a difficult topic to grasp. It is extremely important to everyone since it concerns the existence of the human species as well as practically every other living creature on the planet. Sustainable and environmentally friendly architecture is one of the key goals that humanity have set as the ultimate model for all of their actions in order to create a better existence. As a result, the major purpose of today's design is well-thought-out: advancing towards a greener architecture (Mahdavinejad *et al.*, 2014). At the pace that the world's development demands are being met with the precious and restricted resources available on the planet, it is becoming clear that unless fundamental changes in Man's thinking and behaviour occur, the future of civilization as we know it today is in jeopardy.

This complex issue lacks a straightforward solution, especially because sustainability is a goal that everyone aspires to. Green design has a positive impact on the environment, society, and economy. In terms of the environment, green architecture aids in the reduction of pollution, the conservation of natural resources, and the prevention of environmental degradation. It saves money for the building's operators by lowering their water and energy bills, while also increasing the productivity of people who use the

facility (Rettenwender and Spitz, 2009). Green buildings are also supposed to be beautiful while putting the least amount of load on the local infrastructure.

The structures in which we live, work, and play shield us from the harsh elements of nature, but they also have a wide range of effects on our health and the environment. As the impact of buildings on the environment becomes more obvious, a new area known as "green building" is gaining traction. Green construction is the process of designing and incorporating more resource-efficient and healthier construction, refurbishment, operation, and demolition models (Roy, 2008).

2.6.1 Definition of Green Architecture

Green architecture, sometimes referred to as green design, is a construction method that has a minimal impact on human health and the environment. The "green" architect strives to protect air, water, and the environment by employing ecologically friendly building materials and construction procedures (Roy, 2008).

2.6.2 Characteristics of Green Architecture

Green architecture consists of all types of environmentally friendly architecture and also includes some universal consent (Tascı, 2015). It may include several of the following characteristics represented in Table 2.2.

Table 2.2: Characteristics of green architecture

S/N	Characteristics of Green Architecture
1	Systems for heating, cooling, and ventilation that are designed to be energy efficient
2	Energy-efficient lighting and appliances
3	Water-saving plumbing fixtures
4	Landscapes that take advantage of passive solar energy
5	Minimal negative impact on the environment
6	Solar and wind energy are examples of alternative energy sources.
7	Non-toxic, non-synthetic materials
8	trees and stones from the area
9	woods harvested in a responsible manner
10	Adaptive re-use of older structures
11	repurposing architectural salvage
12	Make the most of your space

Source: Tasc1, (2015)

While most green buildings may not have all of these characteristics, the ultimate goal of green design is to be completely self-sustaining. Sustainable development is referred to by a variety of words, including eco-design, eco-friendly architecture, earth-friendly architecture, environmental architecture, and natural architecture (Cidell, 2009).

2.6.3 Consideration for designing green buildings

Site planning, material selection and reduction, energy efficiency, and indoor air quality are all factors to consider while designing a green building.

1. Take into account site development to lessen the impact of development on the environment. Orient buildings, for example, to take advantage of sun access, shade, and wind patterns to reduce heating and cooling loads.
2. To reduce negative environmental impacts, choose materials that are durable, have recyclable content, and are created locally. There is a rising market for high-quality recycled materials at reasonable pricing.

3. Create an efficient and comfortable atmosphere by incorporating energy-efficient architecture into buildings. Utilize natural components and technologies to save resources and improve occupant comfort/productivity while minimizing long-term operating costs and pollution
4. Create a high-quality indoor environment to improve occupant health and productivity.
5. Recover items from construction and demolition sites and reuse or recycle them to reduce waste (Cheng et al., 2008).

2.6.4 The Principles of Green Building Design

The first step in the green building design process is to have a comprehensive understanding of the site, both in terms of its aesthetics and its challenges. An ecological design method attempts to integrate newly installed systems with Mother Nature's current ecological functions on-site. These ecological functions, among other things, provide habitat, respond to solar motions, purify the air, and capture, filter, and store water. Designers can add components that mimic the operations of various eco-systems into their constructions. Species that thrive in natural habitats may also use habitats created by man-made buildings. To promote biodiversity and a healthy ecosystem, it is critical to develop new habitat on structures in urban areas (Rettenwender and Spitz, 2009). Some elements of green building design are represented in Figure 2.4.

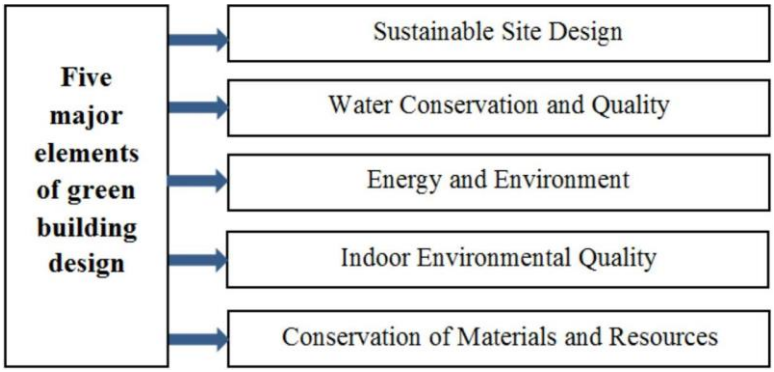

Figure 2.4: Elements of green building design

Source: Cidell, (2009)

The points illustrate the basic ideas, techniques, and technologies that are linked to the five primary pillars of green building design: Site design for sustainability, water conservation and quality, energy and the environment, indoor environmental quality, and material and resource conservation are just a few of the topics covered are just a few of the topics covered. Although this information promotes the use of the USGBC LEED Green Building Rating System, it targets ideas and methods rather than specific remedies or technologies, they are frequently site-specific and differ from project to project (Cidell, 2009).

2.6.5 Deductions of Literature Review

The following are the deductions made by the researcher after a thorough look at academic repositories and literature in the research area.

2.6.5.1 Variables of the study

The researcher deducted the variables shown in Table 2.3 from the studies to be used in this research.

Table 2.3: Variables of the study

S/N	Sustainable (Sustainability) Features	Energy Conservation Features
1	Rain water Collection	Use of Renewable Energy
2	Use of Roof Gardens	High performance Facades
3	Native, Sustainable Landscape Design	Daylight harvesting
4	Material selection	Natural Ventilation
5	Construction Techniques	

Source: Author's work (2020)

2.6.5.2 Eco-friendly design techniques

The researcher made some deductions on design techniques that can be applied in buildings to make them eco-friendly, they are shown in Table 2.4.

Table 2.4: Design eco-friendly

techniques S/N	Sustainable (Sustainability) Features
1	Site development such as taking advantage of the building orientation.
2	Selecting materials that have a negative or zero impact on the environment.
3	Using energy efficient design to create better indoor experience, to promote comfort and increase productivity of a space.
4	Taking advantage of Natural ventilation to increase wellness of building occupants
5	Reduction of waste during construction or demolition by using reusable materials

Source: Author's work (2020)

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

The research method adopted by this study is the Qualitative research method of data collection because it involves eco-friendly variables of sustainability and energy conservation in buildings. The direct observation of buildings was used to collect data using an observation schedule before analysis. A purposive sampling was carried out on six (6) Mixed-use buildings, there are three (3) within Nigeria and two (3) outside the country. The data was gathered by observing nine different variables that are divided into two categories, Sustainable features and Energy conservation features. (See appendix for observation schedule).

3.1 Data Type and Sources

Data on the building features as to if they made use of sustainable and energy efficient systems were obtained from observing with an observation schedule a few mixed-use buildings in Nigeria, by evaluating the functionalities and flow, as well as any eco-friendly aspects that the designs may have. Case Studies were conducted in Nestoil Tower Victoria Island, Lagos, world trade centre, Abuja and Cornerstone Tower, Victoria Island, Lagos, Nigeria; Secondary data were gotten from Internet publications concerning eco-friendly sustainable approach in design of mixed-use buildings. The data was gathered from a variety of sources, including journals, books, seminar papers, periodicals, theses, films, and the internet, all of which were properly cited and referenced.

3.2 Sampling Method

Because of the differences that exist in the various mixed-use buildings, a purposive sampling technique was utilized to choose from a variety of mixed-use developments.

This was accomplished by observing the various case studies of mixed-used developments, studying the sustainable and energy conservation techniques used within the building. The instrument used for collecting data was the observation schedule to observe the variables under study.

3.3 Procedure for Data Collection

Data was obtained by observation of selected buildings based on the variables that were established in chapter 2. The foreign case studies were however obtained from the internet using the same criteria used for the local case studies.

3.4 Method of Data Analysis

The data acquired from this research was analysed using content analysis which comprises the researcher quantifying and analysing the meaning of words or text and extrapolating it (Colorado State University, 2004). This was done with the use of excel spreadsheets, the data was transcribed appropriately, and the results were presented using tables and charts. A narrative discussion about the findings was done. The images captured were shown in plates and used to identify several phenomena observed.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1. Variables for Analytical and Comparative Study

The dependent variables that were observed and identified in the case studies and are represented in Table 4.1.

Table 4.1: Research variables

S/N	Sustainable (Sustainability) Features	Energy Conservation Features
1	Rain water Collection	Use of Renewable Energy
2	Use of Roof Gardens	High performance Facades
3	Native, Sustainable Landscape Design	Daylight harvesting
4	Material selection	Natural Ventilation
5	Construction Techniques	

Source: Author's Work (2020)

Eco-friendly design, is a design approach to construction that minimizes negative effects on human health and the environment is known as sustainable design, by careful selection of materials and sustainable construction techniques. The future life of a material and building is considered a major factor in this criterion, the life span of a mechanism or feature in a building, the manufacturing, application and use of this materials and techniques. The greater aim however is to ensure that they leave a negative impact on the environment.

In order to better evaluate the Variables in Table 4.1 the following building components were evaluated in the case studies

i. Site
ii. wall
iii. floors
iv. roof

v. windows or glazing

vi. Alternative power supply

vii. alternative water supply

viii. site amenities

4.2 Case Studies

The researcher analysed 5 mixed use buildings for this research and their respective data's are presented below.

4.2.1 Case study one: Nestoil tower, Victoria island, Lagos Nigeria

The Nestoil tower is located in Victoria Island Lagos, designed by Adeniyi cocker consultants limited, constructed by Julius Berger PLC and functions as the Oil and Gas headquarters for Nestoil Limited. The building is a first of its kind green building in West Africa. It's a fifteen-story mixed-use building with 7500m2 of office space, 350m2 of residential space, and a multi-level parking structure and recreational activities and Privately owned by Dr. Ernest Azudialu. Its aerial view can be seen in Plate I.

Plate I: Netoil tower aerial view

Source: Author's Work (2020)

Nestoil tower is located at the intersection of Akin Adesola and Saka Tinubu streets on Victoria Island, Lagos. Upon arrival you would be captivated by the clear façade of high-performance glass with horizontal details shown in Plate II, which immediately accentuate a sweeping effect of the curved façade of the building. The building is defined further by arched curtain walls of solid white panels to complete a contemporary composition of this building, this can be seen in Plate III

Plate II: Façade with high performance glasses

Source: Author's Work (2020)

Plate III: Solid white panels

Source: Author's Work (2020)

The interior floor space are grand open floor spaces with Flexible partitions to create smaller office spaces within the floor as shown in Figure 4.1 and Figure 4.2.

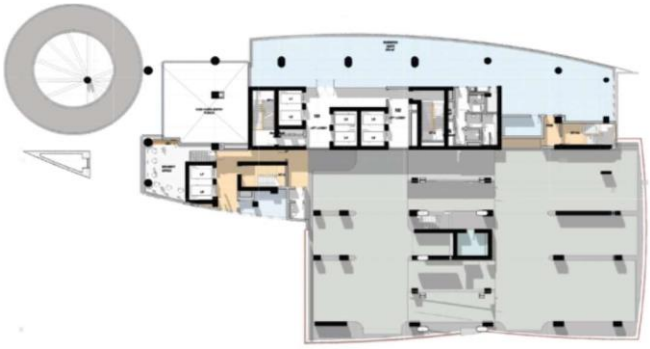

Figure 4.1 : Open floor area design

Source: Living- spaces (2016)

Figure 4.2: Flexible partitions to create smaller office spaces within the floor

Source: Living- spaces (2016)

The observed building features are delineated in Table 4.2, the researcher observed that the building structure incorporated curtain wall systems to aid in the cooling and also a raised floor system, Table 4.3 also shows other deductions from the case study.

Table 4.2: Nestoil tower building features

S/N	Building Features
1	Raised floor to allow for subsurface cabling and flexible office space arrangement.
2	Curtain wall systems with double glazing to reduce solar heat gain
3	Internet Access that is Plug & Play
4	Water Treatments and Boreholes
5	2 units of 1.3mVA and 1 unit of 910kVA Generating Sets on a dedicated transformer
6	A total of 4,110 square meters of premium office space is available for lease.
7	ten high-end residential units
8	Floorplates ranging from 231m2 to 810m2 are available.
9	Per level, kitchenettes and storage spaces are offered.
10	Over 225 cars can be parked on 18 different floors.
11	On the roof, there's a helipad.

Source: Living- spaces (2016)

Table 4.3: Deductions from case study 1

S/N	Building Features	Merits	Demerits
1	Site	Located in a commercial zone the building is a prominent and oriented to harvest the most energy out of daylight energy.	Victoria island is a commercial zone however highly dense with residential buildings there is tendencies for the building activities to serve as a disturbance to the neighbourhood.
2	Wall	The building makes use of open floor plan and flexible partition therein that are made of sustainable materials.	Sandcrete blocks are used as permanent demarcations however the manufacturing process of these blocks is not sustainable
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof	The helipad may be used to evacuate occupants in the case of a fire out break on the lower floors of the building.	The roof of the building does not serve any sustainable purpose; however, it contributes to heat gain of the environment as a result of the material used
5	Windows	The building makes use of heat reduction facades that cause it to gain less heat during hot exterior conditions. Also, glass is recyclable and reusable.	--
6	Alternative power supply		It makes use of fossil fuel generators
7	Alternative water supply	Onsite water treatment available	--
8	Amenities	Internet is available on site	--

Source: Author's work (2020)

4.2.2 Case study two: World Trade Centre (WTC) Abuja, Nigeria

The WTC is a Multistorey building located in Central business district, Abuja FCT, it serves a mixed-use function of Residential, office, retail and hotel complex and runs for 24hrs. it was designed by woods Bagot and constructed by Abuja investment company for First Intercontinental properties limited,. This high-tech construction is privately funded and cost about ₦200 billion, 7 skyscrapers are meant to be on the site on total completion, however, 2 skyscrapers, as shown on the aerial satellite map in Plate IV have been completed so far and the rest are under construction.

Plate IV: Aerial view of site of the world trade centre Abuja

Source: Author's Work (2020)

Figure 4.3 is known as tower 1, is a 24-storey apartment building of about 110m, with duplexes, to exquisite penthouses and pool villas, it is Nigeria's tallest residential building. Its floor plan can be viewed in Plate V.

Figure 4.3: Residential Tower 1

Source: World Trade Center (2020)

Plate V: WTC Tower 1 floor plan (Residential)

Source: Author's Work (2020)

Plate VI is a Grade A-Office space of 24-storeys of office complex and commercial space. At 120m it has been self-touted as Abuja's only Grade A-Office space, it was the tallest building in Abuja in 2015.

Plate VI: WTC Tower 2

Source: Author's Work (2020)

The observed building features are delineated in Table 4.4, the researcher observed that the building structure incorporated High performance facades, Heat and non-flammable glasses, Variable refrigerant flow (VRF) air conditioning system amongst others. Table 4.5 also shows other deductions from the case study.

Table 4.4: WTC building features

S/N	Building Features
1	120 super - luxury apartments
2	9 apartment types (1 to 6 bedrooms)
3	24 spectacular floors
4	2 penthouses and pool villa
5	tallest residential building in Nigeria(@110m)
6	tallest commercial building in Nigeria(@120m)
7	33000sqm lettable office space
8	1440sqm flexible office space
9	the only grade A-Office in Abuja
10	High performance facades
11	Heat and non-flammable glasses
12	Variable refrigerant flow (VRF) air conditioning systems
13	Advanced CCTV security
14	Three level basement parking space

Source: World Trade Center (2020)

Table 4.5: Deductions from case study 2

S/N	Building Features	Merits	Demerits
1	Site	The building is prominently located in Abuja's major business sector and is positioned to maximize daylight energy.	.--
2	Wall	The building makes use of typical open floor plan and flexible partition therein that are made of sustainable materials.	Sandcrete blocks are used as permanent demarcations however the manufacturing process of these blocks is not sustainable
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof	--	The roof of the building does not serve any sustainable purpose; however, it contributes to heat gain of the environment as a result of the material used
5	Windows	The building makes use high performance facades that cause it to gain less heat during hot exterior conditions. Also, glass is recyclable and reusable.	--
6	Alternative power supply	--	It makes use of fossil fuel generators
7	Alternative water supply	Onsite water treatment available	--
8	Amenities	Internet is available on site	--

Source: Author's Work (2020)

4.2.3 Case study three: Cornerstone tower, Victoria Island, Lagos, Nigeria

Situated on one of the rapidly growing financial hubs of Lagos, Victoria Island. The Cornerstone Tower is a 12 floor Grade A-Office building that is located near public transport enable ease of access to the tenant of the building. The building provides a comfortable environment that is resource efficient, a high-tech Green building that can

adequately meet the need of contemporary businesses. Its aerial view can be seen in Plate VII. Plate VIII shows the design innovations added to the building structure for more productivity and sustainability.

Plate VII: Aerial view of the site of the Cornerstone Building

Source: Author's work (2020)

Plate VIII: Insulated roof and higher thermal performance glass during daylight

Source: Author's Work (2020)

Developed by African Capital Alliance (ACA) and cornerstone insurance, the construction and functionality of the build ensures conservation of energy by making use of Sustainable energy efficient features as higher performance glazing as shown in Plate IX to reduce light penetration during the day and light up the environment at night as shown in Figure 4.4 , this feat has enabled the building receive a preliminary Excellence in Design for Greater Efficiency (EDGE) certification from think step-SGS.

Plate IX: The use of high-performance glazing

Source: Author's Work (2020)

Figure 4.4: Night view of the cornerstone tower Lagos

Source: Edge-buildings (2021)

The observed building features are delineated in Table 4.6, the researcher observed that the building structure incorporated materials that conserves energy by 23%, reduced window to wall ratio and Insulated Roof amongst others, Table 4.7 also shows other deductions from the case study.

Table 4.6: Cornerstone tower building features

S?N	Building Features
1	12 Floors
2	Grade A-Office Space
3	Higher thermal performance glass
4	Energy efficient air conditioning
5	Motion Sensor Light, for corridors, staircases and occupancy sensors to reduce energy use
6	Water efficient fixtures that conserve water usage by up 53%
7	Saves energy by up to 31%
8	Uses materials that conserves energy by 23%
9	reduced window to wall ratio
10	Insulated Roof
11	Sensible heat recovery from exhaust air
12	Variable refrigerant flow (VRF) air conditioning systems
13	Low-flow faucets in bathrooms and kitchen sinks, dual-flush water closets, and water efficient urinary systems.

Source: Edge-buildings (2021)

Table 4.7: Deductions from case study 3

S/N	Building Features	Merits	Demerits
1	Site	Located in the financial hub of Victoria island Lagos. The building site shares a close proximity to the transport hub.	--
2	Wall	The building makes use of typical open floor plan and flexible partition therein that are made of sustainable materials.	Sandcrete blocks are used as permanent demarcations however the manufacturing process of these blocks is not sustainable
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof	Makes use of insulative material	The roof of the building does not serve any sustainable purpose; however, supports the HVAC external units of the building.
5	Windows	The building makes use high performance facades that cause it to gain less heat during hot exterior conditions. Also, glass is recyclable and reusable.	--
6	Alternative power supply	Available motion sensitive light system. The building makes use of high energy conservation systems to reduce the use of fossil energy in running.	It makes use of fossil fuel generators
7	Alternative water supply	Onsite water treatment available	--
8	Amenities	Internet is available on site	--

Source: Author's Work (2020)

4.2.4 Case study four: Kohinoor square Mumbai, India

These 52 and 32 storeys complex is a mixed-use building on a 4.6 Acres site located in Mumbai India, it's the first mixed-use high-rise criteria in India. Its façade can be viewed in Figure 4.5, its site plan is detailed and can be viewed in Figure 4.6.

Figure 4.5: The Kohinoor square Skyscrapers

Source: Byanurag (2020)

Figure 4.6: The site planning of the Kohinoor Square

Source: Byanurag (2020)

A sketch of some of its floor can be seen in Figure 4.7, and Figure 4.8 shows how the designer carefully zoned the structure to various uses.

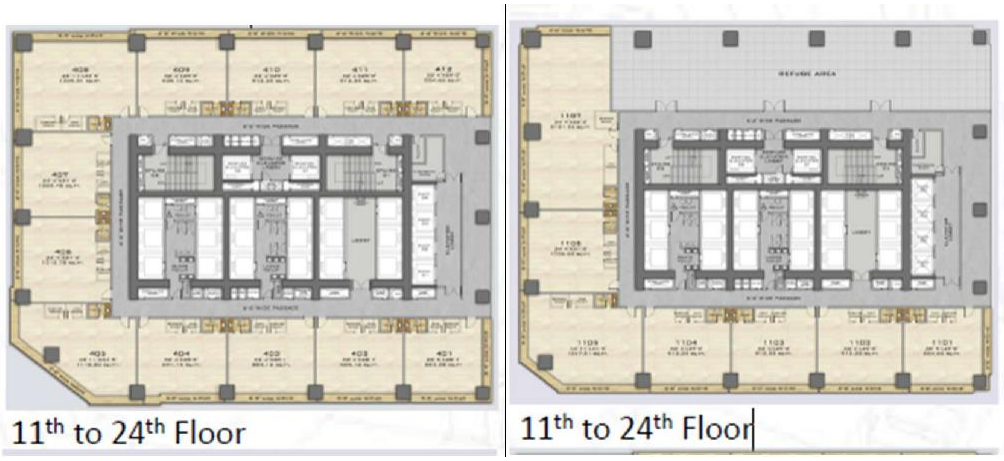

Figure 4.7: The floor plans reveal a central core system and external bearing walls

Source: Byanurag (2020)

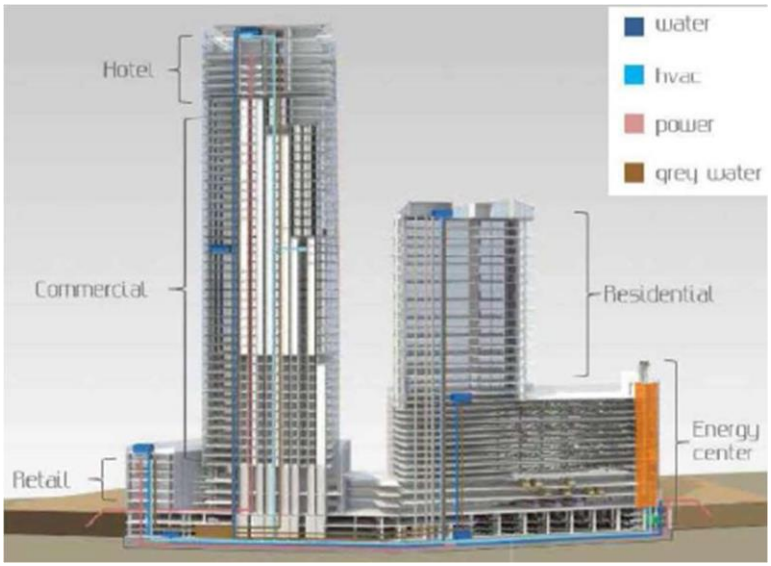

Figure 4.8: Section and zoning of the Mixed-use building

Source: Byanurag (2020)

It also consists of a lot of environmentally friendly features from the orientation to take advantage of the sun study as shown in Figure 4.9.

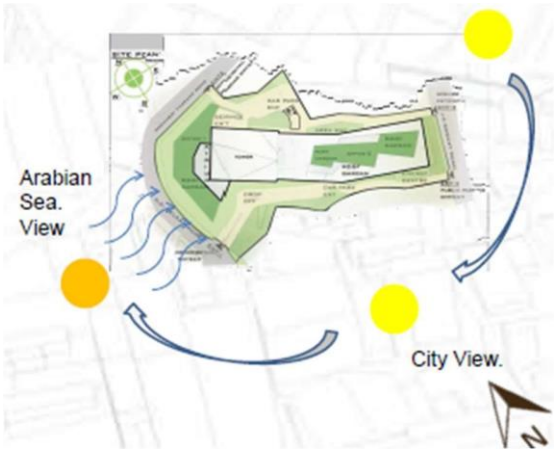

Figure 4.9: The solar Pattern and Planning of the site of the Kohinoor Square

Source: Byanurag (2020)

The observed building features are delineated in Table 4.8, also some of the buildings structural features are shown in Table 4.9. Figure 4.10 shows the pile foundations that were used in the construction of the structure.

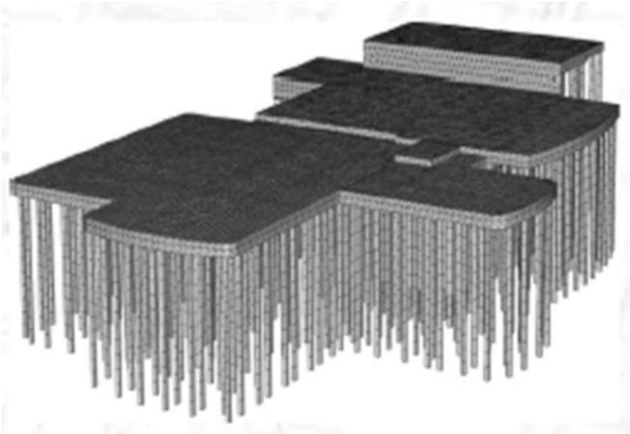

Figure 4.10: Pile foundation used in the construction its foundation

Source: Byanurag (2020)

Table 4.8: Kohinoor square building features

S/N	Building Features
1	Height: 203m main building 142m residence
2	Floor: 52 storeys, 32 storeys count
3	Site area: 4.6 acres
4	First mixed-use high-rise criteria in Mumbai
5	First five floors - high end shopping mall
6	47 floors - commercial offices and five-star hotel
7	13 floors - parking
8	19 floors - residences
9	Parking capacity – 2000
10	There are 132 residential units in total.
11	Each floor has eight flats.
12	At the top of the building, there are four units on each story.
13	Central Core

Source: Byanurag (2020)

Table 4.9: Kohinoor square structural system features

S/N	Structural Features
1	A concrete core, posttensioned concrete slabs, and spandrel beams make up the construction.
2	The average column distance from centre to centre is 9.5 meters.
3	The dimensions of the column are 1.8 x 1.8 m.
4	The tube system is founded on the notion that a structure can be constructed to withstand lateral loads.
5	The columns and beams are connected to form a rigid frame that forms a dense and strong structural wall along the building's façade.

Source: Byanurag (2020)

The researcher also observed some of the sustainable methods applied on the building and they are shown in Table 4.10, from all the observations the researcher made several deductions which are highlighted in Table 4.11.

Table 4.10: Kohinoor square sustainable building features

S/N	Structural Features
1	Collection of rainwater
2	Presence of Sky gardens
3	Availability of High performing facade
4	Ventilation system with high efficiency
5	Controls for daylight gathering and darkening
6	Recycling of black and grey water
7	Green roof
8	Energy centre
9	Native adapted landscape
10	On site waste water treatment
11	Environmentally preferable material
12	Recyclable sorting & collection
13	Natural ventilation

Source: Byanurag (2020)

Table 4.11: Deductions from case study 4

S/N	Building Features	Merits	Demerits
1	Site	The building site shares a close proximity to the public transport hub. Designed to accommodate public guest into its environment as a continuity in design principle.	--
2	Wall	The building makes use of typical open floor plan and flexible partition therein that are made of sustainable materials.	Concrete walls and columns are used as permanent demarcations however the manufacturing process of these blocks is not sustainable and may cause overheating
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof	Makes use of insulative glazing to reduce heat gain Roof gardens present.	--
5	Windows	The building makes use high performance facades that cause it to gain less heat during hot exterior conditions. Also, glass is recyclable and reusable.	--
6	Alternative power supply	Available motion sensitive light system. Onsite green energy centre The building makes use of high energy conservation systems to reduce the use of fossil energy in running.	It makes use of fossil fuel generators
7	Alternative water supply	Onsite water treatment available and grey water recycling.	--
8	Amenities	Internet is available on site	

Source: Author's Work (2020)

4.2.5 Case study five: Linked hybrid, Beijing, China

The linked hybrid building in China was designed by Holl architects for Modern investment group, it was built 61,800sqm site and stands at 68m from the natural ground level it consists of 664 residences and accommodates over 2500 inhabitants, it is a prim and proper mixed-use development consisting of a range of functions from kindergarten, to training, commercial and hotel facilities. Its Aerial view can be seen in Plate X alongside one of its elevations in Plate XI.

Plate X: Aerial view of the Linked Hybrid

Source: Author's Work (2020)

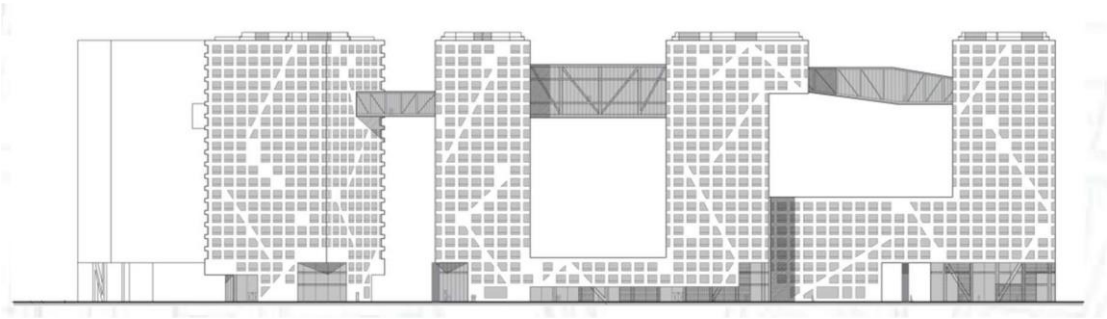

Plate XI: Elevation of the linked hybrid

Source: Author's Work (2020)

The sky bridge is very broad as seen in Plate XII and it is made with reinforced steel ad concrete to give it its strength and sturdiness. Architect Holl demonstrates how his ideal vertical city, a city within a city, might function in the linked hybrid. To prevent it being isolated he calls it, "urban porosity" by introducing pedestrian paths which people are able to access the urban space, which is a main attraction to many people and these are shown in Table 4.12.

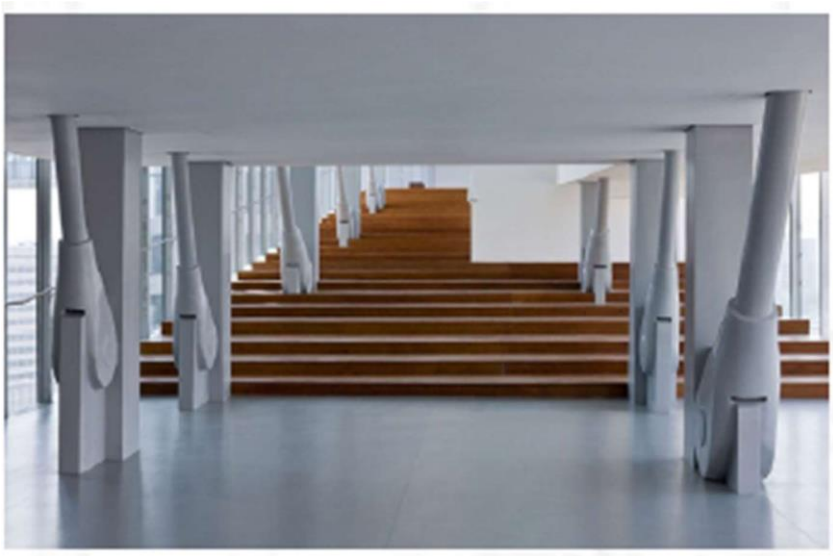

Plate XII: Sky Bridge that links buildings

Source: Author's Work (2020)

Table 4.12: Linked hybrid urban features

S/N	Urban features
1	Cinematheque
2	Hotel
3	Pond/parking below
4	Kindergarten/mount of childhood
5	Mount of adolescence
6	Mount of middle age
7	Mount of old age
8	Mount of infinity

Source:Ali and Al-Kodmany (2012)

The observed building features are delineated in Table 4.13, there are a lot of mixed use spaces incorporated into the building design for a wide variety of users with different social tastes, some of these include reading rooms, design/book store, Presence of architecture gallery, Sculpture gallery Art galleries, Available viewing platform, Deck for dining and many more.

Table 4.13: Linked hybrid building features

S/N	Urban features
1	Presence of reading room
2	Presence of design/book store
3	Presence of architecture gallery
4	Available sculpture gallery
5	Presence of art gallery
6	Available viewing platform
7	Deck for dining
8	Available ultra-lounge
9	Bar/cocktail
10	Listening lounge
11	Fitness
12	Juice bar
13	Group exercise space
14	Spinning room
15	Office, locker rooms
16	Lane lap pool
17	Suspended catwalk
18	Spa/massage
19	Meeting place
20	Viewing platform
21	Presence of Hair/nail salon
22	Health food store
23	Available Tea seating
24	Tea store/gaming place
25	Coffee shop
26	Café seating
27	Available book event space
28	Available book store

Source:Ali and Al-Kodmany (2012)

Table 4.14 shows some of the sustainable features the designer incorporated in the building, Plate XIII shows the geothermal walls that were used to regulate the building temperature and also serve as an alternate means of power supply. The researcher also made additional deductions about the building which are listed in Table 4.15.

Table 4.14: Linked hybrid sustainable features

S/N	Urban features
1	660 geothermal wells dug 100m deep provide 5600kw hours of energy annually and 3700kw hours in winter as shown in plate XXIII.
2	Cooling is distributed through the entire building through the concrete
3	An alarm system is activated when more power is needed
4	The building has no heating boilers or electrical air condition, making it one of the world's largest green project.
5	A plumbing system recycles waste water for irrigation of green areas.
6	Man-made water pool also used as a retention pool which constitute the reduction of about 41% potable water use as shown in plate XXVI

Source:Ali and Al-Kodmany (2012)

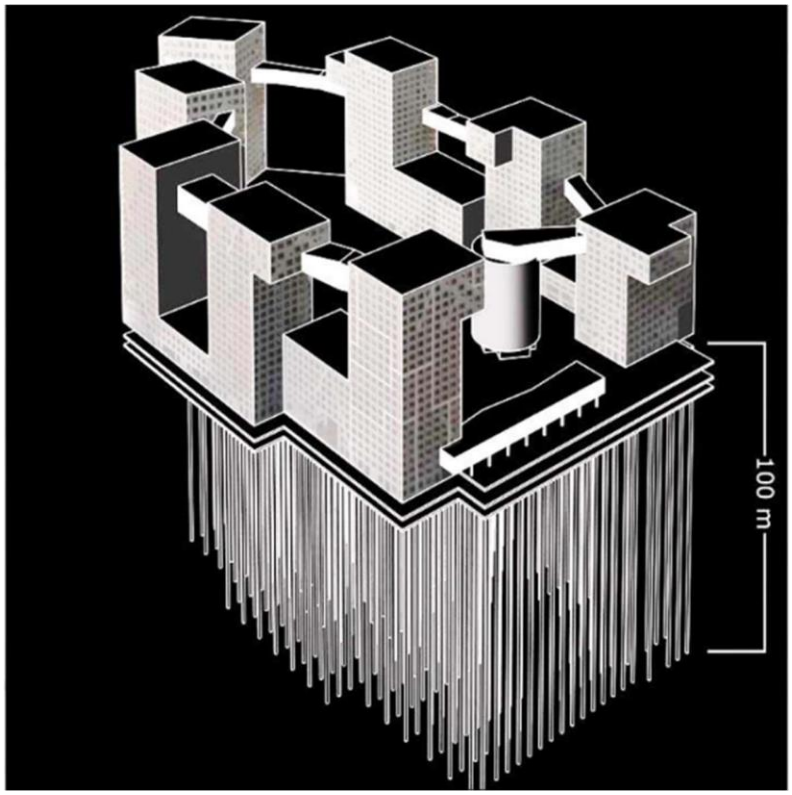

Plate XIII: Geothermal wells for cooling and power generation

Source: Author's Work (2020)

Table 4.15: Deductions from case study 5

S/N	Building Features	Merits	Demerits
1	Site	The building site shares a close proximity to the public transport hub. Designed to accommodate public guest into its environment as a continuity in design principle.	--
2	Wall	Open floor plans with flexible partitions	Concrete walls and columns are used as permanent demarcations
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof	The design makes use of green roof gardens.	--
5	Windows	It has an ingress that reduces the angle of contact of sunlight on the building Also, glass is recyclable and reusable.	--
6	Alternative power supply	Available motion sensitive light system. Onsite green energy centre The building makes use of high energy conservation systems to reduce the use of fossil energy in running. Onsite water treatment	It makes use of fossil fuel generators
7	Alternative water supply	available and grey water recycling.	--
8	Amenities	Internet is available on site Also, a very interactive landscape design	--

Source: Author's Work (2020)

4.2.6 Case study six: Taipei 101, Taipei, Taiwan

The Taipei 101 is located in Taiwan as shown in Plate XIV, designed by C.Y. Lee & partners it is a major landmark in the city of Taipei, formerly the world's tallest building and currently the tallest greenest building at a height of 508m.

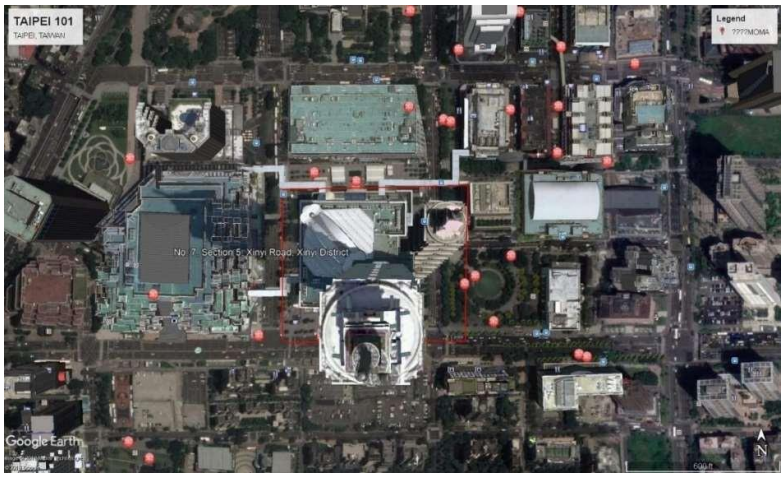

Plate XIV: Aerial view of the Taipei 101 building and environment

Source: Author's Work (2020)

In the dense urban environment of Taipei, is located one of the tallest buildings in the world, called the Taipei 101 its heigh can be seen in Plate XV, surrounded by world class infrastructure and high-rise buildings its post-modernist approach style incorporates traditional design with modern techniques.

Plate XV: The scale of Taipei 101 to its environment

Source: Author's Work (2020)

The building embodies Taiwanese culture and an expectation of things to come, as Architect Lee sought a balance between local culture and internationalism, which can be seen in Plate XVI, other building features have been listed in Table 4.16.

Plate XVI: Typical floor plans of the Taipei 101

Source: Author's Work (2020)

Table 4.16 Taipei 101 building features

S/N	Building features
1	Skyscraper
2	over 100 storeys
3	Site area: 412,500 m2
4	VIP areas
5	Bar and Restaurants
6	Observatories
7	Sky Lobby
8	Commercial Zones
9	Offices
10	Parking Zones

Source: Ray and Roy (2018)

The Taipei 101 was built with a massive structural steel framework as shown in plate XVII to withstand Gravity and lateral loads including natural disasters that are reoccurring in Taipei like typhoon winds and earthquakes by making use of a damping

system as shown in plate XVIII. Table 4.17 shows other structural measures that were used in the building.

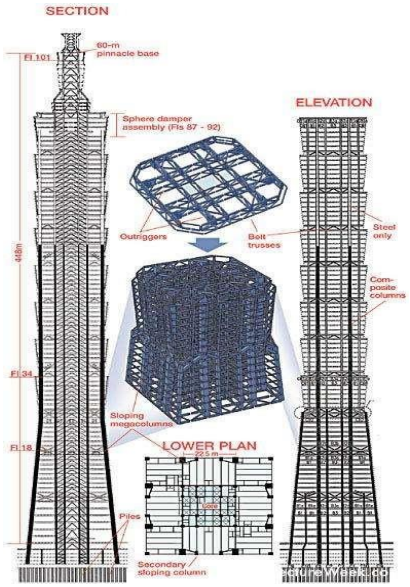

Plate XVII: Structural configuration of the Taipei 101

Source: Author's Work (2020)

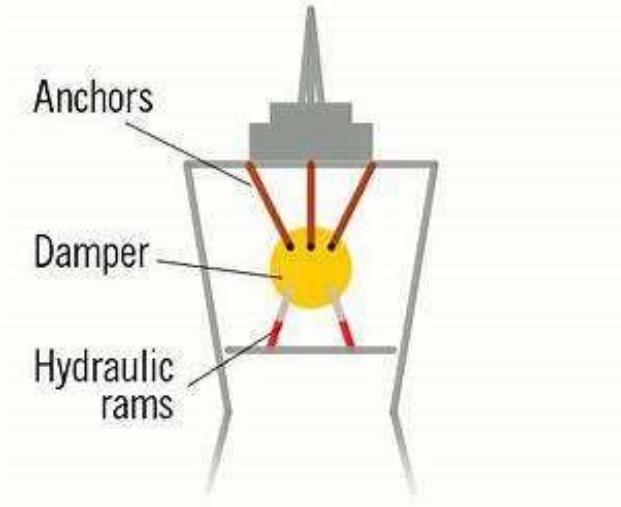

Plate XVIII: Mass Damping system used in the Taipei 101

Source: Author's Work (2020)

Table 4.17:Taipei 101 structural system features

S/N	Structural features
1	Taipei 101 is supported by 36 high-performance steel columns, including eight mega columns.
2	Outrigger trusses connect the columns in the core of the building to those on the exterior every eight levels.
3	380 piles put 80 meters into the ground support the foundation.
4	From the 92nd to the 87th level, Thornton-Tomasetti engineers constructed a 660000 Kg pendulum that acts as a tuned mass damper.
5	60 ksi steel
6	10000 psi concrete
7	Outrigger systems
8	Moment frames
9	Belt Trusses

Source: Ray and Roy (2018)

Popular for being the world's tallest building, the Taipei 101 has achieved this feat by significant actions in line with the sustainable development goals, it has a Platinum LEED certification after carrying out a LEED platinum retrofit on the building the Taipei 101 showed a drastic reduction in building energy and consumption of water, other sustainable features are listed in Table 4.18 and Table 4.19 shows the researchers deductions from the building.

Table 4.18: Taipei 101 sustainable features

S/N	Sustainable features
1	Power usage was reduced (18% drop from 2007 - 2010)
2	Taipei 101 now consumes 30% less energy and water than the national average.
3	It also demonstrates financial success by saving $773,000 in annual operating costs and recouping the $2 million LEED EBOM restoration cost in less than three years.
4	On site water recycling
5	Ventilation system with high efficiency
6	Controls for daylight gathering and dimmer settings
7	Black & grey water recycling
8	Native adapted landscape
9	Onsite waste water treatment
10	Environmentally preferable material
11	Recyclable sorting & collection
12	Natural ventilation

Source: Ray and Roy (2018)

Table 4.19: Deductions from case study 6

S/N	Building Features	Merits	Demerits
1	Site	The building site shares a close proximity to the public transport hub. Designed to accommodate public guest into its environment as a continuity in design principle.	The city is congested and no much space to design elaborate landscapes
2	Wall	Open floor plans with flexible partitions	Concrete walls and columns are used as permanent demarcations, it also makes and extensive use of steel in construction
3	Floors	The use of raised floors in other to allow soffit floor piping and services, this is a very efficient way to service a high-rise building.	--
4	Roof		It has no green roof or roof garden.
5	Windows	Utilises high performance glazing to save cooling cost.	
6	Alternative power supply	Available motion sensitive dimming light system.	It makes use of fossil fuel generators
7	Alternative water supply	Onsite water treatment available and grey water recycling.	--
8	Amenities	Internet is available on site	--

Source: Author's work (2020)

4.3 Deductions from the Case Studies

The researcher after carefully observing and analysing all the case studies came up with several deductions which he compared using the following rating system: A-highly effective B-very effective C-effective D-fairly effective E-not effective. Table 4.20 is a comparative study on the case studies using the established variables. Table 4.21 shows how each case study performed under the different sub headings.

Table 4.20: Comparative study findings based on research variables

S/N	Variables	NESTOIL	WTC	CORNERSTONE	KOHINOOR SQUARE	LINKED HYBRID	TAIPEI 101
1	Rainwater Collection				✓	✓	✓
2	Use of Roof Garden				✓	✓	
3	Recycling/ Grey water reuse					✓	✓
4	Material Selection					✓	
5	Construction Techniques				✓		✓
6	Use of renewable Energy	✓	✓	✓	✓	✓	✓
7	High performance facades	✓	✓	✓	✓		✓
8	Daylight Harvesting			✓	✓		✓
9	Natural Ventilation		✓	✓	✓		✓
10	Motion Sensing			✓	✓		✓
11	Land Conservation	✓	✓	✓	✓	✓	✓
12	Building Orientation				✓	✓	
13	Central amenity systems	✓	✓	✓	✓	✓	✓
14	Mixed-use criteria	✓	✓		✓	✓	

Source: Author's Work (2020)

Table 4.21: Comparative study of building performance in their environment.

S/N	CASE STUDIES	Environmental impact	Land conservation	Energy efficient	Habitant productivity
1	NESTOIL	B	C	C	A
2	WTC	B	A	C	B
3	CORNERSTONE	A	B	C	A
4	KOHINOOR	B	A	A	B
5	LINKED HYBRID	A	C	A	A
6	TAIPEI 101	A	B	A	B

Source: Author's work (2020)

4.3.1 Environmental impact

Building a building can be massive that the only impact that may be taken into consideration are those that have financial implications however it goes beyond that, to achieving highly effective impact on the immediate environment one has to take a step back to look at the life cycle of the building as it affects all life forms and planet around it.

The materials selection for construction should be deliberate, taking into consideration the life cycle of such materials, if they are reusable or recyclable so as not to occupy landfill space as waste in the future.. Buildings make use of a large percentage of a city's energy and also gives off carbon emission, however if a building is able to cater for its energy consumption levels through self-sustainable means such as using renewable energy and recycling then it would have a less negative impact on its environment; one can say building should be so self-sustainable that they serve as cells for the city and in fact give back energy to the power grid.

4.3.2 Land conservation

Having a mixed-use design reduce the problem of congestion, one that urban areas are facing, the population increase and relocation of people to urban areas have caused even more congestion and shanty settlements, in other cities with mega population status such as Tokyo, having a mixed-use building where necessary has helped reduce this, by increasing work to home relationship in some cases commercial activities have been introduced which are some of the greenest building relative to their environments.

Missed use buildings, Reduce the need to travel long distances to access certain amenities. The sustainable development goals advocacy for a healthier community involves minimal distances of commuting so as to avoid emission of fossil fuels into the environment. They also Reduce noise and air pollution. The noise generated from traffic reduces as a result of a more controlled environment. They Avail space to build more mixed-use buildings that would be environmentally friendly and better eco-transport systems and Mixed-use buildings make for more inclusive and interactive spaces.

4.3.3 Energy efficiency

Eco-friendly buildings depend highly on the efficiency of the building when it comes to its ability to harness energy from the environment. The use of automation in energy conservation within a building, Harnessing potential energy which can later be turned to kinetic energy by storing them for when the use arises e.g., high performance facades. And Daylight harvesting, water recycling and natural ventilation are all energy efficiency principles.

4.3.4 Habitant productivity

The provision of amenities for habitants and providing them with a healthy eco environment helps increase their performance because the ease to access helps eliminates time used to seek for those activities.

Having a management system that caters for services that are commonly shared amongst tenants in the same building saves a lot of time for every individual to manage their services individually, this shows a direct relationship between time saving and habitants productivity or performance. Having a central system for services in the infrastructural aspects of the building, increases savings and also ensures safety in management by employed professionals e.g., Central waste management systems, central gas infrastructure system.

4.4 Proposed Eco-Friendly Guideline for Development of Mixed-Use Buildings

In order for the future development of mixed-use buildings to enable the creation of healthier and thriving communities, there has to be a sustainable relationship between the building, its environment and ultimately any life force that interacts with that ecosystem.

To shed further light on this, eco-friendly principles for the creation of mixed-use buildings in accordance with sustainable development goals are listed below.

i. The building is part of the environment and should not be imposed on it.
ii. This expressly means that the impact of a building is continual from its conceptualisation to its demolition, the building should have minimum or negative impact on its environment.
iii. The design should be an extension of its environment.
iv. This means the design should be able to accommodate the public through the creation of public spaces like parks, gardens and retail areas for public access.

v. The criteria of mixed-use use building should harmonize work to shop to living activities.

vi. The building should consist of residential spaces, lettable and institutional spaces and also commercial spaces, this summarises the major needs of an individual and in turn makes it a commonly interactive space to a variety of users.

vii. The buildings primary functions should be zoned definitely.

viii. Whether vertically, horizontally or concentrically the zones and the purpose they serve should be well defined.

ix. The design should use extensively environmentally friendly and recyclable materials.

x. The materials used in construction should be selected taking into consideration their manufacturing, use and after use effect on the environment.

xi. The building should use a decentralised renewable energy source.

xii. The exterior and security lights can be powered by solar energy, the interior air cooling powered by hydro, the water heaters by geothermal energy.

xiii. The building should have a grey water recycle and reuse system.

xiv. The building site should have a system that is able to waste recycle water without faeces contamination on site for reuse in toilet flushing.

The above listed principles are shown graphically in Figure 4.11 and Figure 4.12 for a comprehensive look.

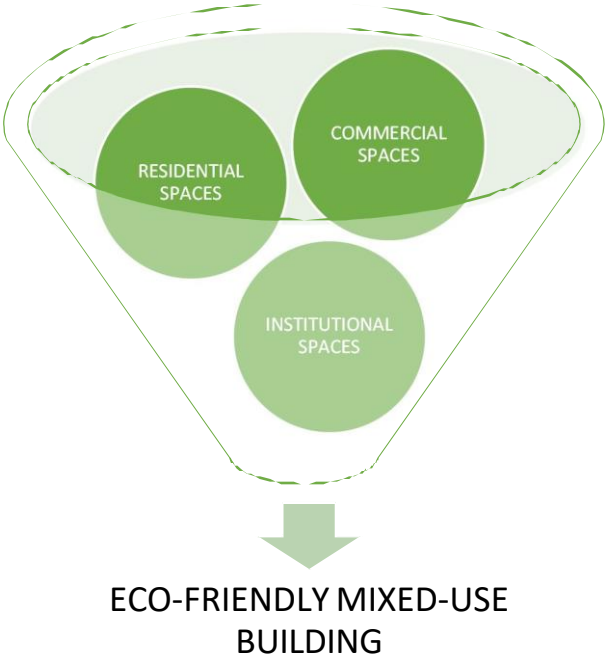

Figure. 4.11: An illustration of Eco-friendly mixed-use building

Source: Author's Work (2020)

Figure. 4.12: The Design framework of the proposed Eco-friendly mixed-use building

Source: Author's Work (2020)

CHAPTER FIVE

5.0 DESIGN REPORT

5.1 The Site

The Site for the proposed eco-friendly mixed-use building, is located in Eco-Atlantic city Lagos, the eco-Atlantic site is a reclaimed land from the eco-Atlantic Ocean formerly known as Bar beach, the city has been well planned and divided into districts based on land use. The site is generally level and accessible from the south; sunrise occurs approximately 6:30 a.m. [site work can begin around 7:15 a.m.] Around 6:30 p.m., the sun sets on the site [site work can end at 5:30 p.m.]. The site has a bounding perimeter of 825.89m and area of 20,750sqm and it is a relatively flat virgin land.

5.1.1 Site selection criteria

In the selection of site, the architect had 3 probable sites as reflected in Plate XIX, and in selection of the most suitable even though there where mutually conflicting, a compromise had to be stuck between the various considerations involved.

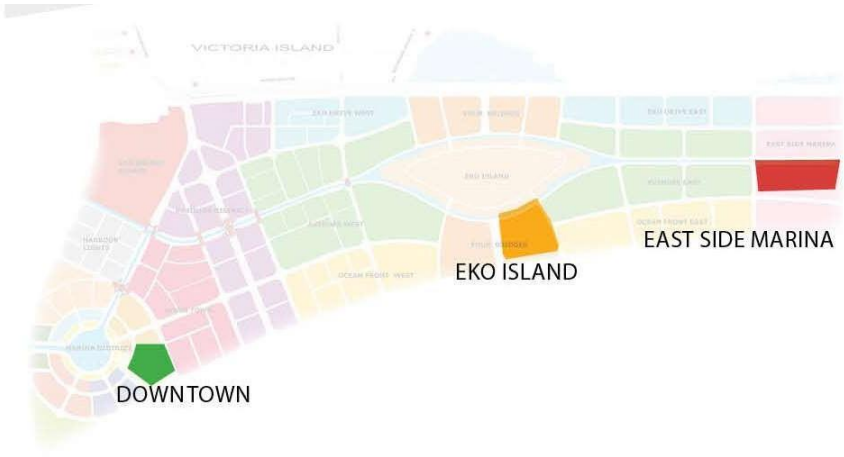

Plate XIX: Locations of probable sites selected from

Source: Author's Work (2020)

1. Site A: Site Area- 25,605sqm, Location- Eko Island
2. Site B: Site Area- 30,950sqm, Location- East Side Marina
3. Site C: Sitearea-20,750sqm, Location- Down Town

Criteria used in selection of the most suitable site, the downtown district was selected as it is a residential district with a lot of opportunities for commercial activities, this will allow for the commercial and institutional use of the building by people that live around this would in turn generate revenue also proximity to natural features like the beach and water front noise it is relatively a quiet neighbourhood.

5.1.2 Site selection justification

The justifications for selection of this site are;

1. Eco-Atlantic city is a city with a well-planned structure to support eco-friendly living.
2. The chosen site's land use would allow for the complete functionality of a world-class mixed-use building design.
3. A skyscraper can be built because of the soil carrying capacity.

5.1.3 Site characteristics

The abundance of vegetation across the property, road access on the west perimeter of the site, and the site's relatively flat topography were all factors in the site's inventory. On the site, there are shrubs and sea shells.

5.1.4 Climatic conditions

A thorough examination of the environment and its climatic impact can help the designer provide better solutions to maximize or minimize the impact of the environment on the building over the course of its life, as well as better solutions to harness potentials or avoid potential hazards.

From November to March, average daily maximum temperatures can reach 38°C, with lows of 27°C in August as seen In Figure 5.1. Hot days are common throughout the dry season in the start of the year, and cold nights are common during Harmattan, which lasts from December to January.

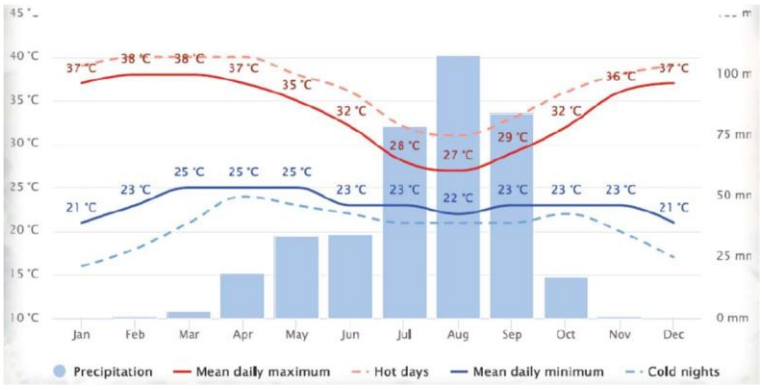

Figure 5.1: Showing Average Temperature precipitation of eco-Atlantic city

Source: Meteoblue (2021)

From March through October, the Eco-Atlantic metropolis sees the extremes of the Nigerian seasons, the dry and wet seasons, with greater rainfall and humid weather. This is seen in Figure 5.2.

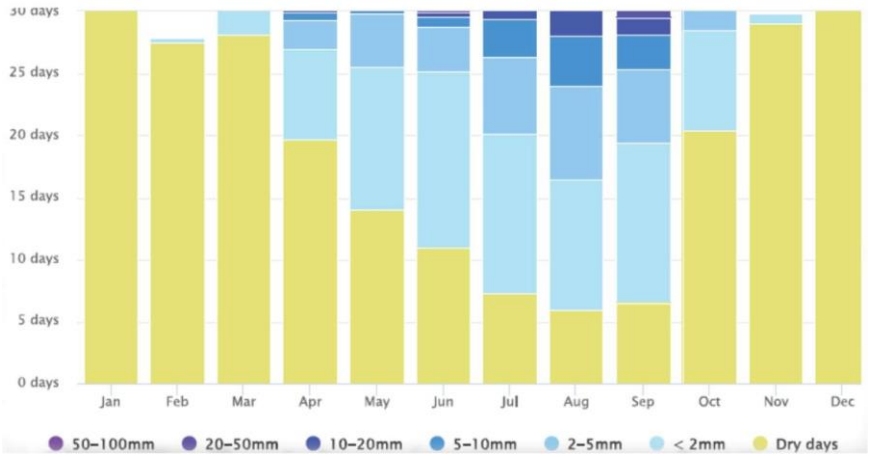

Figure 5.2: Average Temperature precipitation of eco-Atlantic city

Source: Meteoblue (2021)

Eco Atlantic is located in the south west region of Nigeria, just before the Atlantic Ocean, the sun rises from the east, where the sea lies, and sets in the west, softly rising upend and gradually increasing the intensity of its heat until midday, when it cools as it sets in the west by morning. Figure 5.3. shows this, The maximum temperatures are shown in red, while the lowest temperatures are shown in a lighter shade of red.

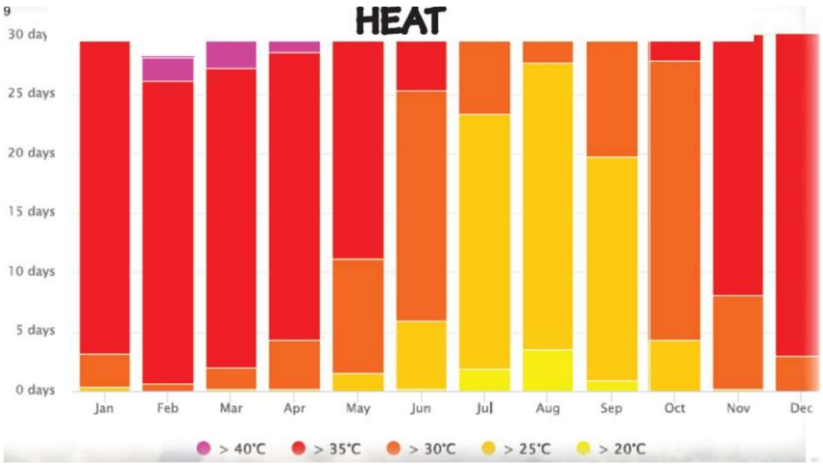

Figure 5.3: Maximum Temperatures of eco-Atlantic city

Source: Meteoblue (2021)

Tropical Continental Air Mass (North east trade wind) and Tropical Maritime Air Mass (South west trade wind) are the two most common wind types in Nigeria, with the former bringing little or no moisture winds from the Sahara Desert and the latter blowing humid air mass over the Atlantic into Nigeria. The wind speeds and velocity are shown in Figure 5.4 and Figure 5.5.

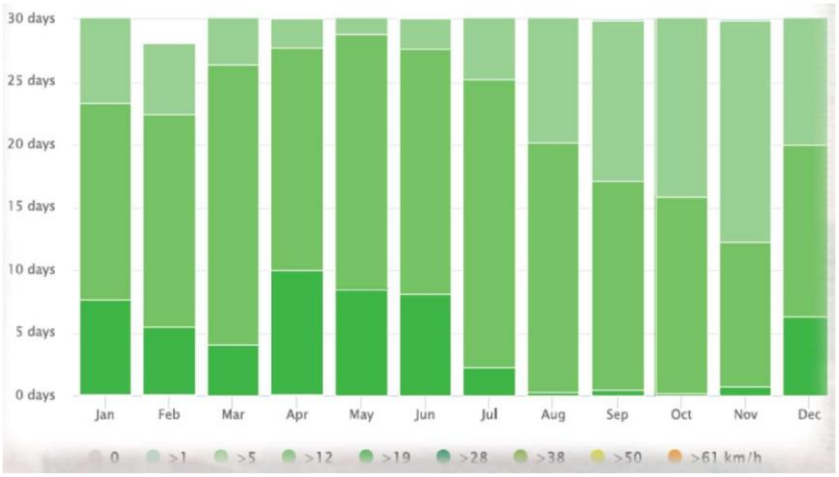

Figure 5.4: The wind speeds over eco-Atlantic city

Source: Meteoblue (2021)

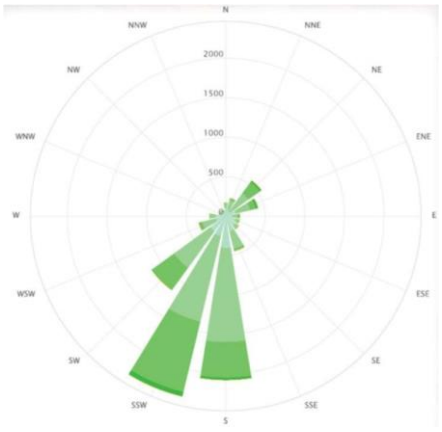

Figure 5.5: Wind rose diagram of eco-Atlantic city

Source: Meteoblue (2021)

5.1.5 Site analysis and evaluation

Before any site work begins, a reconnaissance study was conducted to note various site features and characteristics such as soil vegetation, wind direction, sunrise and sunset direction, access to the site, terrain that would benefit building orientation, construction process, and functionality.

Small plants and short trees on fertile terrain indicate the presence of subterranean water at shallow depths, which can aid in the provision of water for building by drilling temporary boreholes and wells: In addition, the presence of this vegetation denotes a suitable habitat for soft landscaping plants. Because the site is generally flat, only a small amount of site clearance is required on the area where construction work will be done, however before construction the site will be filled as some of the reclaimed land has settled with time naturally causing the Natural ground level to drop.

Sunrise on site occurs at 6:30 a.m. (site work can begin at 7:15 a.m.); sunset occurs around 6:30 p.m. (site work can stop at 5:30pm). Trade winds from the North-east [dry air], building orientation should consider fenestrations away from this direction for best ventilation results and rather to [Humid air] South-West trade wind from the Atlantic Ocean can be maximised, that is why the building orientation will maximize the ocean breeze.

The site is accessed from the south and east boarder, towards the south west is the downtown district round-about. The roads around the site aren't busy as they're driveways however vehicular traffic is the only source of noise. The presence of electricity poles denotes an electrical grid connection, while the existence of telecom

services on hand-held devices denotes the availability of telecom services, as well as the presence of water.

5.2 Design Report

West Africa experiencing rapid population growth, and Lagos state already with a population above 21 million persons is at high risk if not managed properly, it is however up to Architects and urban developers to reduce the impact that a large population is having on the earth with their activities which mostly cause an increase in greenhouse gas emissions; the built environment is responsible for about one-third of the Global greenhouse gas(GHG) emission and consumes over 40% of the world's energy (UNEPSBCI, 2009) and (USAEPA .Environmental Protection Agency, 1999). Also, the united nation Environment Program (UNEP, 2008) estimates that figure to double by the year 2030, which also coincides with the UNDP's deadline in the form of SDGs under which is the need for governments around the world to make their cities and human settlements inclusive, safe, resilient and sustainable. The need to have mixed-use developments that reduces the radius of an individual's daily activities so that there is less carbon emitting activities by that individual that could cause GHG emissions, thereby resulting in safe, sustainable and healthier environments.

5.2.1 Scope of work

The primary emphasis of this work is to integrate certain activities in a sustainable mixed-used building to reduce the need for individuals to consume time and resources before getting to needed activities. Have auxiliary supporting structures, make use of sustainable construction methods, shared amenities to cut cost and make use of affordable and

renewable energy sources and green architecture. The design would integrate: - Residential, Commercial and Institutional buildings

5.2.2 Safety requirements

These buildings are intended to serve its inhabitants and people that live close by.

The approach of this design in terms of security is one that considers the wellbeing of its habitat by strategically zoning all the different activities according to hierarchy, from the basement parking which is mostly for residential who live in the building to the visitors parking which is for those temporarily coming into the space; also the mixed facilities are placed in hierarchy from the commercial on the lowest to the institution which is on a higher level to the residential which is on a highest floors, the building also has provision for a refuge hall or refuge level which is design to withstand and reduce the spread of fires across levels and also inhabitants can take refuge in that space until emergency arrives. The building is also design to support advanced security technologies like complete surveillance of all floors.

5.2.3 Ventilation of the building

The movement of air within this building to remove stale air and replace with fresh is performed by both Natural and Mechanical means. Within the commercial and institutional spaces of the building, the building makes use of natural ventilation, supported by mechanical ventilation but mainly natural, as a high amount of people populate those spaces and it would take much energy to cool it mechanically. The sky lobby also admits air into the residential towers from which the stack effect helps circulate including the natural ventilation system helps circulate throughout the building. The

building also has mechanical ventilation systems, which have a central control system on the mechanical floors, and it is connected to each floor.

5.2.4 Lighting of the building

The building makes use of both Natural and Artificial lighting. The glazed facades help admit in natural daylight in form of visible light rays, the facades are made of high-performance glass which admits in visible rays but repels infrared rays to keep the building at optimum temperatures. While doing this it stores up solar energy for use by the artificial light fittings.

Artificial Lighting makes use of stored up energy by the high-performance facades, they also are supported by generators should case there by demand for more energy than that which is available, they artificial fitting are also motion sensitive i.e., they turn off automatically once no once is in that space to conserve energy.

5.2.5 Concept development

The site concept and build form is based on achieving maximum cooling by strategically siting artificial lakes and the building form maximises the large area to admit cooled air as shown in Plate XX.

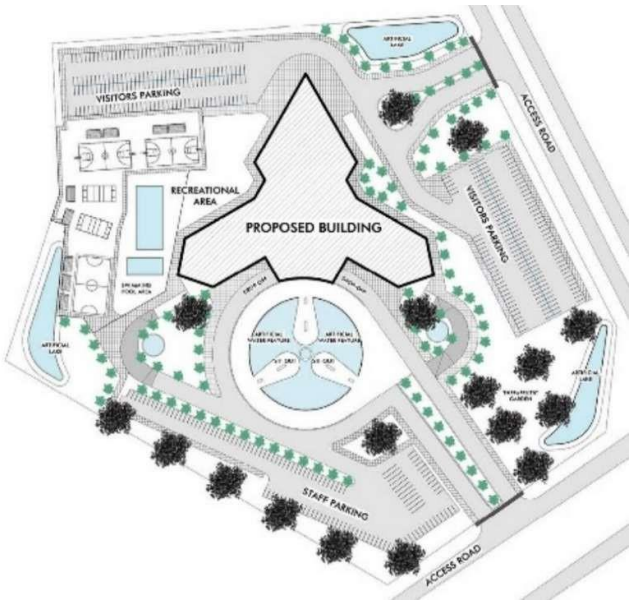

Plate XX: Artificial Lake cooling concept

Source: Author's Work (2020)

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The concept of the design is inspired by the lifestyle of original Lagos dwellers. The primary source of income and way of life of these people was to fish (fishing), trade and go back home. This is illustrated in Plate XXI.

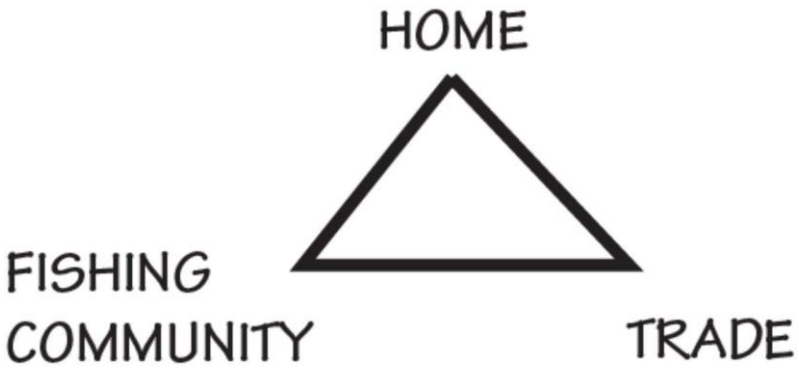

Plate XXI: The triangle of activities of original Lagos dwellers

Source: Author's Work (2020)

This triangle of activities thus guided the zoning and some of the features in the design they were able to live in the same community and trade within the closest proximities as their houses and markets were on the shores of the sea. The design is then zoned vertically according to privacy of activities, this is shown in Plate XXII, with the residential spaces at the highest because they are the most private and then the institutional before the commercial and then the landscape of the site, this concept is both a security preventive measure and also for surveillance and crowd control.

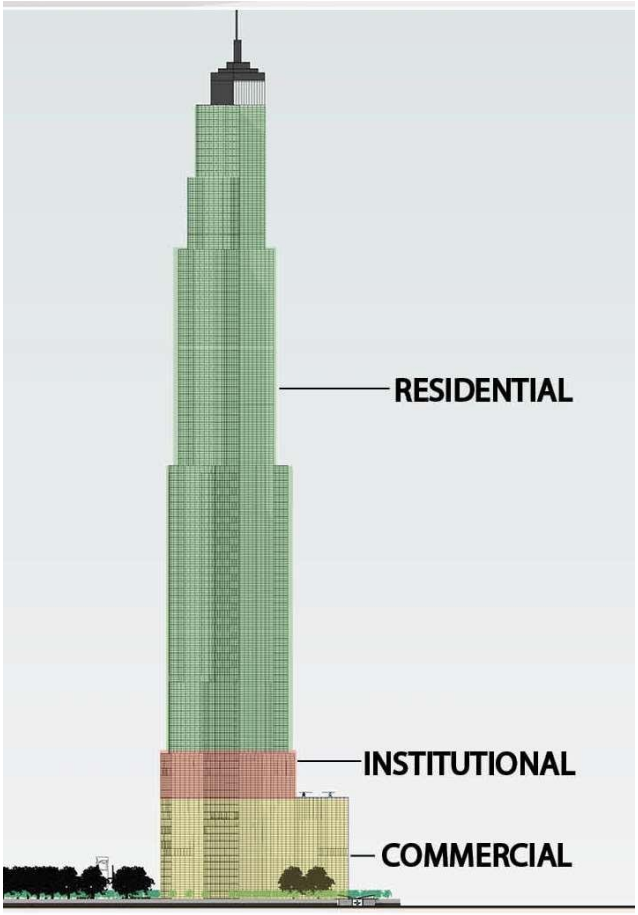

Plate XXII: Vertical Zoning of the Mixed-use Building

Source: Author's Work (2020)

5.2.6 Building construction

The foundation of this structure is the Pad and Pile foundations an example is shown in Plate XXIII, a series of friction piles are driven into the soil as support and is unified together by a concrete pad, this now serves as a support to transfer the entire load of the structure into the subsoil.

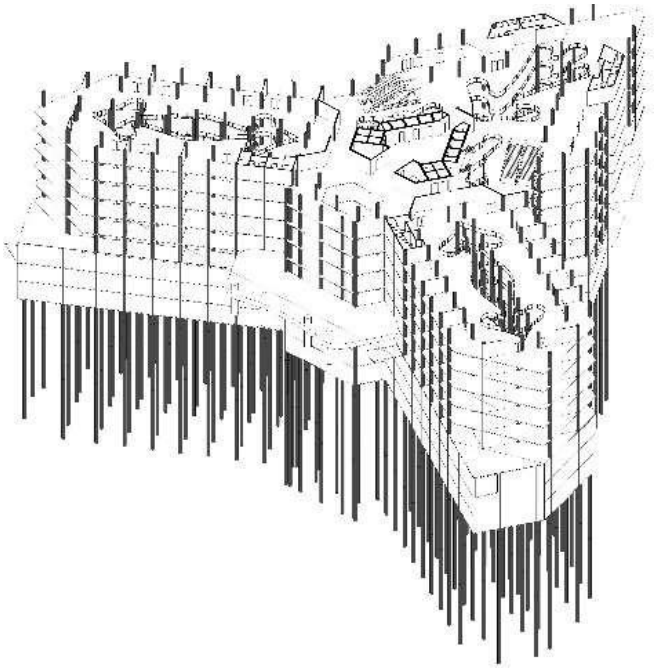

Plate XXIII: The piles of the structure

Source: Author's Work (2020)

Designed as a frame structure the exterior of the building makes extensive use of high energy efficient curtain panels and on the interior are sandcrete block walls and glass walls for portioning of spaces. The columns are connected on different level by concrete floors of different types, hollow blocks and structural timber for the suspended floor, to allow service cables to pass through the soffit of the flooring system. The roof is sloped

glazing on an outrigger truss system connected to the structural system of the building, as an option to reduce the weight of the building.

The design makes use of the rigid post and lintel structural system made of columns and beam elements, for the exterior the design makes use of a hybrid outrigger truss system as support for the exterior glazing and support from wind and lateral forces, Plate XXIV illustrates the structural system implemented.

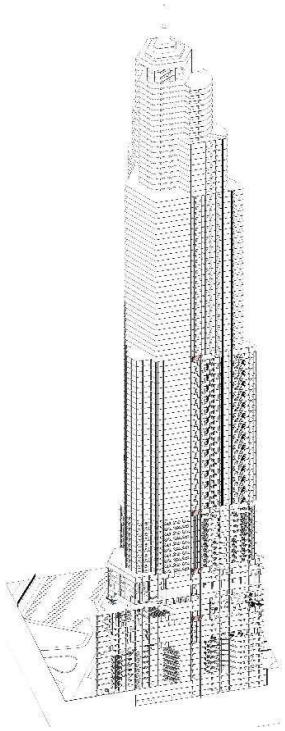

Plate XXIV: The 3D section of the proposal

Source: Author's Work (2020)

To allow simplicity of construction, maximise renewal energy sources and day lighting, also security measures appropriate materials were selected in the course of this design which where economically favourable and environmentally friendly, durable and readily

available in proximity to the site to reduce carbon emission in the course of transportation to the site.

5.2.7 Landscape and external works

The proposed eco-friendly mixed-use building's landscaping design is based on the author's findings from user observations of landscaping in mixed-use buildings, case studies, and a review of related literatures. To promote traveller comfort and psyche alleviation, as well as control air flow and reduce the influence of solar radiation on the building, a beautiful integration of inner and exterior landscaping features was created within the terminal building. Because of their importance in this design, plants and fountains are the most conspicuous landscape features.

The gate buildings, fencing, and power house were all suitably sited to complement the overall architecture.

5.2.8 Site services

the site is serviced is connected to the electric grid, it also has naturally occurring ground water asides the renewable energy measures taken into consideration, the site is also serviced by a major highway and shares a close proximity with the Eko Atlantic city marina or ferry terminal.

The site is fertile from results drawn from site analysis, boreholes on site can supply efficient amount of water to the building, supported by geothermal wells and a rain water collection and recycling system. Power is supplied to eco Atlantic city by Lagos state electricity distribution company, if as the power would be substantial, geothermal wells,

solar panels and glazing as well as roof turbines will be used to harness renewable energy sources as a means to make it a sustainable energy driven design.

The environment is expected to be neat all the time and so provision for both disposable and recyclable waste will be made to ensure that recyclable matter and plastics do not make it to the ocean or litter on the environment. The Eco Atlantic city is well known for its water canal design, the underground drainage system serves as preventive measures for increase in water level and also dispose of sewage, shown in Plate XXV.

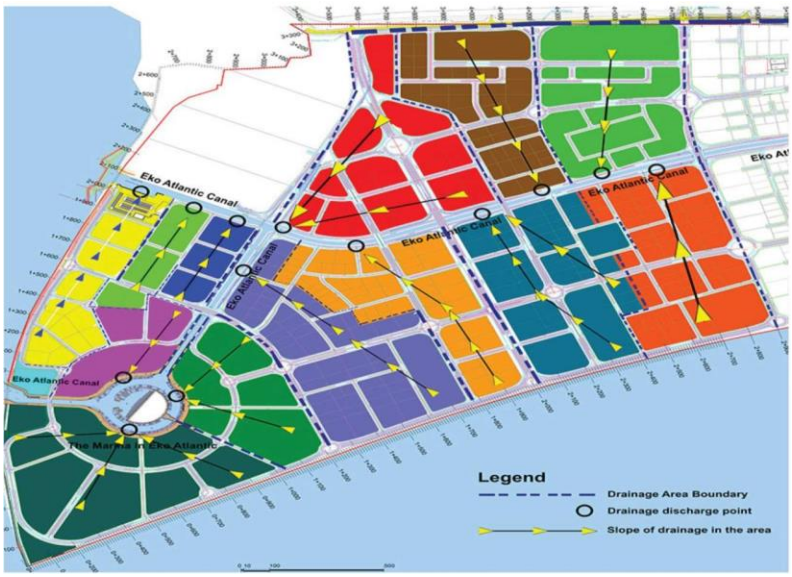

Plate XXV: Drainage channelling in Eco Atlantic City

Source: Author's Work (2020)

5.2.9 Fire safety

Fire detection equipment, such as fire alarms, fire extinguishers, and smoke detectors, are included in this building's fire safety technology. Hydrants will also be placed in strategic

locations throughout the sites. Also, a refuge floor that doubles as a sky lobby with emergency supplies should in case the fire guts the higher floors.

5.2.10 Building security

In and around the building, security surveillance devices will be installed to ensure that the residents are kept under constant watch. Security access cards will also be used to open doors that are not exposed to the public. In situations where a high level of security is necessary, motion detection systems will be used. Within the interior and external landscaping of the building, street lighting fixtures as well as motion sensitive lighting will be employed to improve visibility on the site.

5.2.11 Budling maintenance

The materials used require minimum care; however, a day-by-day maintenance plan will be written up and provided to the building maintenance manager to follow in order to ensure the building's long-term durability. Fixtures and fittings should also be checked and changed if necessary.

5.3 Contribution to Knowledge

The research is geared towards achieving a ensuring a sustainable approach in the design of buildings is encouraged in other to create sustainable cities and communities for the future. As a result, the research aims to bring to light, raise awareness, and educate individuals, both in the construction industry and out, of a healthier, cost effective and the conservative opportunities of land resources that mixed-use ecological buildings possess in ensuring the security of future generations and also to curb the environmental impact of man’s activities on the earth.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

From the study of the case studies cited in previous chapters, it can be deduced that settlements tend to turn into a mixed-use development whether planned or unplanned, the needs of people in carrying out their activities slowly gravitates and slowly is revealed in their environment. We also find that a work to home relationship is always something that we cannot separate when we are considering the structure of a city. The introduction of high-rise buildings with mixed-use criteria has made this concept easily adaptable in high population areas. Even when there are challenges on what kind of function to mix in these buildings the environmental impact on already existing neighbourhoods is significant, building a high-rise eco-friendly building enhances human experiences because.

i. It promotes urban options for residents to work, shop, and play in the same neighbourhood.

ii. This life shares amenities such as parks and green areas, therefore promoting a better interactive social life.

iii. With security at an alarming level, it provides more surveillance and in return a more secured urban area.

iv. It develops the sustainable habits of occupants in the building this in turn has a bigger impact on the city as they are more sensitized.

v. A great mixed-use eco-friendly building encompasses a more liveable urban environment, healthier occupants and a healthier community.

6.2 Recommendations

Developing cities like Lagos face the problem of overpopulation and improper planning for the high population they now experience, human and vehicular congestion is an everyday experience in most of this city, and this causes a ripple effect of many other environmental problems like noise pollution, excess carbon emissions into the air. To tackle some of these challenge in developing cities here are a few recommendations;

i. Urban policies should be made from studies like this on infrastructural developments in developing countries, so as to serve as a foundational base in drafting policies for city planning.

ii. Local metropolitan planning authorities need to know the advantage of sustainable development and should endeavour to put a criterion on sustainability in development and should encourage mixed-use building types in cities

iii. Accurate data on potential of cities in regards to their population and demographics should be made available to investors, this potential will serve as an encouragement to invest in these parts of the economy.

iv. Research results from studies like this can be used to make proposals such as the project in this thesis and made available to private sector this would show the potential and opportunities and help in ensuring planned and controlled growth in the cities rather than haphazard growth that currently plagues a lot of developing countries.

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APPENDICES

Appendix A: Questionnaire

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

DEPARTMENT OF ARCHITECTURE

DESIGN OF AN ECO FRIENDLY MIXED USED BUILDING WITH EMPHASIS ON THE SUSTAINABLE DEVELOPMENT GOALS IN LAGOS STATE.

This is an observation schedule carried out for the effective observation of selected buildings; which is to be evaluated as part of academic curriculum.

Observer: _____

Time: _____

Date/Location: _____

NAME OF BUILDING (case study)

A. SITE/LANDSCAPE

Are there any presence of Landscape? _____

1. Categorize the presence of the landscaping design under:

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

Are there any other forms of shading devices and natural cooling features on site?

_____

2. Categorize the presence of this feature under:

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

General Comment:

_____

_____

B. FENESTRATIONS

1. What kind of cooling/ventilation mechanism is used?
2. Are there any presence of windows? _____
3. Categorize the windows functionality under:

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

   General Comment:

   _____

   _____

   _____

C. WALL

What kind of wall material was used?

What type of wall partitions were used? _____

Categorize how effectively sustainable this material is in respect to environment and availability of material.

A – VERY EFFECTIVE

B – NOT SO EFFECTIVE

C – NOT EFFECTIVE

D. ROOF

1. What kind of roof was used?
2. Does the roof support collection of rain water?
3. Categorize how effective it is:

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

C – NOT EFFECTIVE

E. BUILDING ORIENTATION

1. Was the building orientation taking into consideration at the design stage?

   _____

2. Categorize the effect of the building orientation on thermal cooling of the building

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

3. Categorize how much the building orientation will maximize sunlight during cold seasons under.

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

General Comment:

_____

_____

F. FLOOR

1. What type of flooring system was used?
2. What materials and techniques were used?
3. Categorize how sustainably effective the floor in the building

   A – VERY EFFECTIVE

   B – NOT SO EFFECTIVE

   C – NOT EFFECTIVE

D. MATERIAL USE

ROOF MATERIAL _____

CEILING MATERIAL _____

WALL MATERIAL (STRUCTURE)_____

WALL MATERIAL (INTERIOR) _____

FLOOR MATERIAL (INTERIOR) _____

DOOR MATERIAL _____

WINDOW MATERIAL _____

General Comment:

_____

_____

G. SKETCHES & OTHER OBSERVATIONS (***attach photos***)

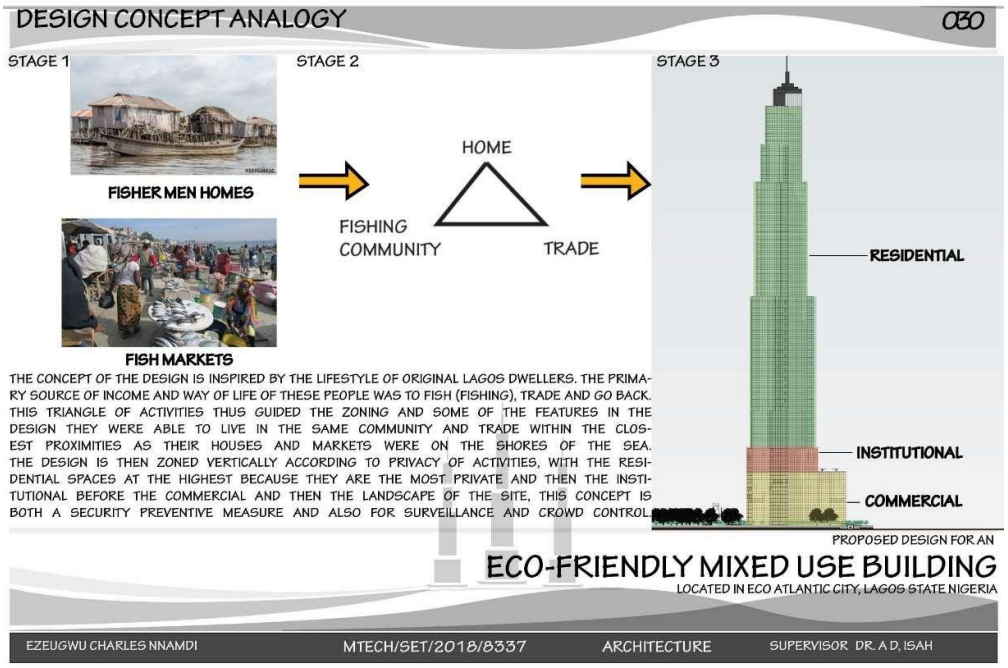
SKETCHES

Appendix B: Checklist for case studies

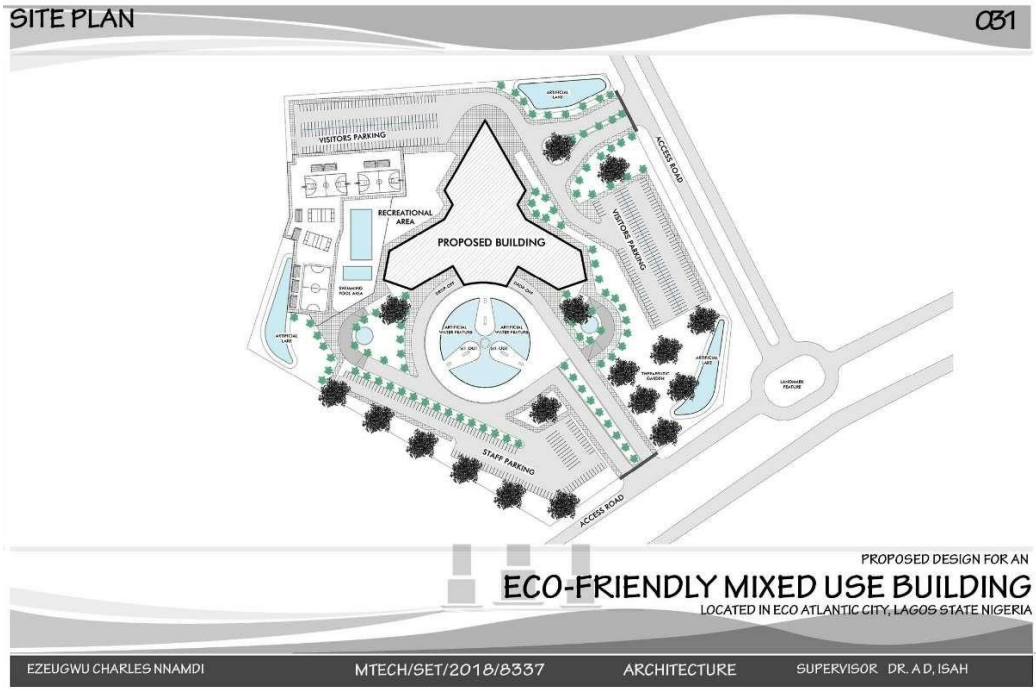
This is a checklist carried out for the effective observation of selected buildings; which is to be evaluated as part of academic curriculum.

SN	Variables	Case Studies					
		A NESTOIL	B WTC	C CORNERSTONE	D KOHINOOR SQUARE	E LINKED HYBRID	F TAIPEI 101
1	Rainwater Collection						
2	Use of Roof Garden						
3	Recycling/ Grey water reuse						
4	Material Selection						
5	Construction Techniques						
6	Use of renewable Energy						
7	High performance facades						
8	Daylight Harvesting						
9	Natural Ventilation						
10	Motion Sensing						
11	Land Conservation						
12	Building Orientation						
13	Central amenity systems						
14	Mixed-use criteria						

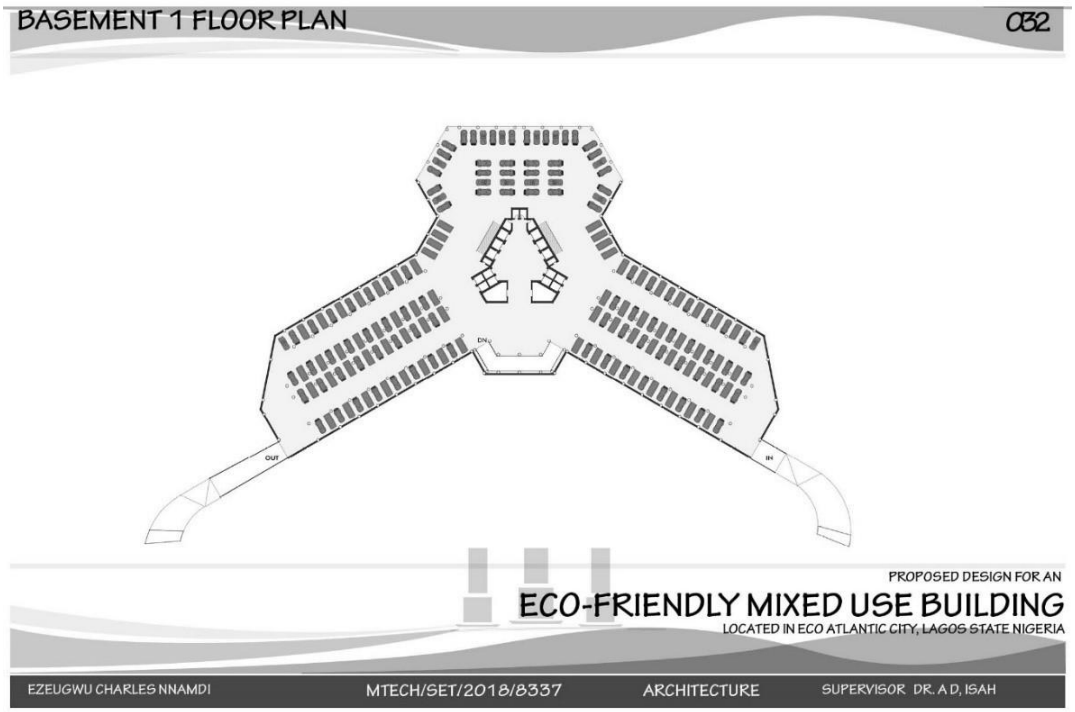
Appendix C: Building Concept



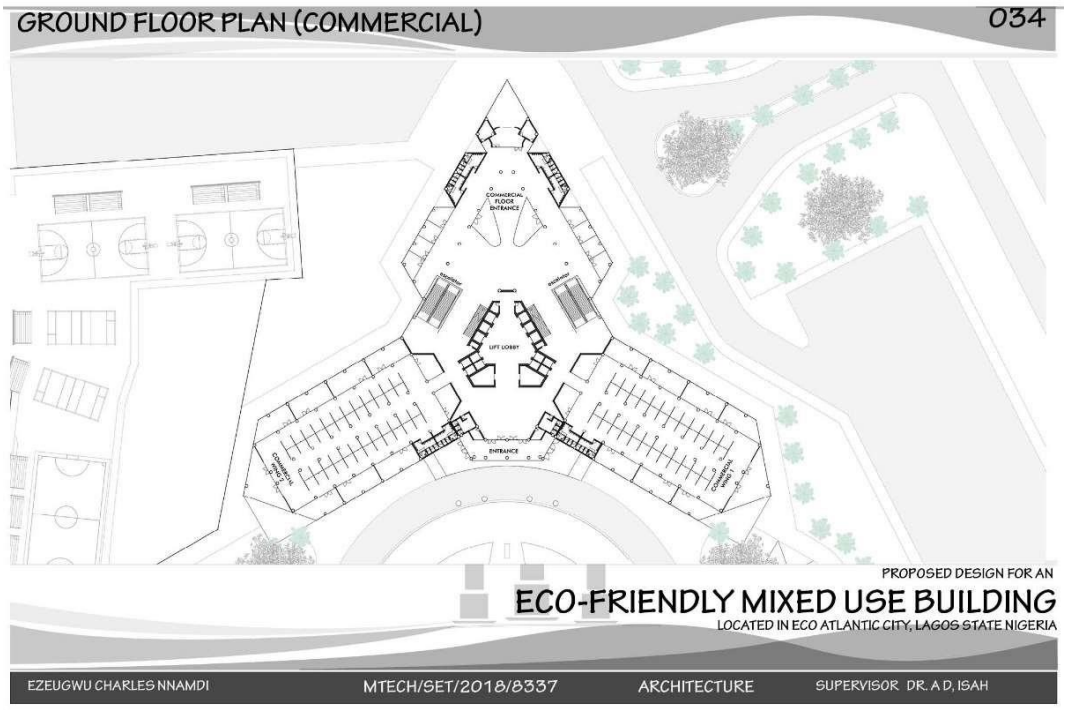
Appendix D: Site plan



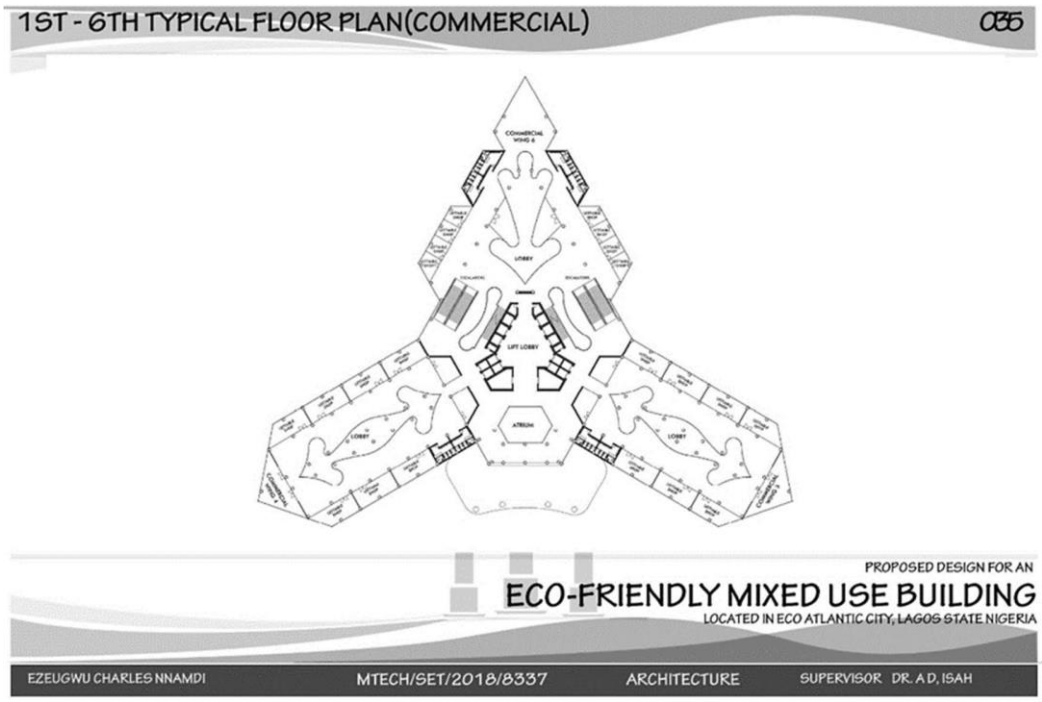
Appendix E: Basement floor plan



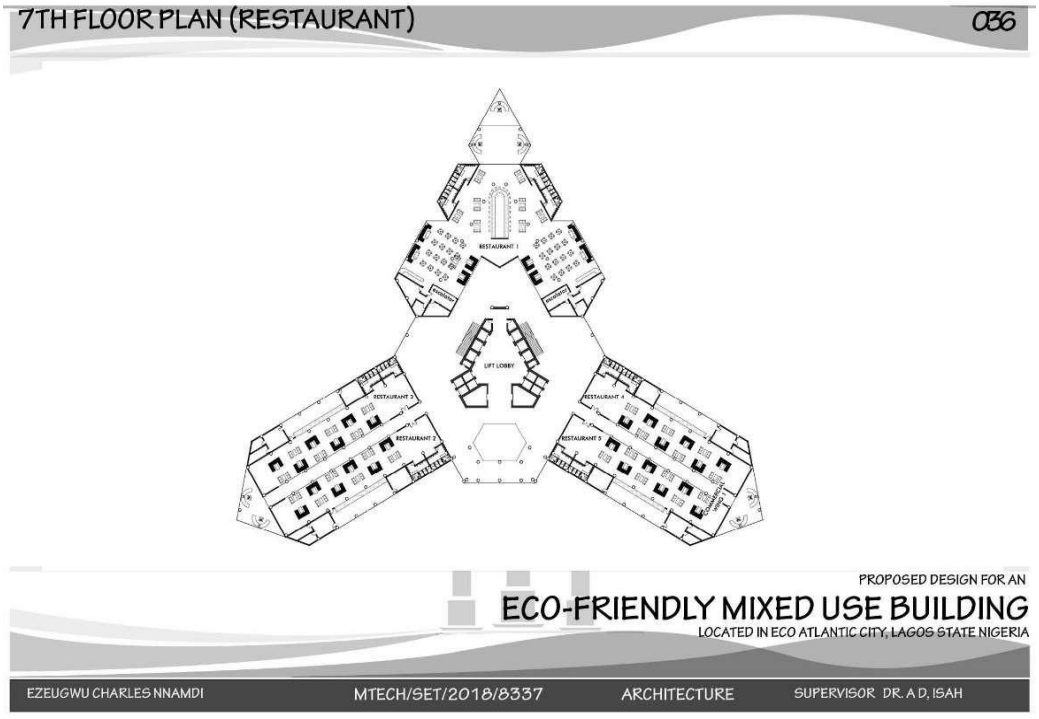
Appendix F: Ground floor plan (commercial)



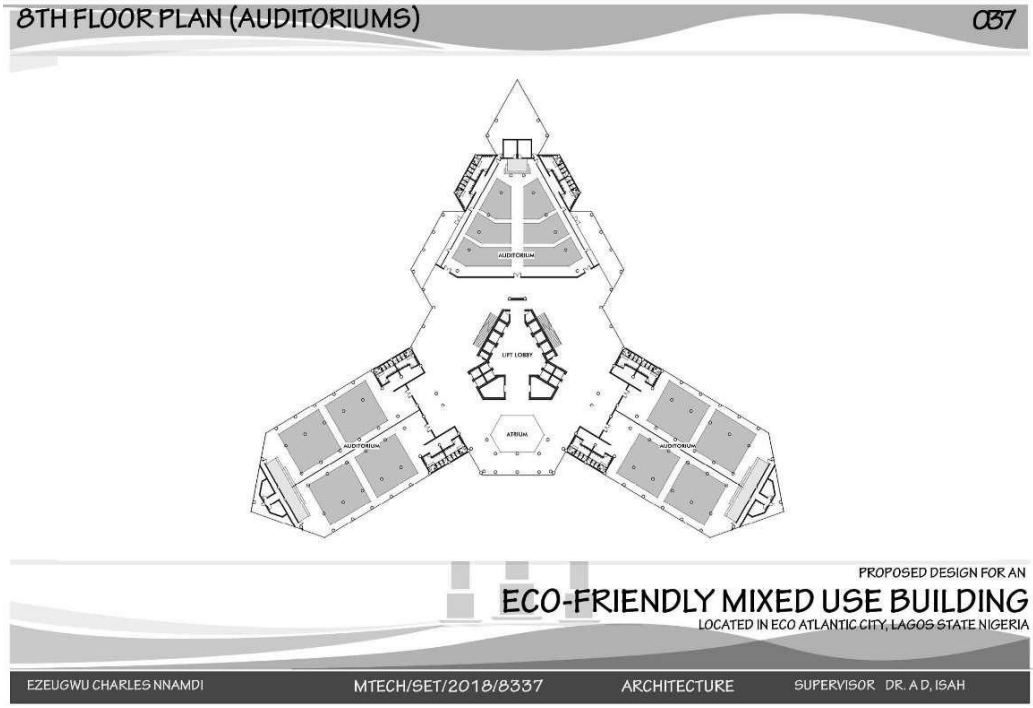
Appendix G: 1st to 6th floor plan



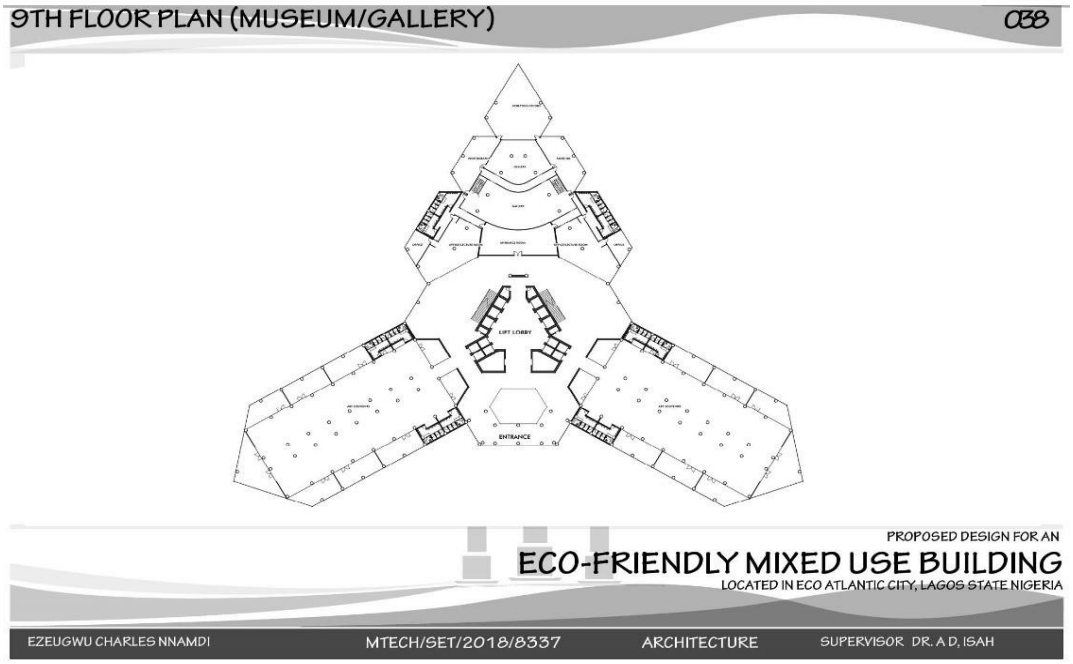
Appendix H: 7th floor plan



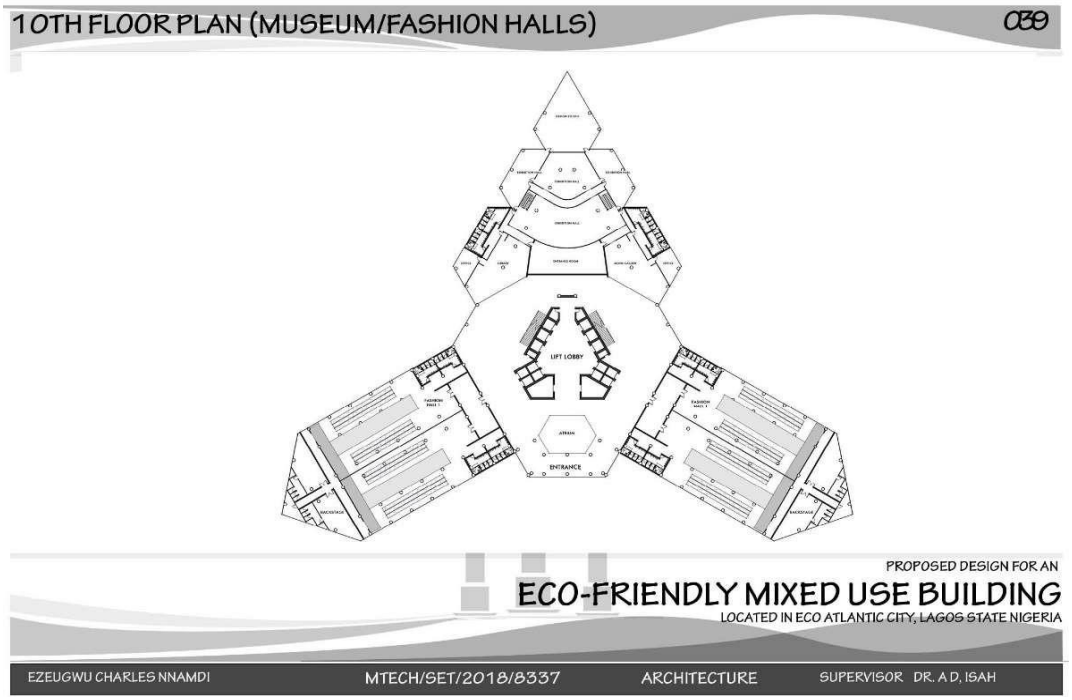
Appendix I: 8th floor plan



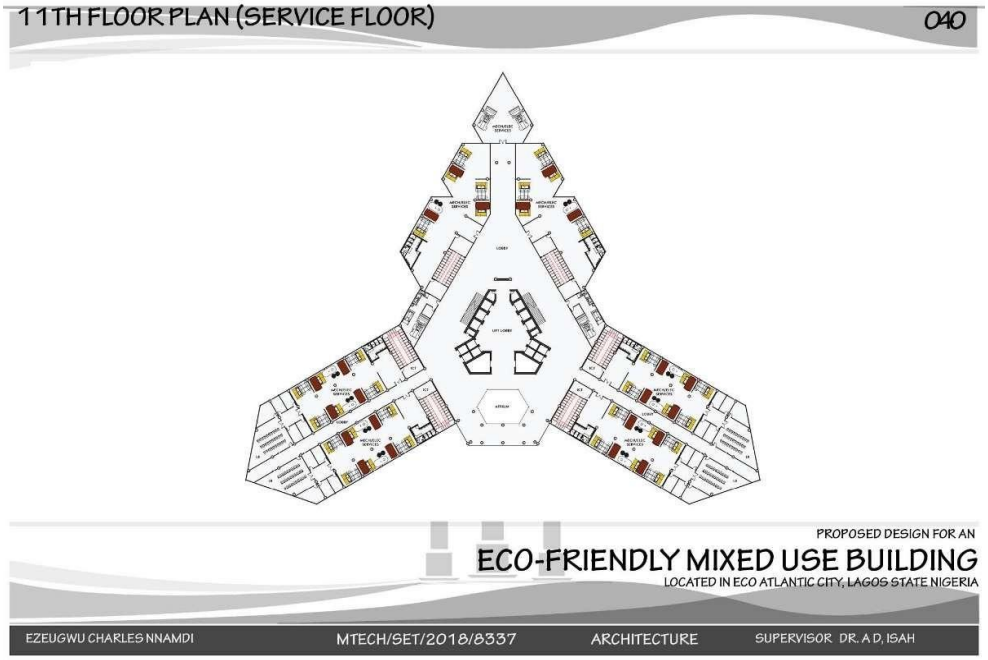
Appendix J: 9th floor plan



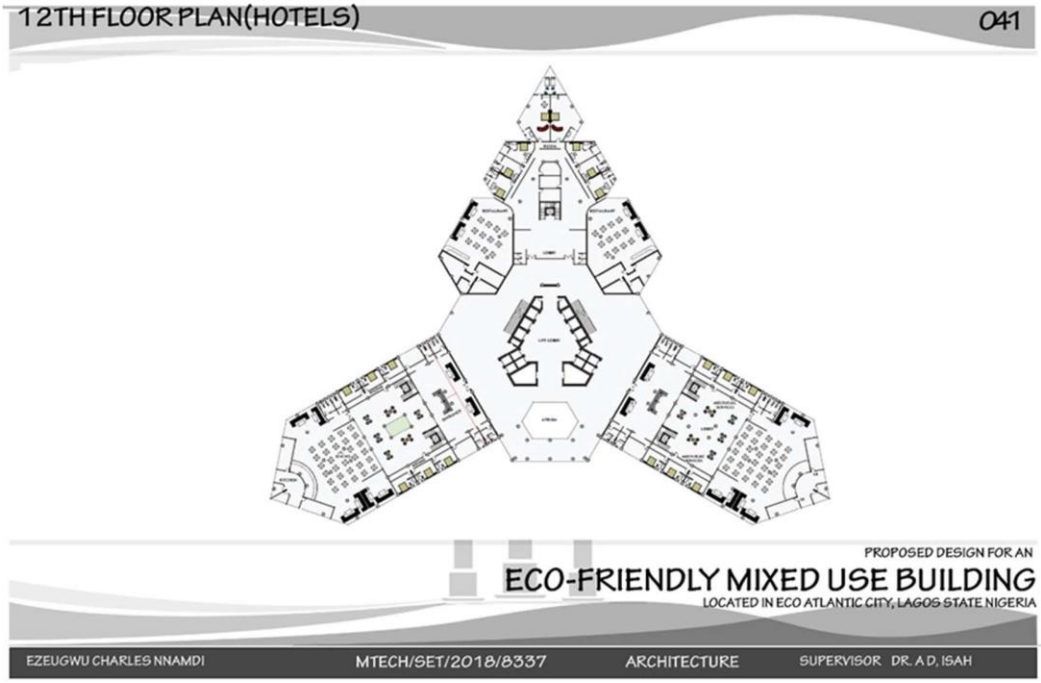
Appendix K: 10th floor plan



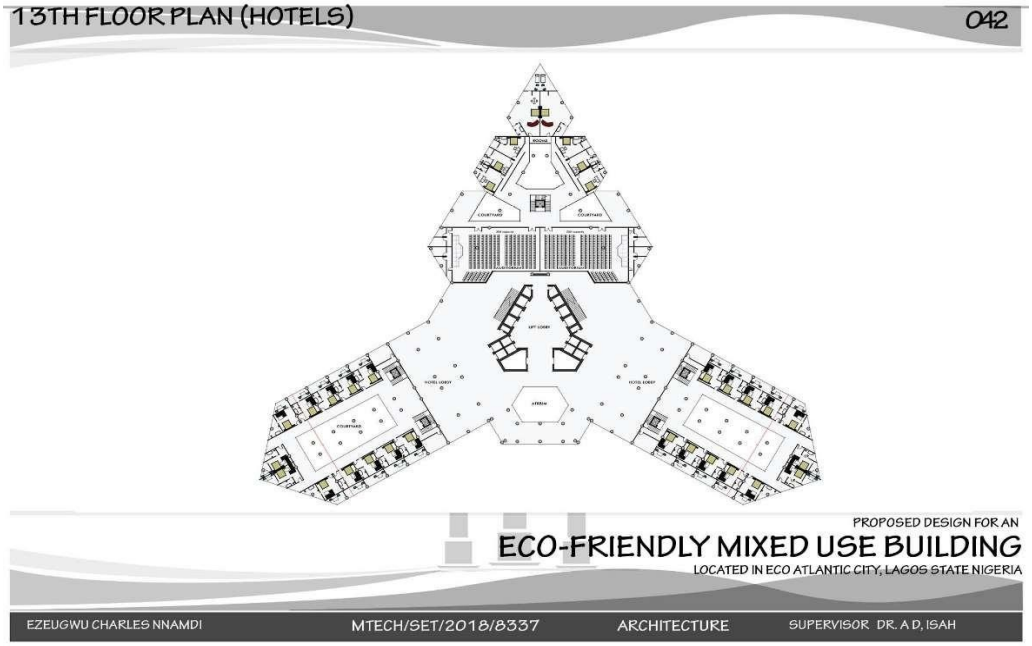
Appendix L: 11th floor plan



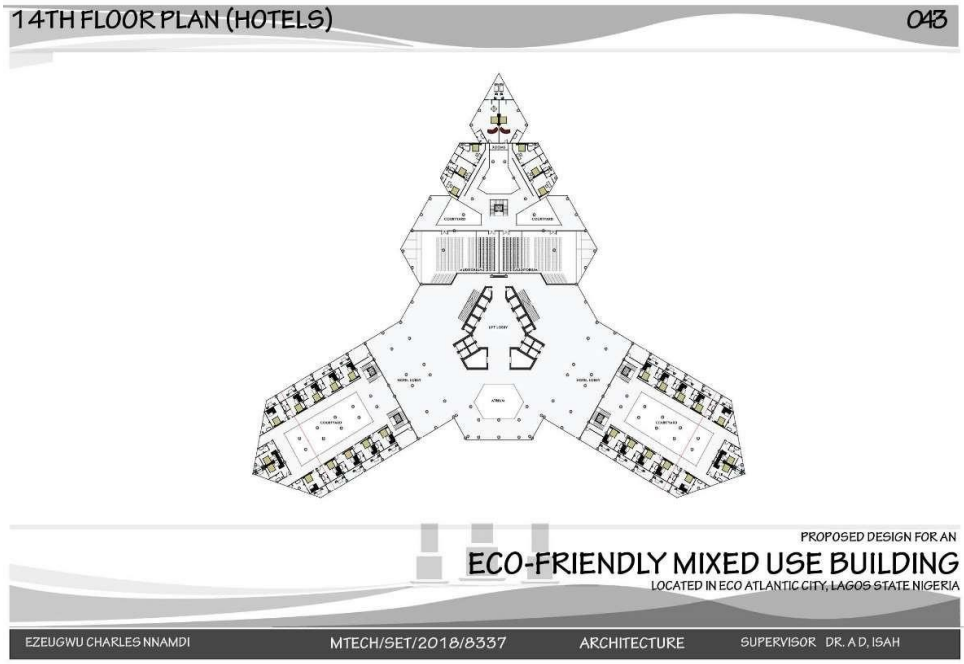
Appendix M: 12th floor plan



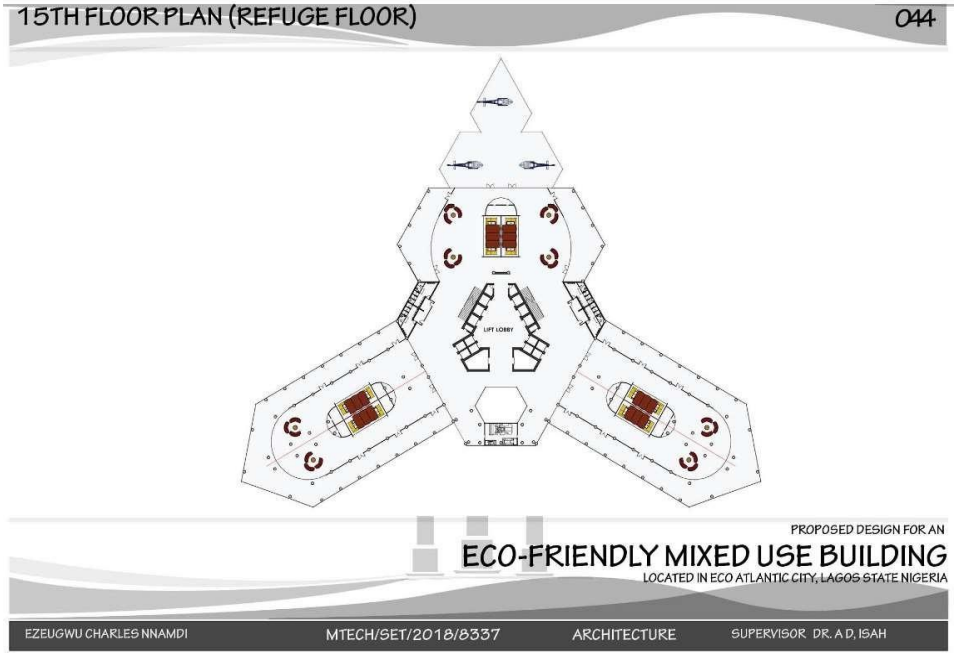
Appendix N: 13th floor plan



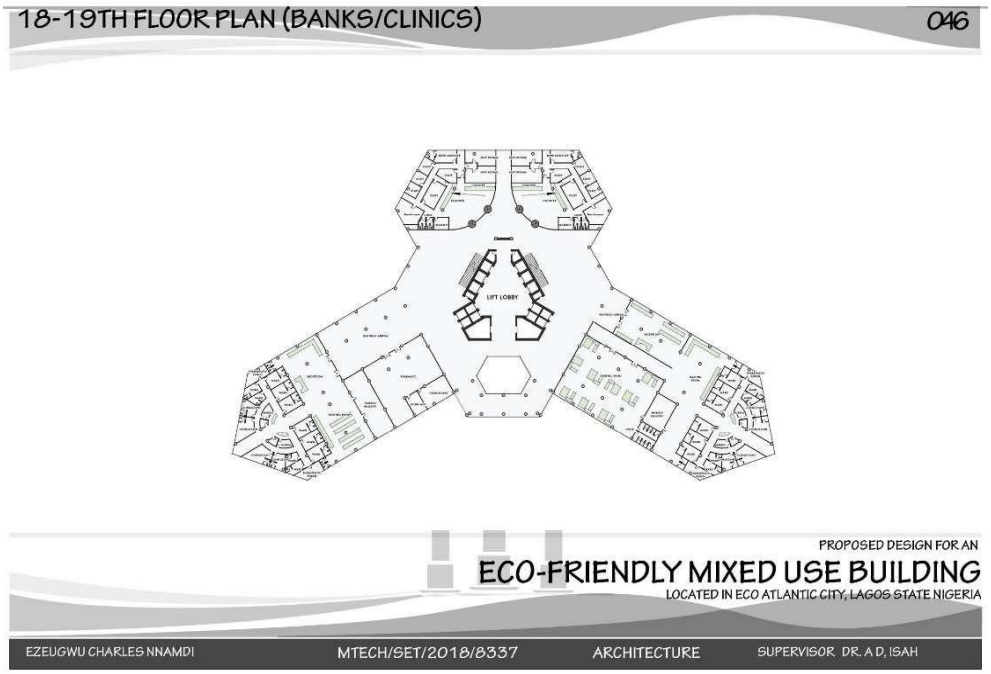
Appendix O: 14th floor plan



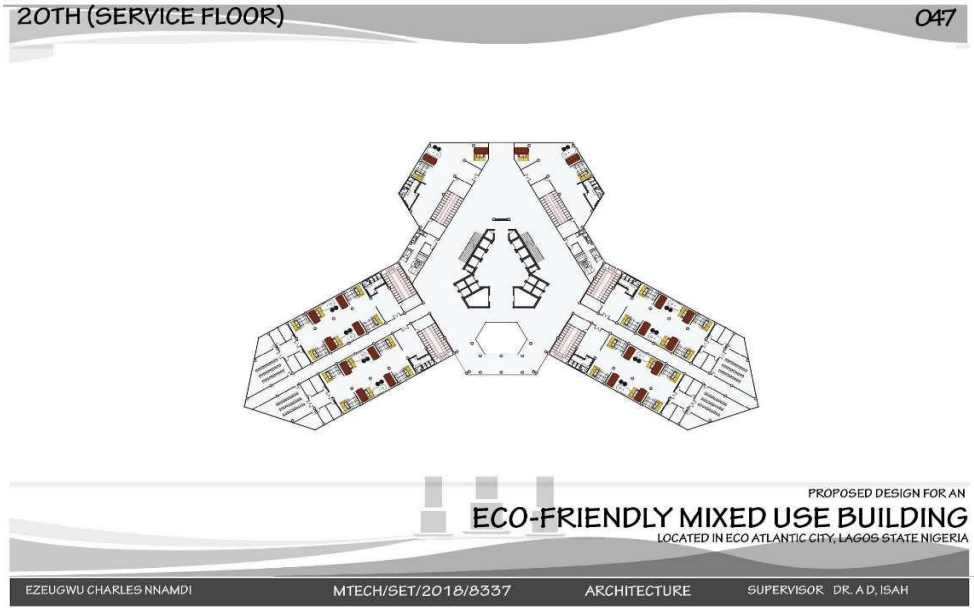
Appendix P: 15th floor plan



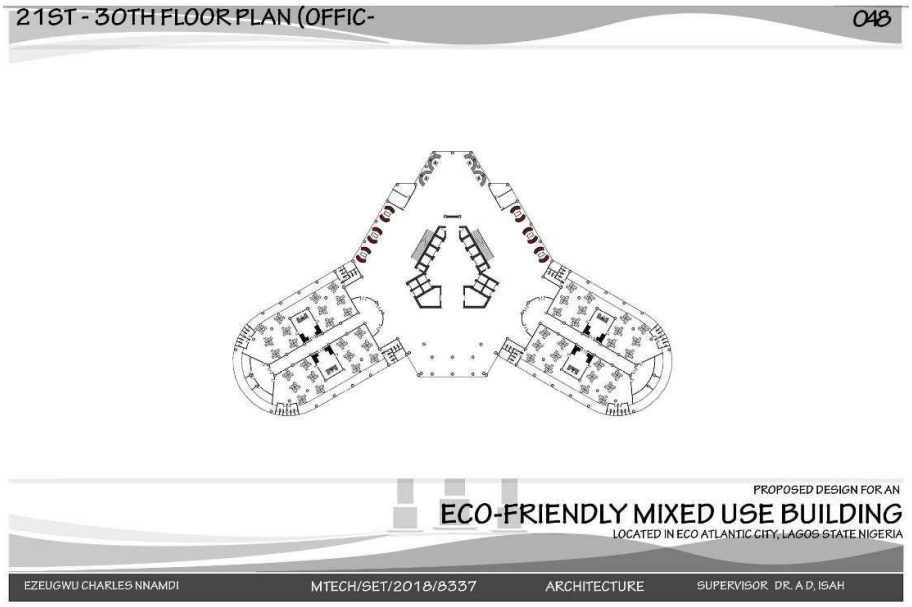
Appendix Q: 18th -19th floor plan



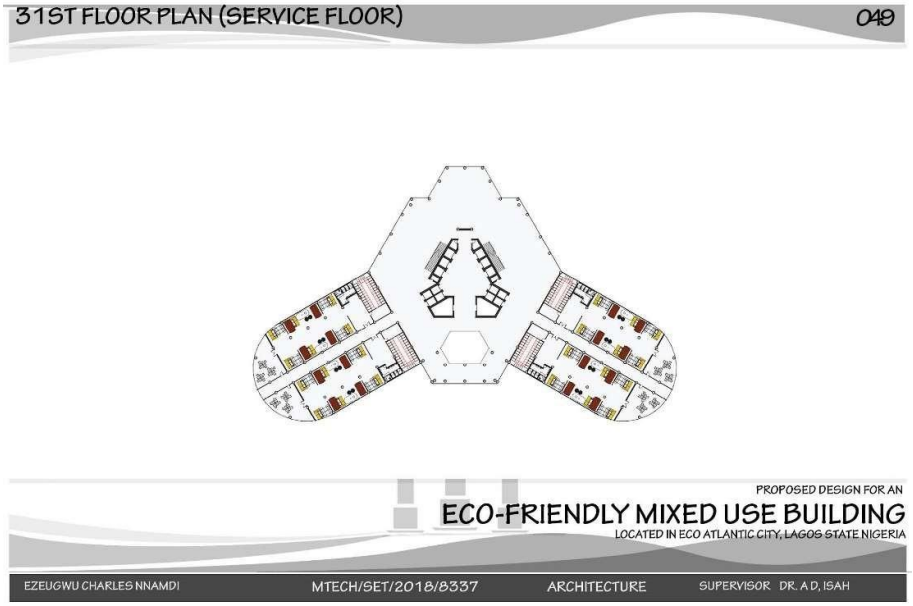
Appendix R: 20th floor plan



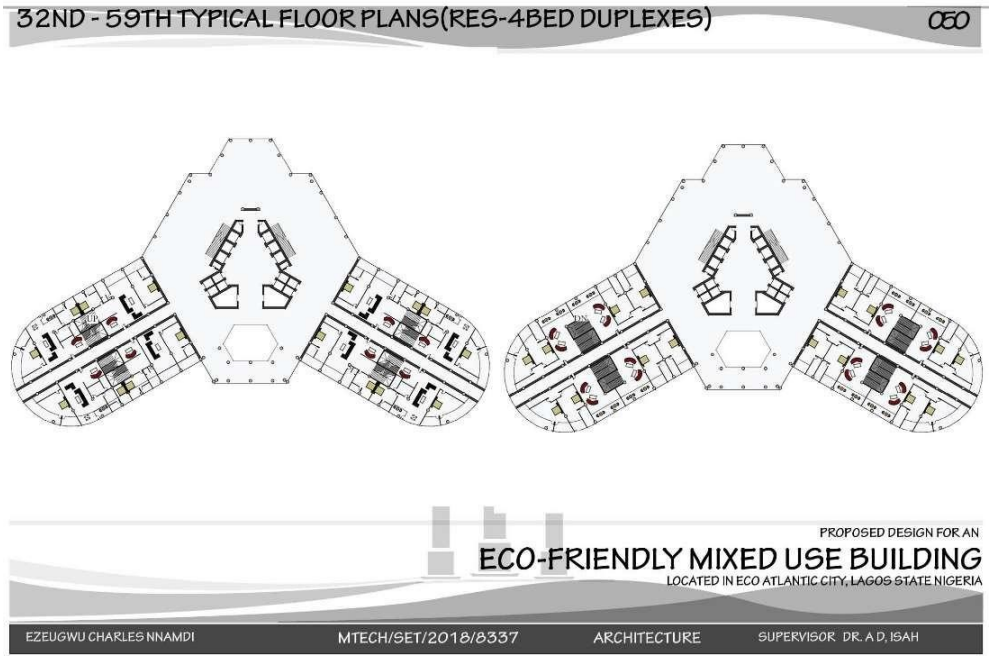
Appendix S: 21st – 30th floor plan



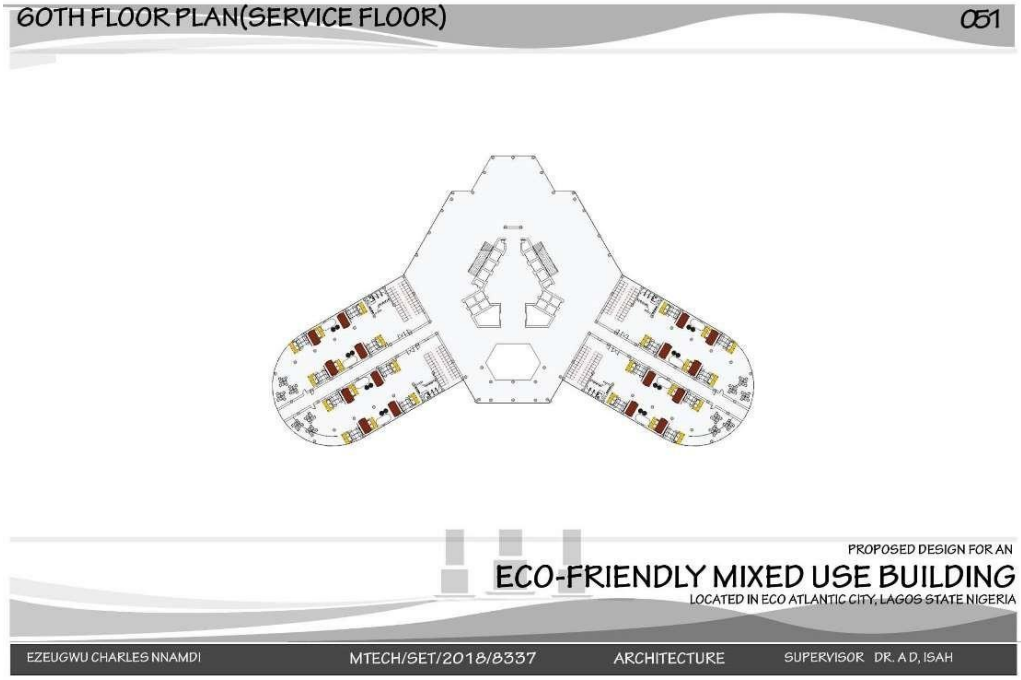
Appendix T: 31st floor plan



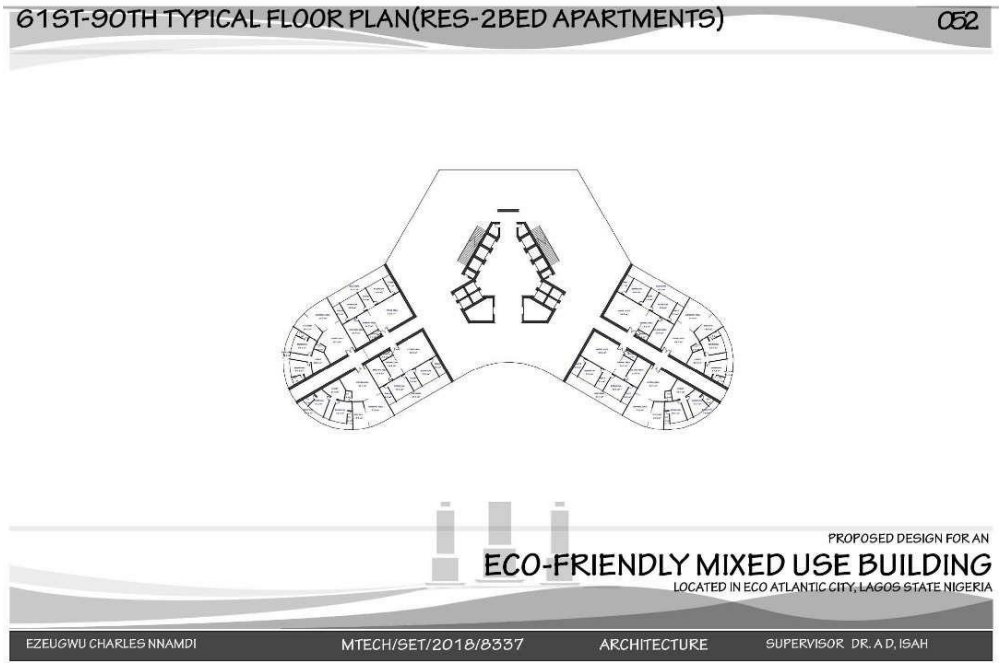
Appendix U: 32nd – 59th floor plan



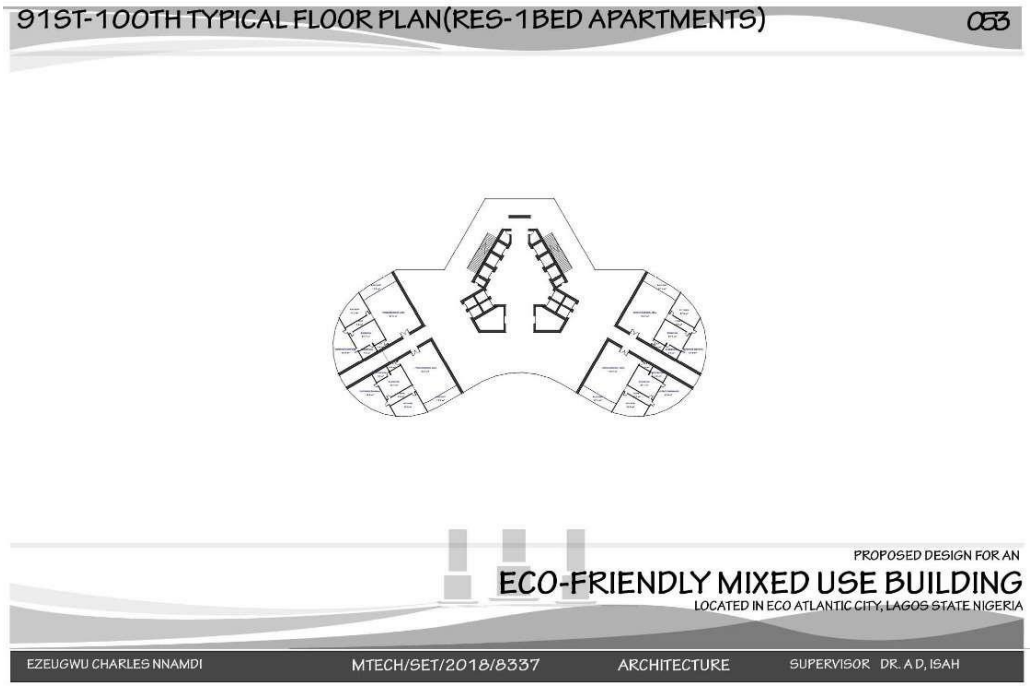
Appendix V: 60th floor plan



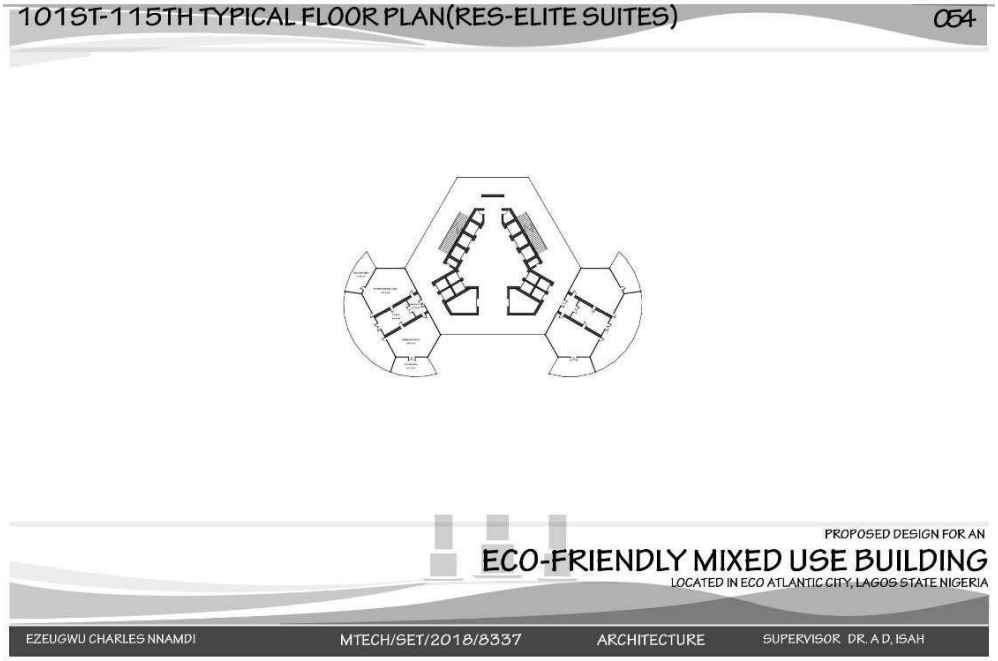
Appendix W: 61st – 90th floor plan



Appendix X: 91st – 100th floor plan



Appendix Y: 101st – 115th floor plan



Appendix Y: Roof plan