ASSESSMENT OF INDOOR AIR QUALITY PRINCIPLES IN THE PROPOSED DESIGN OF A NURSING HOME IN ABUJA, FCT, NIGERIA

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ABSTRACT

Researches done in healthcare indicate that patient outcome is linked with the hospital's physical environment. This environment includes the specialised health facilities like Nursing homes which functions primarily as a place for rest, recovery and restoration of health and wellbeing of older adults through its facilities. In order to optimize performance in the face of challenging climatic conditions, the study streamlines to one of the principles of Sustainable Architecture - Indoor air quality. Recent research has linked recovery rate and prevention of ailments to the environment in which it is taking place. The objective of this study was to evaluate the effect of the condition/performance on the perceived Indoor Air Quality (IAQ) and the indoor air-related symptoms of senior's facilities. The methodological approach of the research is predicated on extensive literature review, qualitatively studying the Old people's home in Minna. In this study, Indoor air quality design considerations gotten from literature are used as a reference for comparison with what is found in property. The design considerations or Variables are expected to work as a reference for promoting environments that are adapted for the needs of older adults. The perceived IAQ and the related symptoms were collected by means of an indoor air questionnaire survey and observation schedule among the senior adults in the facility. The performance was significantly low in the facility, given Natural ventilation as 30%, Outdoor landscape as 5%, Indoor landscape as 0% and shading device as 65%, making residents prone to illness related to poor indoor air quality. Therefore, it is imperative that IAQ design consideration (Natural ventilation, Natural lightning, Landscape configurations, Shading devices) be adapted in the design of residential apartments for the elderly as it helps prevent, promote and provide a curative remedy for their well-being.

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CHAPTER ONE

1.0 INTRODUCTION

This thesis presents findings from a qualitative and quantitative research study that was conducted in purposively selected Nursing home facilities in Nigeria. It highlights the ways in which the design considerations of indoor air quality principles were incorporated in their designs. In this introductory Chapter, the rationale for this study is explained and an overview of the thesis is provided. The Chapter starts off by presenting the context within which this study was conducted as well as the researcher's background. This is followed by statement of problem, the rationale and objectives of the study and then proceeds to briefly outline the research questions. Finally, an overview of the justification of the study and the scope of the research were highlighted.

1.1. Background of study

Nursing home refers to a health care institution that provides treatment with specialized medical and nursing staff as well as medical equipment serving as both an informative and educative environment for the convalescent, the elderly/physically disabled and also a retirement home (Bentayeb, 2015). The Institution strives in similar environment like other healthcare facility; a facility aimed at serving residence that are in need of rehabilitation services, care for prevention of nonacute, long-term conditions (Eckel, 2012). Specialty in diagnosis and clinical services are gotten outside the facility. Most residence are not necessarily bedridden, but are elderly and frail; some make use of aids like wheelchairs and walkers. These older adults are undergoing a recovery for long-term on illness but does not need to be in hospital, and others are undergoing preventive care services.

Treatment with advanced medications and technologies has been realized to be the fundamental aim of this area, however engaging in complex and more intensive process has an outcome of serious effects for the environment and humans. Therefore, it is imperative for seniors to receive care in order to maintain their identity as relates to their environment. Sustainability refers to the construction and applying the stages that are efficient in resources and environmentally accountable throughout the lifecycle of a building; from conceptualization to design, buildability, operation, maintenance, renovation, demolition. It also accrues to classical building concepts as relates to durability, economy, utility and comfort.

According to Harm (2011), "A sustainable healthcare facility promotes general health by the continuous reduction of adverse environment effects and on the long run eliminating diseases". It recognizes the relationship between the environment and health, which is demonstrated through operations and strategy. It is a kind of facility that connects basic needs with primary practice for prevention and environmental activity by being involved with efforts to enhance community health and a sustainable economy. Residence for care of older adults which is in-here operationalized, a Nursing home is an important option for additional care and support.

1.2 Statement of problem

In Nigeria, as health reform sets in, health care facilities are gearing up for many challenges; some are not old to the healthcare industry, most are facing the existing challenges that has plagued for over 10 years. As identified by Ubbing (2011), the major problem in health centres, among others as too many patients, few employed physicians, inadequate communication between health providers is unhealthy healthcare

environment. It is the desire of the author to investigate, and present a solution based on this investigation, the design of facilities needed by the medical profession for the specialized care of the aged and aging. The major area of concern is in the environment in which the medical staff is to work and the patient is to be treated and recuperated to a point when he can again be returned to his previous environment. It would be well for hospitals in the future to think about the responses of the patient, and his feeling of dignity, status, and position as a human being including a product requiring medical or surgical treatment. According to Karliner (2009), the health segment, by the use of a reasonable quantity in operation, constructions as well as resources of small, large, compound organizations, technical power employment with so much waste became a worry on the health sector. The World Health Organization, security-health cluster opined on producing medicine for prevention that, among others, one most respected and trusted sectors in the society is the health sector, also known to consume a lot of energy. Therefore, it enables the achievement of a healthy climatic condition that is efficient in cost (Heymann, 2008).

To create an environment that is friendly, the health sector should deploy fundamental measures like improving the design for healthcare, introducing a sustainable strategy for waste management and reduction in the use of chemicals and products that has minimal effect on the environment (Karliner, 2009). Hence, the need to provide such a facility in Nigeria to cater to recent findings in taking care of older adults. As such this study will assess strategic sustainable strategies in the design of health facilities to enhance patient's well-being and caregivers with the use of nature to bring about treatment of illnesses that accompanies aging. Indoor environments are fundamental environmental factors capable of impacting health. The quality of air in the indoor environment of

health care facilities

and other private and public buildings where people spend over 80% of their time daily is crucial for the overall health of old people (Harm, 2011). It is one of the main factors affecting the health, well-being and deteriorating conditions of the aged. The effect on health rises as exposure to and density of air pollution increases. Indoor air contains a complex mixture of bioaerosols such as fungi, bacteria and allergens along with non-biological particles contribute to about 25% to 34% of indoor air pollution. Sources of indoor bioaerosols are often located outdoors and particles are transferred to the inside through openings of the building envelope (windows, doors) and other components.

1.3 Aim and objectives.

The aim of this study was to assess principles of indoor air quality to improve healing environment for the patients. The aim is achieved through the following objectives:

i. To identify the principles of sustainable architecture.

ii. To examine the design requirement for Indoor air quality as a principle of sustainable architecture.

iii. To assess indoor air quality design consideration in the design of existing senior's housing facilities and its effects on the residents.

iv. To propose a design of a senior housing facility using principles of IAQ that enhances indoor thermal performance so as to provide a safe and self-healing environment for older adults.

1.4 Research questions

The following are the questions that the research focused on answering.

i. What are the architectural features that can be applied in Nursing homes to meet

the specific needs of the patients?

ii. To what extent have existing facilities applied indoor air quality considerations to create a self-healing and illness-prevention free environment?

iii. What components of indoor air quality as a principle of sustainable architecture can enhance wellbeing?

iv. How can IAQ principles be applied in a nursing home to enhance a self-healing environment?

1.5 Justification for the study

Long-term care also referred to as nursing home involves medical care and rehabilitation care made available to persons needing aids with living activities on a regular basis. It has been estimated that a minimum of 70 percent of persons above age 65 needs care services on long term at some point in their life. Long term care has been a major subject within the health economist due to the growth in the population of the elderly; this is because they are main providers of this care service. Studies in earlier times, including studies by Beukeboom *et al.* (2012), centred on the cost for effective care as well as the rate of requests for care-home services; so as to have a better understanding of how it functions.

Older adults today have it better than they did at any other point in history; medical advances enable the possibility of living longer and more comfortably than in the past. In the earlier years, there arose the need to improve the prospects of the chronically disabled, skilled caregiving, ingenuity, and resourcefulness as well as conserve expensive hospital facilities for the seniors. According to Abanyam (2013), services that should be incorporated include basic and skilled nursing care, rehabilitation, and a full

range of other therapies, treatments, and programs for the optimal care and well-being of seniors' resident in this type of facility. Over the years, the model evolved to help improve the conditions in Nursing homes as recommended by National Institute of building services.

1.6 Scope of study

The depth of this project is to make a proposal for the provision of suitable facilities of a nursing home. The spaces provided in the facility will accommodate green design strategies to mitigate the negative impact of the environment thereby improving health and promoting sustainability. There shall be exploratory research of relevant literature and several research methods and comparative analysis of data that will be gotten from some selected case studies of which the outcome of the result will be demonstrated on a proposed nursing home in order that the research is authenticated.

CHAPTER TWO

2.0 LITERATURE REVIEW

The chapter addresses the literature framework of the study, reviewing relevant works of scholars that have worked in the subject matter. The chapter also went on to introduces the framework for the case study that comprises the main focus of the research described in this thesis. The first part adequately discussed the historical development of hospital and the various classifications, the second part discussed its sustainable in design and the third part sufficiently described the context of a Nursing home.

2.1 Historical Development of Hospitals

The term 'hospital' is ‘hospitalis’ in Latin; it relates to people and their treatment. It was primarily seen as a place for the poor or for travelers that got weary, then a place of treatment of illnesses. It appeared first as Aesculapia in Greece; named after god of medicine in Greek. For many years, healthcare centers became developed in cognizance with religious organizations like the European hospital originated by the Monastery in the middle-ages and Hindu hospital in Sri Lanka at fifth century BC (Mitchell, 2007).

2.2. Classification of Hospitals

People visit the hospital for different purpose; treatment, therapy or diagnosis, then exit the facility on the same day, these are called outpatients, some others spend the night, or for a couple days or weeks; these patients are called Inpatients. Hospitals are usually distinct from several other medical institutions because of allowance for admitting of

patients (Sime, 1996). Others are usually called Clinics.

2.2.1. General Hospitals.

It is a common type of hospital equipped to take care of immediate illnesses. The general hospital provides entire medical service to people that are ill, as well as care for expectant mothers. There exist well-planned medical personnel, personnel in administration and technical with chairman of staff of attendance and heads of departments.

- A standardized laboratory with equipment that are essential for performing of parasitological and biochemical examination. Equipment used for preparing specimens for pathology are available.
- Facilities that essential for the laboratory to perform task optimally should be sufficient to perform tests like lightning and sufficient space.
- Facilities with the consulting services of a radiologist. Including a unit for radiology comprising of tube stand, transformer, attachment of stereoscope with a table, adjustable fluoroscope device on vertical and horizontal position, stereoscope, viewing box, and a dark room with films development;
- A unit for surgical operations, with available facilities like a room for operation, a room for sterilization, an office-work room, a room for dressing and a room for scrub.
- An Isolation unit comprising of adequate rooms based on the requirement of the healthcare facility usually located in a different building close to the other buildings or entirely isolated from all others, having toilets and lavatories.
- Maternity unit facilities with its entrance including wards for patients, delivery and labor rooms and a nursery room.
- Mental unit: There is usually provision made for this unit comprising of a

number of rooms that are soundproof secured for patients, with convenience.

- Dental Unit: For very large general hospitals, there is recommendation for including a dental section separately, with a dental surgeon that is licensed standard equipment for diagnosing and treating tooth diseases, performing surgical operations when required.

2.2.2 District Hospital or Intermediate General

In order to function in this capacity, the facility should be equipped with a minimum of sixteen wards and a maximum of 75 wards for optimum health care services to patients.

- Medical staff of qualified persons
- A laboratory approved same as a general hospital, including sufficient room, supplies and equipment for performing blood count, urinalyses, serological test and other basic facilities
- Operating rooms with recommended supplies and equipment and allowance for adequate sterilizations.
- Maternity Unit comprising of wards for delivery.
- X-ray facilities comprising equipment that are not very massive but are convenient for use.
- Isolation equipment, having control and care for contagious diseases with proper and adequate procedures.

2.2.3 Specialized Hospitals

Specialty hospitals offer focused services to treat medical conditions that require a particular subset of skills and technology. These include hospitals for rehabilitation, chiropractic facility, trauma centre, pediatric hospital, Seniors' healthcare facility. More recently, specialty hospitals have begun focusing on cardiovascular surgery, orthopedic

surgery, general surgery, and women's health (Mitchell, 2007).

2.2.4 Teaching Hospitals

A Teaching hospital is a combination of treatment of patients with tutoring nurses and students in nursing and medical schools. Many of these hospitals conduct medical research, as well as provide care to the poor and uninsured. Teaching hospitals are almost always affiliated with one or more universities and are often co-located with medical schools (Burbridge, 1957). The purpose of these residency programs is to create an environment where new doctors can learn to practice medicine in a safe setting which is supervised by physicians that provide both oversight and education.

2.3. Green Hospitals

The idea behind Green Hospital is a healthcare facility that is eco-friendly, such as to protect the environment as well as save the lives of people. There is a lot of energy consumption in hospitals leads to prominence of toxic wastes which may be of adverse effect to humans and to the environment; therefore, green hospitals is defined a hospital helps curation, while making use of natural elements in an effective and eco-friendly manner. According to Marcus and Barnes (1995), green hospitals makes efforts to reduce wastes, recycle materials, producing fresher and cleaner air by using sustainable building materials, the use of efficient and efficient designs. It has been revealed from many studies that a healthcare centre that is appropriately designed will enhance the process of curing a patient. For this purpose, Architects focus on sustainable design measures in order to improve the wellbeing of the patient and health workers in such institution. It is important for them to have a very good working knowledge of how building designs can improve curation by planning to meet such need. A Green hospital or healthcare however enhances recovery in patients, reduces stain for health workers,

improve quality care and lowering water consumption and energy. Areas that are of focus for green hospitals or healthcare centres include: lighting, Indoor Air Quality (IAQ), sustainable building materials to enhance an interior space, natural landscape configurations.

2.3.1. Boulder Community Foothills Hospital

Building type: Health care Facility, Location: Colorado, USA Architect: Haptic Architects, Completion date: 2003.

The 380,000 square feet was completed in and is the first certified Hospital in USA, it is a hospital designed to treat children and women. There are gardens with outdoor seating with different views, basically designed to preserve open spaces and make the natural surrounding noticeable. There is surgery, paediatric and neo-natal intensive cares; including structures for services, an office with an equipped. Because of the need for a long-term care, there is a part of the site reserved, while the other part is an area that is opened. Plate I and II below shows different views of the institution.

Plate I: Exterior Boulder Community Foothills Hospital
Source: Huelat (2008)

Plate II: Interior of Boulder Community Foothills Hospital
Source: Huelat (2008)

2.4. Nursing Home

A Nursing home is a facility or an institution for the care of persons that are ill but do not have to be in the hospital, but cannot also be treated appropriately in their houses of long-term care of patients who are not sick enough to need hospital care but are not able to remain at home. In history, people residing in nursing homes were old people, those that are sickly, people with disabilities and care on nursing service was not major. In recent times, this facility, actively help in health care for patients, helping them to live a healthy live or preparing them, and/or with a member of their family when necessary (Hassan, 2013). The Institution minimize expense on hospital bills for the sick and helps to the wellbeing of the disabled; there are varying care quality, and likelihood of abuse exist. Seniors who were disabled and poor lived in Alms-houses before the nineteenth century. A couple of displacement existed among the elderly in America due to the

industrial revolution, there was difficultly for immediate family members to properly care for their aged ones. For this reason, the local government at that time established group housing as against outdoor welfare that comprised of food donations, wood, clothing to people that lived independently (Ponting, 2007). Therefore, all categories of people including the disabled, the orphans, the insane, started residing in the Alms house. Just around the commencement of the twentieth century, churches, women organizations became founders of institutions, for the elderly in their ethnic and religious groups.

The major concerned that began was the fact that people outside these organizations started possessing these charities were the less privileged resided. Not only were 'more worthy' the aged populace then started residing in residential facilities, but other category of people commenced in the provision of facilities for the visually impaired, the insane, young people. Most people living in the alms houses as at 1920 were poor elderly people; at that time seniors lived in alms houses owing to being lonely, lack, being humiliated and neglected. The government, however were interested; the bureaucrats were amazed to discover that there was an overestimation the effect of pension on the elderly that were needy for the assumed month. A particular individual explained that different types of illnesses often arose requiring personalized interest that could not be gotten in the homes or in the alms houses. However, the residents living in the alms houses had very little welfare attention despite the fact that they were not large in number; the government decided in their own capability to eliminate the institution entirely (Harm, 2011). Older adults that were sickly were therefore in need of long-term care and had look for private institutions for treatments as in the enactment of social security, the government reacted by the converting county homes to private individual

control, with the same residence and their supervisors; this met the goal for the residents to receive monthly remunerations by the federal government and private healthcare by private individuals. According to (Ubbing, 2011), the Congress in 1954 passed in the constitution laws that permitted developing public organizations for the seniors in need. The residents in the private and public nursing homes were given federal aids because many elderlies required long-term care.

2.4.1. Overview of Nursing homes

Nursing homes are mostly used by individuals that cannot be taken care of in their homes and do not have to be treated in the hospital. The facility provides residential care for older adults and the disabled. Nursing home is also called homes for rest, old-people home, care homes, long-term or skilled nursing facility. These different terms seldom have slight differences in meaning as relate to private or public institutions, and if nursing care service, assisted living, and emergency care. The nurses in the facility are responsible for taking care of medical needs of the residents and are also responsible for the employees based on their respective ranks. Majority of the nursing homes in establishment provide nursing hands-on for 24 hours, while others provide short-term nursing following an injury, an illness or a surgery. Other services provided in a nursing home include physical therapy, speech and language therapy, therapy on occupation. Others include daily housekeeping and planned activities as well as memory care services, often called Dementia care.

2.4.2 Historical development of Nursing home.

The elderly populace who were incapacitated, needy and isolated formerly resided in almshouses together with a couple sick and homeless individuals, before civic groups and organizations established special houses for the elderly which is now widely

referred to as a Nursing Home in Europe and in the United States.

The development of nursing home recently reflected in political and demographic realities that reformed the growing old experience. In America at large, nursing home has become a recognized and standard care typology for older adults in the twenty-first century; a reasonable number of seniors are resident in this institution that became available at a wide range (Hassan, 2013). Some of the earlier nursing home that were established include; Indigent single and widows' women society in Philadelphia (which was established in 1823), Boston's home for Aged women (established in 1850). The founder of these institutions referred to the nursing home as a facility for their less privilege classes.

2.4.3 Review of existing green Nursing Home Facility

2.4.3.1 Heritage Nursing Home, Michigan, United states

Heritage Nursing Home is located in a residential area in Zeeland, that is quiet and serene. It is family-centered residential community; the building's shape keeps residence connected closely; the nursing station is centrally located, where the members of the staff can monitor the residents' room in order respond aptly to requests. The major motivation is to realize the rehabilitative potentials of residents that are experiencing very challenging issues in their health. They have an integrated nursing team with services like physical therapy, speech and language therapy, therapy on occupation. Care is on a personal level and optimum measures to create a safe environment and promote independent living. As relates to the variables for Indoor air quality, there is adequate use of natural elements for the indoor and outdoor landscape sceneries, most of the windows were shaded, preventing excess solar radiation and glare from entering into the indoor environment. Large sized windows are also used in the

building allowing for adequate ventilation and lightning. Plates III, IV and V shows different view of the facility.

Plate III: Exterior of Heritage Green Nursing Home
Source: Envelope and space planning (1999)

Plate IV: Site layout of Heritage Green Nursing Home
Source: Envelope and space planning (1999)

Plate V: Interior of Heritage Green Nursing Home
Source: Envelope and space planning (1999)

2.4.3.2 Brookdale Green Mountain, Lakewood

A typical of sustainability, Views are shown in Plates VI, VII and VII below.

Plate VI: Exterior of Brookdale Green Mountain
Source: Envelope and space planning (1999)

Plate VII: Another view of the Interior of Brookdale Green Mountain
Source: Envelope and space planning (1999)

Plate VIII: Layout of Brookdale Green Mountain
Source: Envelope and space planning (1999)

2.5 Green/Sustainable Architecture

Green architecture and Sustainable architecture and green architecture as used interchangeably by different researchers are both central to harmonizing man and the

environment. It can also be referred to environmental design. The principles are broadly categorized into three with inherent strategies that are employed to stimulate congruence between human beings and the environment as well as promotion of healthy living.

2.5.1 Meaning of Sustainable Architecture

The word 'Sustainability', etymologically originated from the Latin word sustinere, which alludes to hold (from tenere –hold, keep, comprehend, represent, support). Sustainability was used to describe means of resourcefulness in a manner in which things can be sustained or continued in the future by generations to come (Poodineh, 2017). The most widely quoted definition of sustainability globally was put forward in 1987 by the World commission on environment and development; one that does not affect requirements of generations in future, but adequately meets the requirements of the present generation. Figure 2.1 shows three categories it encompasses.

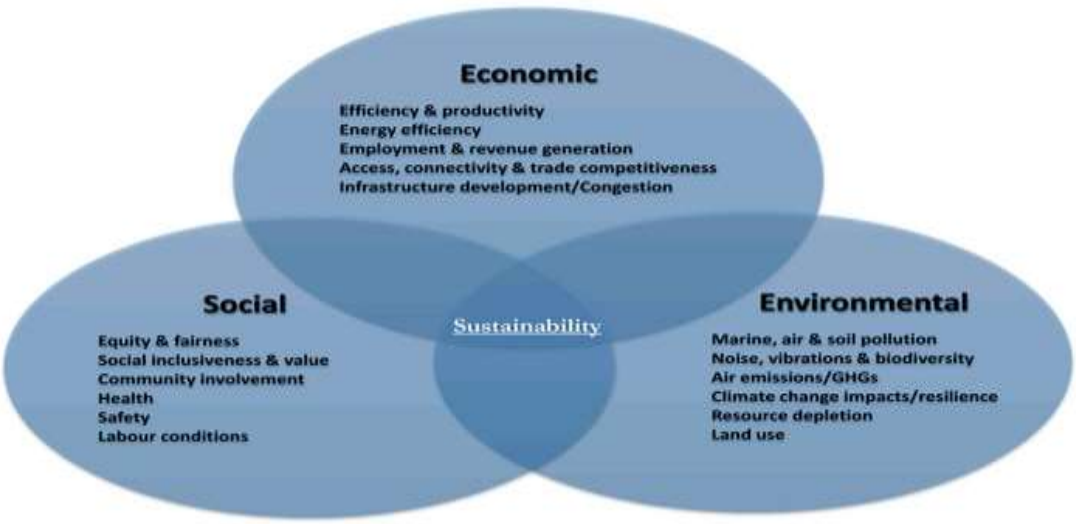

Figure 2.1: Categories of Sustainability
Source: Poodineh (2017)

Green, Sustainable or Eco-friendly Architecture as used interchangeably by different

authors refer to the same concept. All actors in Engineering, Architecture and the construction industry has been confronted with the term. In one way or the other, the industry presents a unique challenge to sustainability. Construction projects require large amount of materials, energy and water resources and it produces waste in large tons. Though a number of definitions exist for the term sustainability, it still remains elusive due to lack of details on how to apply its principles in practice (Sassi, 2006).

In the bid to understand the meaning of sustainability and apply its principles into practice, definitions according to different authors are identified. Attaman (2010) revealed that the word 'green' is generally made use of in architecture, though not properly defined. He defined it as the design and construction of buildings that are technologically, materially, ecologically, and environmentally stable. He also stated that in respect to sustainability, it is narrowed into: sustainability of technology and materials, sustainability of resources and the environment. Sinha *et al*. (2012) quoted the Environmental Protection Agency definition of Green Architecture as "designing buildings with the use of measures that are responsive to the environment from conceptualization, constructing the building, operating, maintaining the building, renovating and rebuilding".

According to Roy (2008), Green architecture or Sustainable architecture is a way to design and construct buildings that minimizes adverse effect on the environment and health of humans. Based on this definition, the duty of the architect or designer is to safeguard earth, water and air by selecting environmentally friendly practice on construction and building materials. Also, Ghani (2012) defined Sustainable

Architecture as creating and responsibly managing of healthy buildings that are focused on efficiency in resources and the ecological principles.

The buildings aim to reduce negative environmental impact through resource efficiency and energy conservation. The definitions from different authors are synonymous. They all stress sustainability in Architecture as addressing the adverse social and environmental impacts of building by making optimal use of design methods and materials or resources that are not detrimental to the immediate environment. The philosophy behind this is simply to ensure that actions taken at present do not consequently affect the ability for generations over time to conveniently work with sustainability principles. Based on consequent usability in different structures, it has been said to create an environment that enhances comfort and creates a healing effect. Sustainable Architecture is a three-way interaction between the environment, economy, and the society. Thus, the sustainable Architecture principles are broadly categorized into the social framework, environmental framework and economic framework. Environmentally, green architecture ameliorates issues of solid, atmospheric and liquid pollution conserves nature and biodiversity. As relates to economy, it invariably reduces the cost of the lifecycle of a building, and as relates socially, sustainable buildings are seamless and beautiful with human activities (Ragheb *et al*., 2015). Table 2.1 shows the triple beam framework of sustainability.

Table 2.1: Environmental, Social and Economic Framework of Sustainability

Categories of a sustainable economy	Categories of a sustainable environment	Categories of Social sustainability
i. Creating an avenue for selling of resources and expansion in sales.	i. Minimizing waste products and release into the surroundings.	i. Safe environment for working and to maintain good health
ii. Reducing the price of items by reducing the use of energy.	ii. Minimizing adverse effect for better health.	ii. Effect on the immediate society and living quality.
iii. Making opportunities for adding value.	iii. The use of resources that can be reused.	iii. Advantage to specific categories of people such as those with disabilities.
	iv. Eradicating harmful substance.	

Source: Ghani (2012)

2.5.2 Historical development of Sustainable Architecture

Literally, sustainable architecture in history is synonymous with the history of human kind because from the outset of humanity (hominids), the relationship between man, the environment and ecology were established (Attaman, 2010). The evolutionary line of humans separated into Homo habilis and Homo erectus four million years ago. The first homo habilis were capable of making stone tools that helps separate the edible substance from the carcass. However, they have a more advanced intuition which was more skillful, innovative and could adapt more seamlessly with the environment. The possibility of making and controlling fire grave invented by the Homo erectus gave them the power to migrate to other areas and adapt to different climatic conditions by making cloths and shelter (Attaman, 2010). Groups of human beings were nomadic;

hence areas of shelter were basically for temporal purposes. In other areas, human beings constructed wind breaks with stones or used wood to make simple shelter, covered with leaves and animal hides, but areas in Asia and some areas in Europe had an offer for habitation. The resilience of human beings was tested between 100,000 to 35,000 BC (Attaman, 2010). The Ice Age was bitterly cold, but they survived and at some point, migrated to areas that were not previously inhabited. At this time, human beings developed improved composite tools and weapons which were lighter and more efficient in providing shelter. The changes in climatic conditions gave opportunities to the explosion of human populations that already developed strategies to survive under the harsh conditions.

Animals and plants started to colonize larger areas around the earth including areas that were previously not habitable in Africa, Europe and America and this gave rise to a steady growth in the population of human beings. Dependence on hunter tribe groups on different cultivated plants became imperative and this led to the formation of settlements and farming communities. The paradigm shifts from nomadic to agrarian societies where human beings modified the environment to suit their settlement brought about changes in the ecology. These new settlements required resources to meet different requirements ranging from provision of shelter to heating, and cooking of food. To meet these requirements, deforestation started and this consequently caused soil erosion and other ecological problems surfaced around the areas that were occupied (Ponting, 2007). The ecological destruction which caused major environmental changes gave rise to environmental protection awareness in the 18th century. Most of the early reactions were short accounts and local environmental policies were formed.

The mid-eighteenth century witnessed an industrial revolution which gave rise to

technological advancements leading to a radical departure from hand to machines. New materials for building like steel and iron emerged and other sources of energy such as steam engine, coal, petroleum and electricity were developed (Attaman, 2010). However, these new technologies increased natural resource exploitation, spurred massive population growth within the urban settlements. Consequently, the need to protect the increasing population and nature became a serious and urgent issue.

After the World War II in the early 1900s, environmental movements began to emerge with intense activities of how to protect nature and mankind from extinction. In as much as the intent was the same, the movements became more global and complex during this period. The latest program to enhance the environment include improvement in technicality, improvement in material, new discovery by science, stress on ecology, rise in population, inadequate resource and disparity in the economy.

World commission for development and environment in 1987 organized a summit and came up with the definition of sustainability as the ability of the present generation to meet their needs also making it possible for the generations ahead to meet their own needs. Architecture was identified as a direct response to the emergence of this movement. A new approach to designing buildings to reduce negative environmental impacts were required and this gave rise to the term Green Architecture which also refers to Sustainable Architecture or Environmentally Friendly Architecture. Some architectural and construction establishments commenced rating and certifications to foster international best practices in architecture (Dinç, 2009). Table 2.2 shows the environmental impacts that triggered the birth of sustainable architecture.

Table 2.2: Environmental impacts that led to Sustainable Architecture

ACTIVITY	IMPACT ON ENVIRONMENT
Drilling and Mining	Erosion of land, Pollution of aqua life, Felling down of trees, elimination of plants, erosion of land, eradication of animals
Creation and assembling	Consuming energy and a lot of waste.
Transporting and dissemination	Release of CO_2, use of resources, consuming energy.
Construction	Release of CO_2, effect of waste from materials used for building because of their inherent chemicals.
Maintaining	Use of resources and replacing them, Release of CO_2, consuming energy, resource use and replacement, effect of waste from materials used for building because of their inherent chemicals, pollution of H_2O.
Demolition	Contamination by toxic substances, poisoning of the environment.
Waste Recycling	Decomposes by filling of land, producing harmful gases, contaminating water in the ground.

Source: Attaman (2010)

2.5.3 Contemporary Practices in Sustainable Architecture

The twenty-first century is generally characterized by significant transformations of civilization, social, economic, political, information and rapid development of innovative technologies (GilMastalerczyk, 2016). The Architecture, Engineering and

industry for construction is among others the greatest economic sectors worldwide. Huge financial capital is always required for construction projects as well as natural resources; hence the role of architecture in sustainable development cannot be overemphasized.

The period between the last quarter of the twentieth century and the present is known as contemporary times. Prior to this time, there was no strong reference to the role architectural designs have on sustainable development and designers' responsibility was mostly at their discretion (Sharma, 2010). Although the understanding of sustainable architecture is ever evolving, the content and scope of this design concept has been clearly articulated in contemporary times by over 600 green certification systems worldwide with the Leadership in energy environmental and Building Research Establishment Environmental Assessment as the frontiers of green rating systems.

The rating systems moderate comparative level of performance and compliance of new projects to the environmental responsive goals and efficient use of resources throughout the life cycle of building projects (Sharma, 2010). Also, these systems have put forth guidelines to facilitate architecture and construction processes that environmentally accountable with emphatic advocacies on efficient and optimum employment of natural resources. To address issues of ventilation, thermal comfort, lighting and life cycle expenses of buildings, the use of renewable resources and less energy consuming techniques are highly recommended. The transformation of these concepts into practice is reflected in a couple of contemporary buildings that will be analyzed in this literature review. Michelle Kaufman predominantly advocates the mass awareness of green residences and resource efficiency, a system of moderating homes to display information such as insulation efficiency, use of electricity and carbon emissions that is

similar to the eco labelling concept generated in the aspects of ecology in the industry (Gil-Mastalerczyk, 2016).

Also, a new toll known as living building challenge has been proposed to foster net zero

prerequisites in buildings such as reuse of water and other important renewable natural resources. As sustainability concepts lays emphasis on conservation of natural resources, landscaping in the built environment has also been integrated in contemporary times towards achieving the goal of sustainable development. In conclusion, the contemporary practices currently been explored in sustainable architecture are answers and results of research, advancement in technology and a better understanding of the ecosystem.

The design of buildings should not only be premised on aesthetics but high performance and environmental responsiveness. At the foremost steps of design, humanity and the environment are deeply rooted in the process to ensure harmony and survival because the most essential role of architecture is the creation of built environment that ensure mental health is maintained, physical comfort, wellbeing and productivity of inhabitants is optimized. Figure 2.2 shows a typical illustration of a sustainable building in contemporary times.

Figure 2.2: Contemporary Sustainable building
Source: Gil-Mastalerczyk (2016)

2.5.4 Green design Principles and Strategies

Literally, a principle is said to be a fundamental proposition or assumption that guides the basic foundation for a system of behavior, belief or chain of reasoning. On the other hand, a strategy alludes a plan of action properly defined to achieve a particular aim. Similarly, Green design principles are fundamental prepositions of sustainable development that guide designers to create buildings of high performance with less negative impact on the environment (Gil-Mastalerczyk, 2016). The principles entail a comprehensive and an integrated approach throughout the building's phases from construction, operation, maintenance and decommissioning. Each of the design principle entails a set of unique strategies that can be disaggregated, analyzed and employed by architects to reduce the environmental impacts buildings they design. In order to educate designers and meet the goal of coexistence, Kim (1998) broadly proposed three dimensions of sustainable Architecture including; resource on economy, design for life cycle, humane design. The first is emphatic about recycling and reusing

resource employed in buildings. Design for lifecycle provides a framework to analyse the process of the building including its negative impact on the environment. Lastly, humane design is based upon human interaction with nature. Figure 2.3 shows the sustainable design principles postulated by Kim (1998).

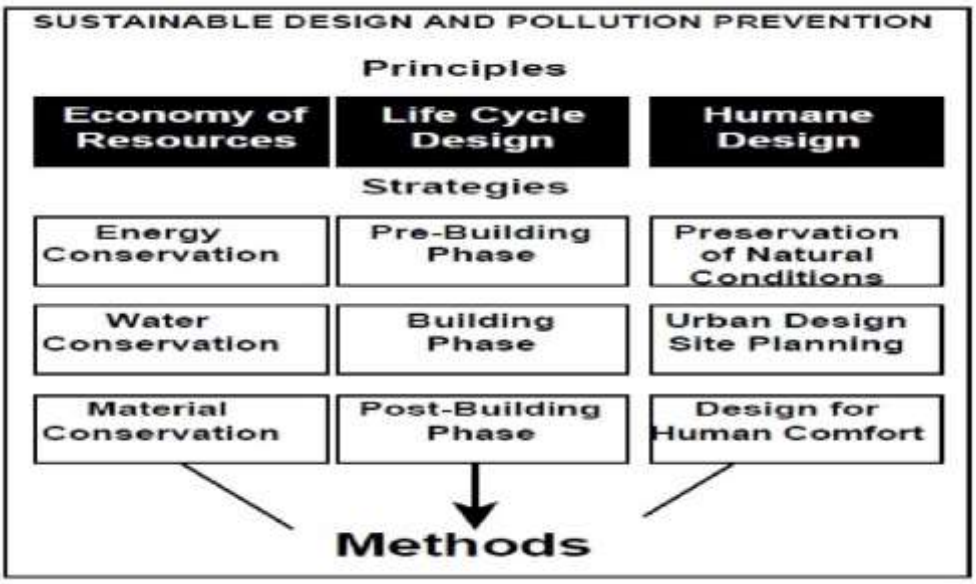

Figure 2.3: Sustainable design principles
Source: Kim (1998)

These principles provide the architectural framework for employment of strategies and methods to produce environmentally responsive buildings and are discussed in details.

2.5.5 Economy of Resources

The economy of resources entails a reduction in the employment of non-renewable resources for the operation, maintenance and building construction. For the construction of buildings, a natural and manufactured resources flow continuously in and out during the entire process. The flow of these materials begins from the time of construction and continues throughout the life cycle of the building in order to foster an environment that sustains human activities (Kim, 1998). Also, the resources should be in a way such that it can be reused after demolition of the building. The strategies for economy of

resources each focus on a resource that enhance a building's performance and are discussed as follows;

2.5.6 Energy Conservation/Efficiency

The energy-efficient siting and design of buildings are beneficial in terms of economy (cost savings), social (poverty reduction in fuel), and the ecosystems (Reduction in resource exploitation and emission of greenhouse gases) (Sherman *et al*., 2005). Sustainable building design with respect to energy efficiency aims at enabling inhabitants of buildings to maintain their quality of life with minimal CO_2 emissions (Sassi, 2006). Changing the source of energy from fossil fuel systems to renewable energy appears to be the most direct and solicited solution. However, the economic and technical barriers of employing renewable energy sources by far outweigh the possibilities. According to Osama *et al.* (2017), the high cost of energy resources and extraction strategies, the transmission and distribution issues associated with energy resources significantly influenced the concept of improving its efficiency and conservation worldwide. The strategies for energy conservation are discussed as follows:

i. Passive Design Strategies

Passive design is an approach to design of buildings that depends on the architecture of the building to reduce consumption of energy of buildings. Passive building elements such as the architectural, structural and envelope take cognizance of the environment to carefully optimize the building's envelope with the climatic conditions (Ragheb *et al*., 2015). Passive design on solar makes use of the following methods to achieve energy efficiency in buildings including forms and shapes of buildings, facades orientation to

enable cooling and heating, space planning, natural day lighting and ventilation, responsible landscape to reduce heat island effect, thermal insulation, thermal storage of walls and roofs, efficient site planning based on bioclimatic conditions. Some passive design strategies adopted in a building are shown in Figure 2.4.

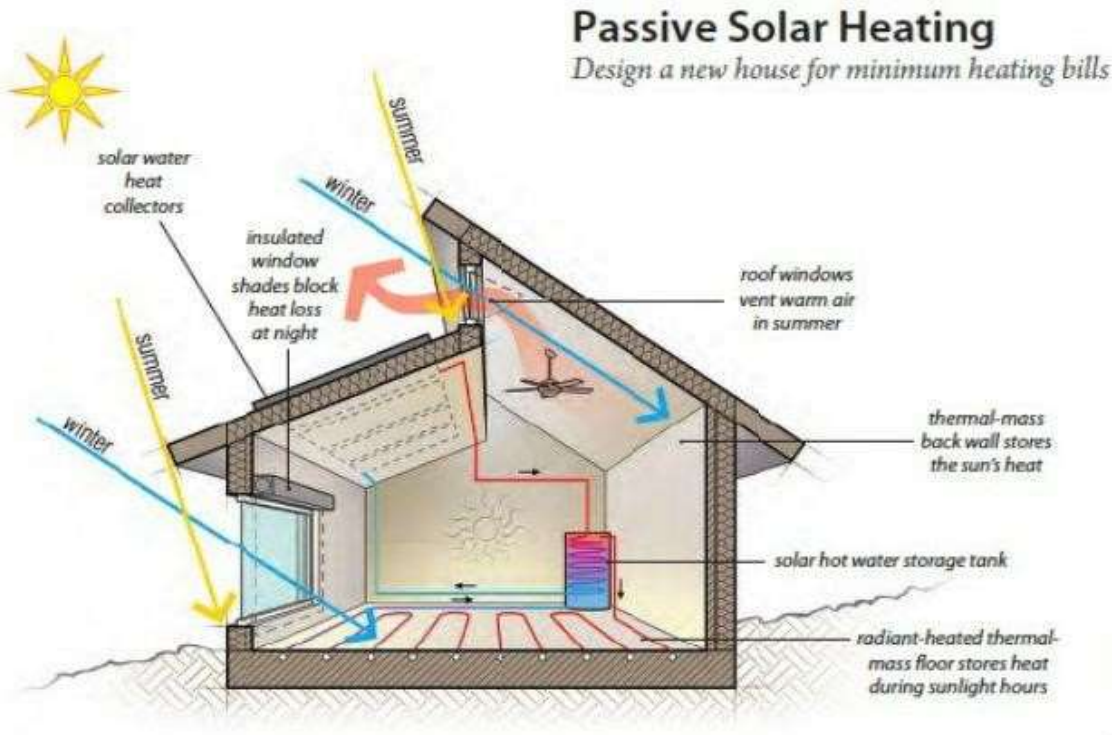

Figure 2.4: Passive design strategies
Source: Ragheb *et al*. (2015)

ii. Alternative energy sources

A source of energy refers to source from which energy can either be directly extracted or recovered through processes of transformation or conversion. Generally, energy generation depends on the availability of resources and techniques of extraction. Also, energy generation is directly related to the needs of users, economic level and environmental impact (Attaman, 2010). Currently, the amount of energy required worldwide is far higher than what is been produced and more than 75% of the energy generated is based on fossil resources which are exhaustible and cannot be renewed.

On this note, it has become imperative and critical to develop new ways of generating

energy. The following energy sources are not dependent on fossil resources and do not deplete the ecosystem, and promises for sustainable development: energy from the sun, energy from wind, energy produced by turbines, fuel energy, energy by geo-thermal (Attaman, 2010).

iii. Building materials with low Embodied energy

This type of energy is said to be the sum of the total energy that is consumed by all the procedures involved in the extraction, processing and delivery of a material. The threat of continuous increase in global warming levels demands a major reduction in carbon emissions from construction processes. According to Sherman *et al*. (2005), the following strategies should be employed to minimize embodied energy without reducing the efficiency of building materials: Re-use of existing structures where possible, design of buildings with long life and ease of maintenance while adapting to emerging trends, use local building materials with low energy and site design with significant reduction in pavement. Concrete, brick and timber are used very widely and they have low energy emissions.

2.5.7 Water Conservation/efficiency

Water is very vital for survival on earth. A building requires water in large quantities to serve different purposes of cooking, drinking, flushing toilets, washing cloths and cleaning. Water is essential for life on earth. The water required for these purposes usually require treatment and delivery and this requires energy. Water resources are prone pollution and this creates a serious environmental issue.

In providing solutions for water related issues in the environment, the first step is to minimize the quantity of water used which will in turn reduce waste water. The following strategies are usually employed to reduce the water foot print of buildings.

i. Re-use/Recycling of water.

Water recycling is a process of water recovery or reclamation from run offs or waste water for potable or non-potable use by supplying it directly or indirectly into water systems. The two basic methods are rain water harvesting and grey water recycling from households. A typical rainwater harvesting strategy adopted in a residential building is illustrated in Figure 2.5.

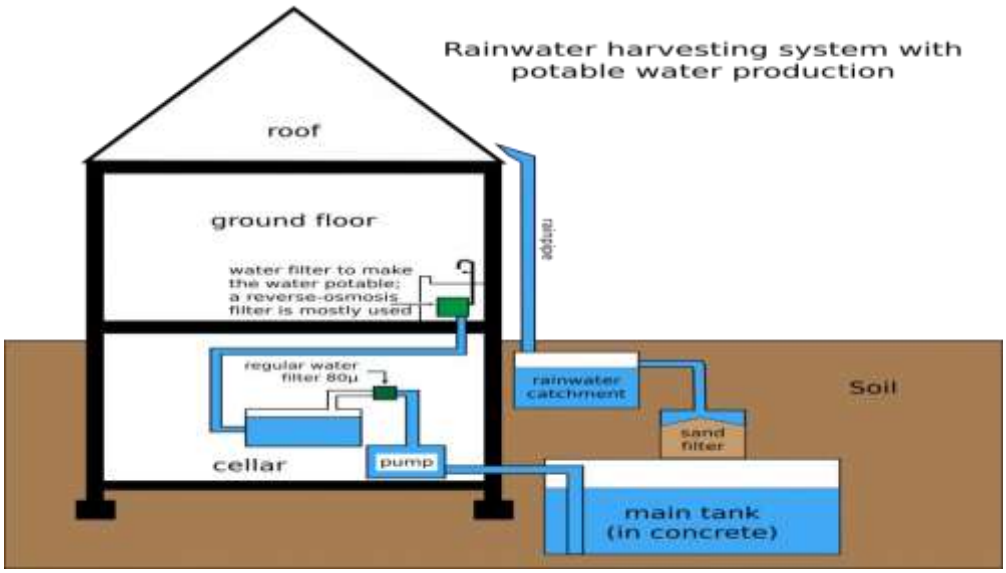

Figure 2.5: Rain Water harvesting strategy
Source: Ragheb *et al*. (2015).

ii. Low-flow fixtures.

Water can be conserved throughout a building's lifecycle via designs for plumbing which helps to recycle water in water closets or by the use of water for carwash. Waste-water can be reduced by making use of fixtures used to conserve water such as low flow shower heads that not high and low toilet flushes (Ragheb *et al*., 2015).

iii. Conserving water by landscaping.

Landscaping generally refers to the modification of the visual features of land with the aim of creating a beautiful landscape. Landscapes create serenity, harmony and pleasure within an outdoor space. Some are water saving and require high maintenance.

Xeriscaping is a method of landscaping which is used create beautiful and water efficient landscapes. They focus on soil improvement, turf areas, use of mulches, efficient irrigation and low water demand plants.

2.5.8 Materials/Resources conservation

During the construction stage of buildings, an influx of buildings materials usually occurs and this generates significant waste. Also, after construction of the building, a low level of supply of materials continues primarily for maintenance, renovation and replacement activities (Kim, 1998). All these materials at different phases are output and usually require recycling or disposal. These materials have a copious impact on buildings ranging from cost, constructability and environmental impacts. In recent times, substantial research has revealed a better understanding of the extraction, processing and management of materials reduce negative impact on human beings and the environment (Sassi, 2006). The strategies for conservation of resources include; Application of building materials that reusable, application of non-toxic material, proper solid and liquid waste management, rehabilitation of existing buildings and avoidance of resource depletion materials. Table 2.3 shows the features of green building material.

Table 2.3: Features of building materials for sustainability.

Green Features		
Process for manufacturing	Operation for construction	Managing of waste
Minimizing of wastes	Efficient use of energy	Biodegrade
Preventing pollution	Treating and conserving water	Ability to reuse
Recyclable	Not toxic	Reusability
Minimizing Energy consumption	Source of energy that can be renewed	Other
Natural resources	Prolonged Living	

Source: Sherman *et al*. (2005)

2.6 Certified Green Buildings in the World

The section of the literature review evaluates some certified buildings in the context of sustainable architecture. Buildings that are designed and constructed with a lifecycle that is resourcefully efficient. Based on defined meaning of sustainable architecture, the cases studies comprise of improved technology with the use water and waste management processes that are efficient, therefore minimizing the adverse effect to the environment. The building is analysed based on advanced green technologies, active and passive designs, self-sufficient and eco friendliness. Notable case studies are:

2.6.1 Editt Tower, Waterloo, Singapore

Building Typology: Commercial. Location: Singapore. Architect: TR Hamzah and Ken Yeang. Completion date: Construction on-going.

The structure was designed to highlight a method of constructing eco-friendly sky scrapers. The client's requirement was an exposition building that houses retail, exhibition and conference activities. The architect didn't only meet this requirement, green approaches were adopted for the building and this led to its green certification award (Attaman, 2010). Strategies such as sustainable site design with total inclusiveness and place making, collection of storm water for reuse, landscaping, waste management, use of solar energy and building materials with recycled content were adopted in this design to minimize negative effect on building on people and the surrounding. The skyscraper which has 26 suspended floors boast of natural ventilation into all spaces, alternative source of energy, and natural lighting. Adaptability for future uses was also considered in the design and of eco-friendly tower enriches the biodiversity of the local surrounding. Some of the green features are further elaborated.

Green materials: The facades of the buildings have incorporated plantings and the

terraces are largely vegetated. The building has an inbuilt system of waste management that is sustainable and materials with low embodied energy.

Green technologies: The rain water collection and re use of grey water in the building makes it self-sufficient and reduces the water footprint by 55.1%. The sewage generated in the building is used as fertilizer and biogas fuel. Solar energy is harnessed with the use of photovoltaic tiles to increase the energy efficiency of the building. The sustainable systems in the Editt Tower Building is shown in Figure 2.11.

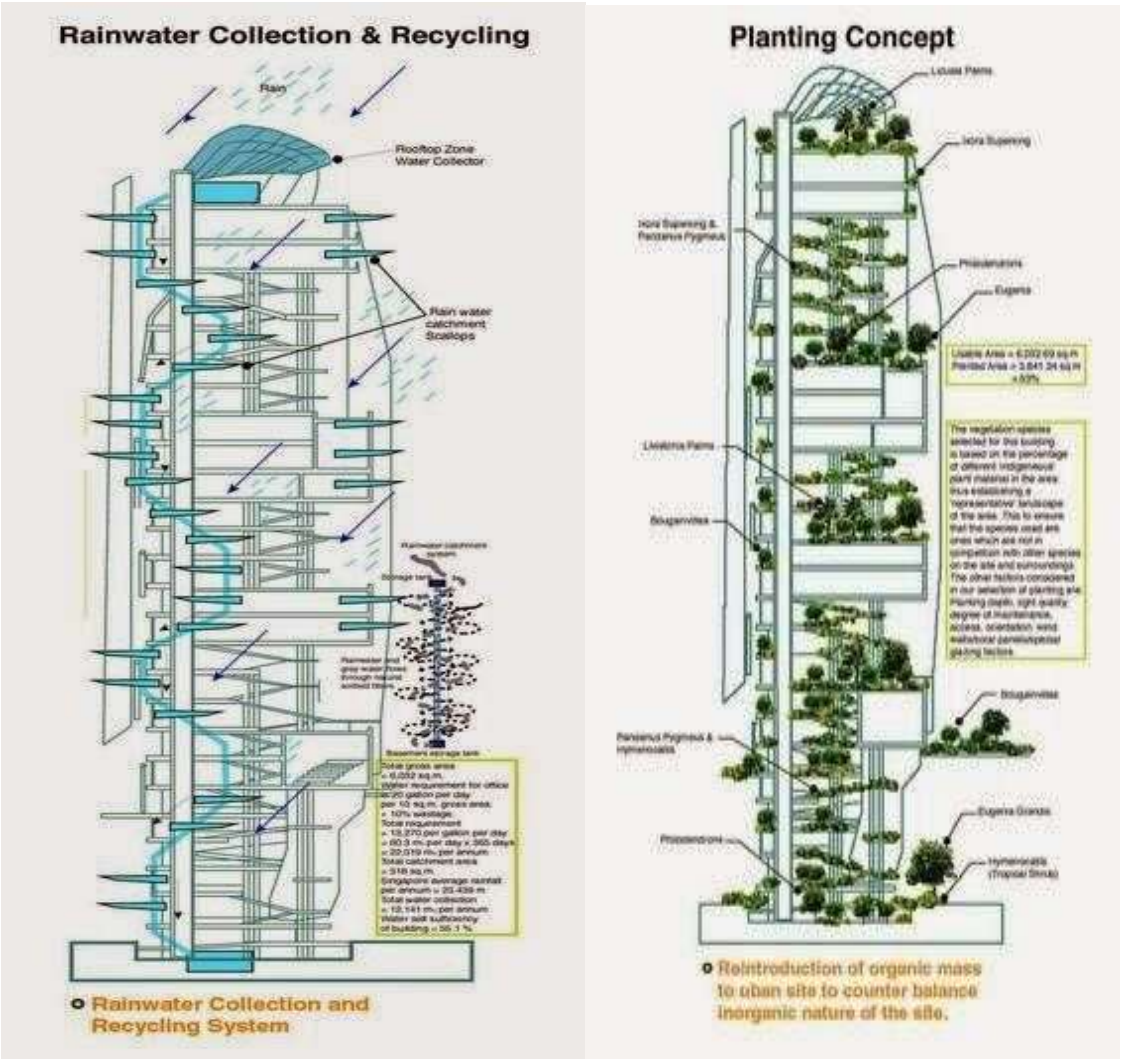

Figure 2.6: Rain water collection and organic mass of Edit tower
Source: Attaman (2010)

2.6.2 Main railway station, Stuttgart, Germany

Building typology: Public, Location: Stuttgart, Germany, Architect: Ingenhoven Architects; Date of completion: 2013.

The main station was visualized after the nineteenth century to transform the railroad terminal of Stuttgart into a contemporary and regional hub. The architect and his team laid emphasis on creating a zero-energy building that integrated seamlessly with the local environment which was made up of municipal buildings, and a recreational park in an urban setting. The underground building has components that are durable, elastic, and tent like concrete structure which has about 30 light shafts projecting into the recreational park (Attaman, 2010).

Green materials: Shell structure made of concrete that is continuous; the concrete shell is extremely strong and it sustains the entire structure of the main station. The lighting system in the main station is enhanced by a ceiling material that is reflective in nature and saves energy by way of reflecting artificial light at night and releasing it in the day time to lengthen the lighting system in the building. Photovoltaic cells are installed on the northern side of the main station to offset the energy needs and reduce CO_2 emissions from artificial energy sources.

Green technologies: The light shaft has a shape which traps natural lighting in abundance throughout the day thus reducing the energy needs of the building. The apertures in the light shafts also allow natural ventilation to pass through it thereby reducing the need for much venting load and significantly improving the quality of air inside the building. The entire space is covered by the shape of concrete which also increases the durability of the building. Three dimensional views of the Main rail way station are shown in Plate IX and Plate X.

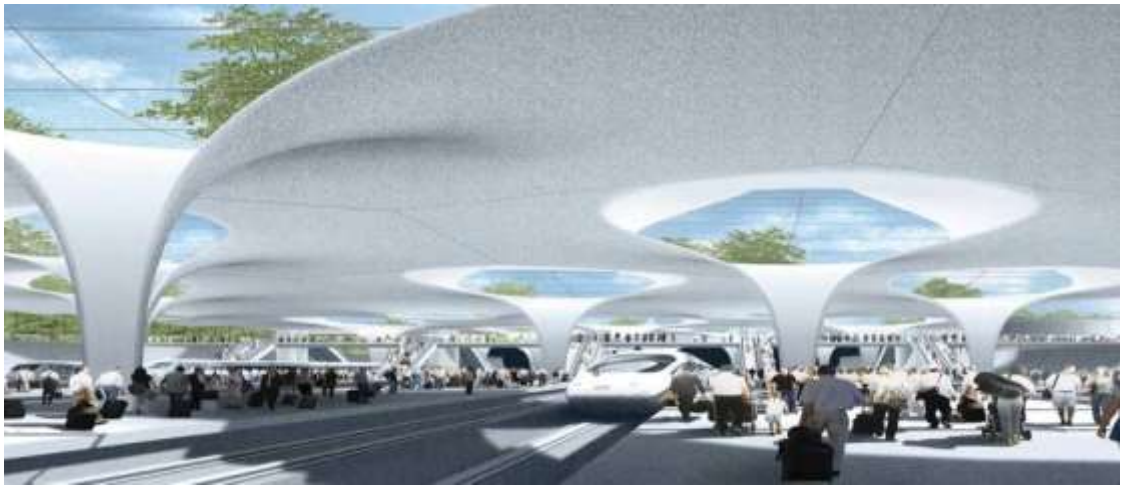

Plate IX: Interior design of the Main station
Source: Attaman (2010)

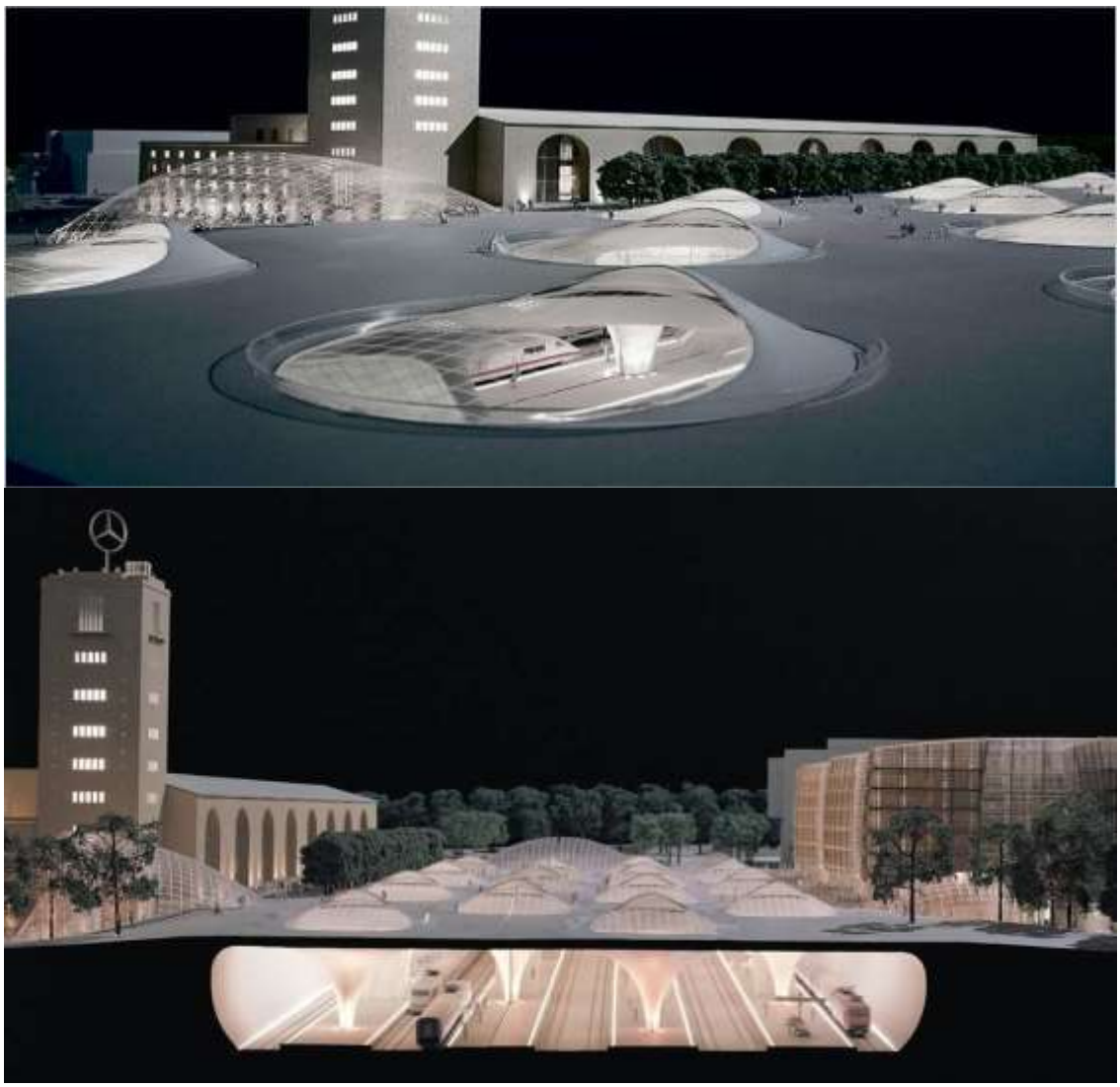

Plate X: Exterior design of the Main station

Source: Attaman (2010)

2.7. Design Considerations for Indoor Air Quality in Nursing homes

2.7.1. Natural lighting

The users of buildings are isolated from their natural environment due to the dependence on man-made lightning. All through ancient times, humans have been depending on the sun for living; assuring that light from the sun is a major element associated with the health of man (Huelat, 2008). The settings of the outdoor is received via openings into a building, connecting the surrounding outside and the indoor. Older adults would naturally react positively to bright environment than a dark and dull one. Generally, on viewing sunlight, the human eye responds totally (Huelat, 2008). Daylighting is categorized into direct component and diffused component. The former involves light that gets to the surface of the earth from the sun directly, while the latter is light from the sky as seen at the atmosphere (Joye *et al*., 2011). Both categories should come into play when relating to natural lightning. However, excessive light from the sun can cause glare and poor vision, if not properly managed by building elements in a building (Joye *et al*., 2011). The amount of lightning entering into a building is dependent on the size of a window or any opening of a building as shown in Plate XI.

Plate XI: The Amount of Day Lighting penetration in the Interior Space
Source: Joseph *et al*. (2007)

There are particular glasses used in window that permits light to penetrate into an interior space; this type of glass has the ability to transmit light very effectively (Joseph *et al*., 2007). The older adults depend on sufficient light much more than the rest of the population; it also has an affiliation with working much more effectively. A lot of error abounds in place of work where light is not adequate (Joseph *et al*., 2007). Natural lighting can be further explaining on a theory known as Attention Restoration Theory. This theory explains that people will be apt and attentive when they spend a reasonable amount of time with natural sceneries. Natural lightning, from studies enhance output in the academy, minimizes absent-mindedness, and improve life generally (De Dear, 2004). This is to say that low exposure to natural light leads to illnesses, stress, irritation, anxiety, depression, among others (Huelat, 2008).

According to Ulrich (2002), daylighting helps to ease work that require viewing, it controls the circadian system in the body that has an effect in the way seniors behave and their mood. Sunlight produces vitamin D that helps in absorbing reaction that take place in the system, thereby stimulating serotonin, which is an antidote for depression; it also helps to suppress melatonin, which induces sleep in the body system. The access of natural lightning is expected to have a direct link with the health of seniors and enhance their physiology (Joarder *et al*., 2013). The outdoor is as well very important because ultra violet light that enables the production of vitamin D is obstructed due to glare; however, illumination on the walls of a space is not the same as illumination close to the windows. Determining the size of windows and using control for lightning will lead to moderating admission of natural light and reduced the use of electrical lightning (Joseph *et al*., 2007). Factors that contribute to determining the size of windows are the amount

of natural light due to daylight distribution and the correlation with requirement when designing. An example is the loss or gain of heat and ventilation. For an ideal, the area for glazing should be 8% and above, while the area for the room should be below 20%, because the windows transmits natural light into the room. The weather forecast and analysis also has an effect on the range stated above and devices and certain technical measures exist in order to control daylight that enters a space; they include shading device, top lightning, light shelve (Joseph *et al*., 2007).

2.7.1.1 Light shelves

They help in enhancing amount and quality of light in a space (Joseph *et al*., 2007). Light shelves are over hangs placed at the outer part or at the inner part of a space or placed at both. Figure 2.2 shows an example of the application light shelve design. Light shelves effectively shade the room from direct impact from the sun which reflects on the top of the space to enable light to penetrate and create a uniform dissemination (Conner *et al*., 1997). They shade the space from direct sunlight which is then reflected onto the ceiling for deeper penetration of the light into the room and hence, provide more uniform distribution (Conner *et al.*, 1997). The condition for light shelves design criteria can be explained as follows:

i. They have active heat gain from the sun and therefore are best for dry climatic conditions.

ii. They should be positioned on the side of the building that receives large quantity of daylight.

iii. It should be reflective enough to keep enormous amount of natural light.

iv. Light shelve are much needed in areas that are glazed more than 2.2metres. Light shelves are applied in the following ways; using the ratio of 1/3:2/3 to open up windows and locating them at a head height greater than 2.2m. Natural light is also maximally

reflected by faint finishes. When positioned at the south elevation, the width is recommended to be 1.25m to 1.5m multiplied by the clerestory height, and when positioned at the east side and west side, it should be 1.5m to 2.0m (Conner *et al*., 1997). Figure 2.7 below explains the effect of positioning.

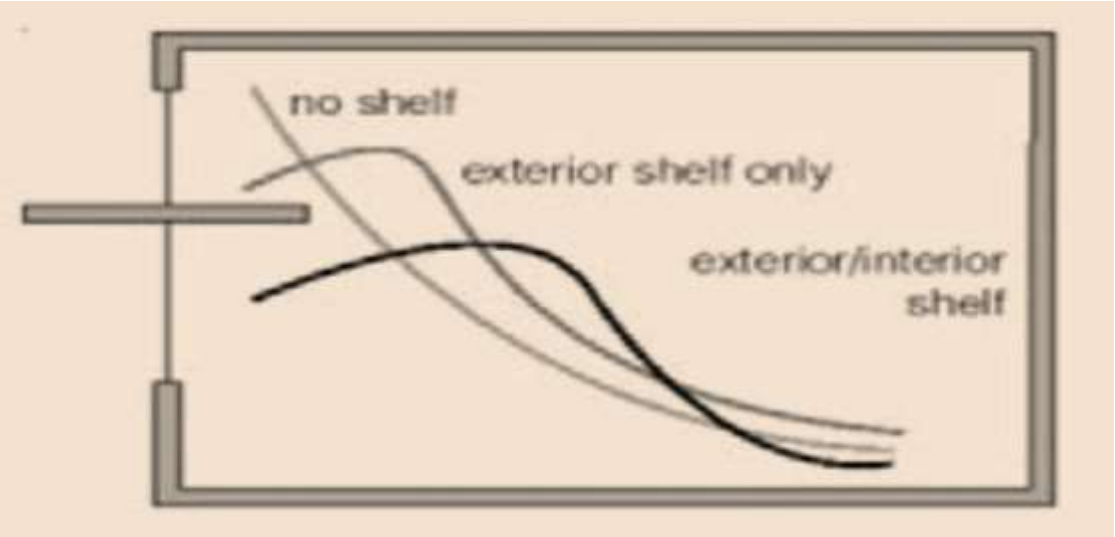

Figure 2.7: Positioning of Light Shelf and its effect on the Illuminance Level
Source: Ulrich (2002)

2.7.1.2. P-lightning

The type of room that top lightning lite is quite different from the room that emits lightning via window. Lighting provided by top light is dispersed in a uniform manner within the room (Ulrich, 2002). Figure 2.3 shows an illustration of top lighting types.

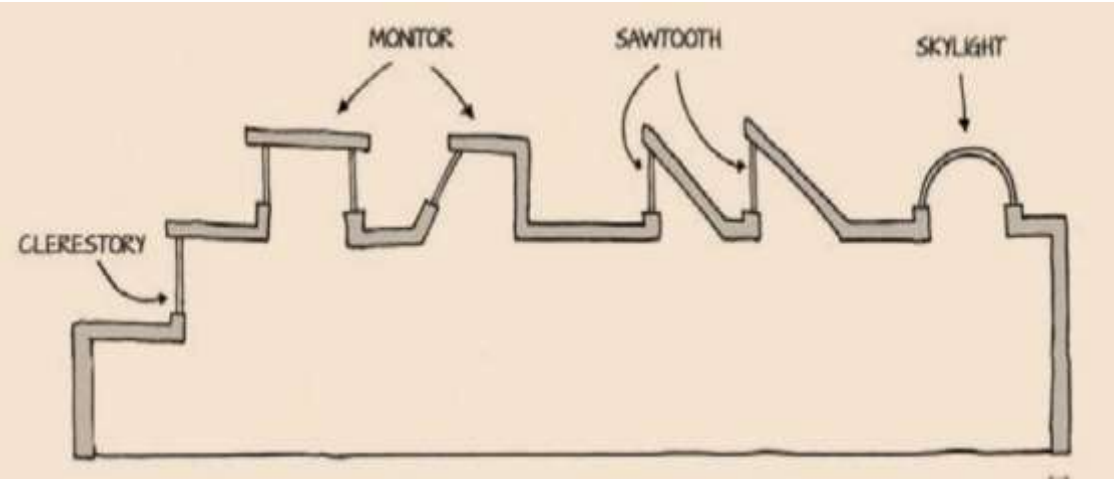

Figure 2.8: Top Lighting types.
Source: Ulrich (2002)

2.7.2. Shading devices

Shading devices can be placed at the external part of a building or at its interior in order to minimize excessive radiation from the sun that enters from openings in the building. It helps to control glare by adjusting the intensity and distributing properly natural light that enters the space enabling thermal comfort. Direct light can be managed in circulation spaces; however, its availability is essential for visuals and relationship with the outdoor surrounding (Conner *et al.*, 1997). Techniques for shading the internal part of a building is not as efficient as the ones for the exterior part, though they can control solar gain and reflect sun, however they permit heat from the sun and also obstruct views to the outdoor surrounding. Examples of interior shading device are blinds and light coloured louvers.

External shading devices are positioned at the external part of the building to obstruct excess heat from the sun. They are regarded to be more effective than internal shadings. This type of shading devices includes:

i. Horizontal overhang.

ii. Horizontal overhangs with screening.

iii. Vertical fins

Fragmented horizontal and vertical overhang are the best form of shading devices. The window height is very large at its vertical and horizontal positions. Therefore, different sections are fragmented with equal depths and equal widths as shown below figure 2.4 (Conner *et al.*, 1997). The equation to determine the size of vertical fins and horizontal overhangs (Givoni, 1998); where x is the azimuth angle is shown below:

$$\text{Tan } 90\text{-}x = W/H$$

For the determination of the horizontal overhang size including screening, the equation

is as shown below (Givoni, 1998).

Tan 90-x = W/H2-H1

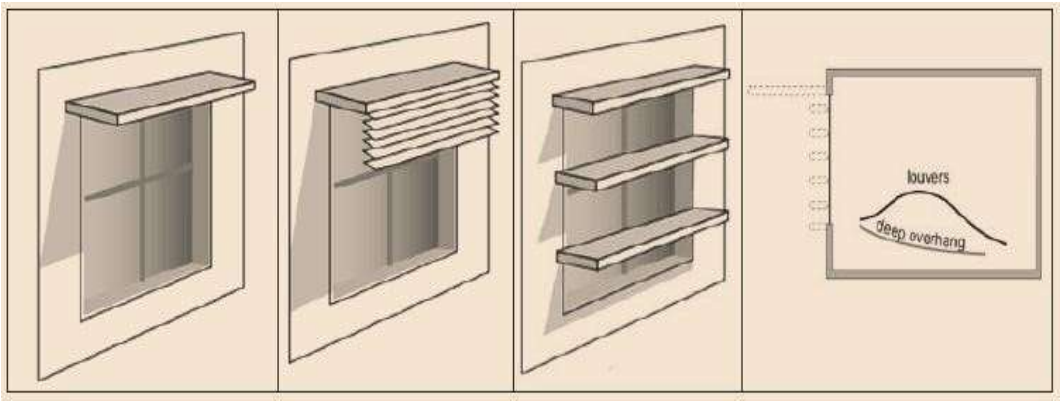

Figure 2.9: Fragmented Horizontal Overhang that is fragmented and Horizontal Overhang with screening and variety of the effect of Overhang and Louver.
Source: Conner *et al*. (1997)

2.7.2.1 Azimuth

The azimuth angle explains the position of the sun above the horizon; it is dependent on time and the longitude (Conner *et al*., 1997).

2.7.2.2 Daylight Factor

For the provision of the appropriate natural lighting in a building design, the criteria are expressed to evaluate in a day light factor which brings out the competence of daylight in percentages for a whole space (Li *et al*., 2014).

Daylight factor criteria is shown in figure 2.10;

$$DF = \left[\frac{A_{glazing} \cdot \theta \cdot R}{A_{total}} \right] x1$$

Figure 2.10: Equation for Daylight Factor
Source: Givoni, 1998

• A glazing = Area of glazing area

• = ϕ Angle of sky

• A total = Total area of internal surface

• R = Surface reflectance of internal surface (0.8)

For day lightning to be optimum, space would vary based on functionality. Generally, the range is within 2% to 5% while the space beneath is less than 2% and are not sufficient. Studies has shown that average day light factor criterion for patients' wards is 3%, spaces that have their value less than 3% are not sufficiently receiving natural lighting except there is presence of light shelve. Figure 2.11 shows the angle:

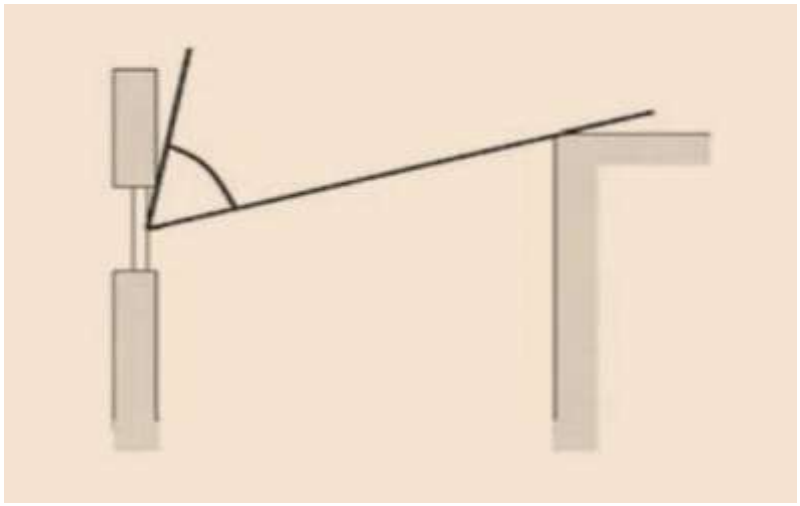

Figure 2.11: Visible Sky angle
Source: Mudiare (2013)

Angle of visible sky is a degree angle vertically positioned, at the end of glazed area through directly viewing the sky (Mudiare, 2013).

2.7.2.3 Shading device requirements in Nigeria

Nigeria is said to be a tropical climatic region. According to Givoni (1998), tropical climatic regions have significant direct radiation unlike other categories of climate. Orientation to the north are set aside on little radiating effect, thereby permitting positioning of windows that are sufficient for natural lighting; For orientation to the south, shading is very much easier because the sun's location is at an angle that is high.

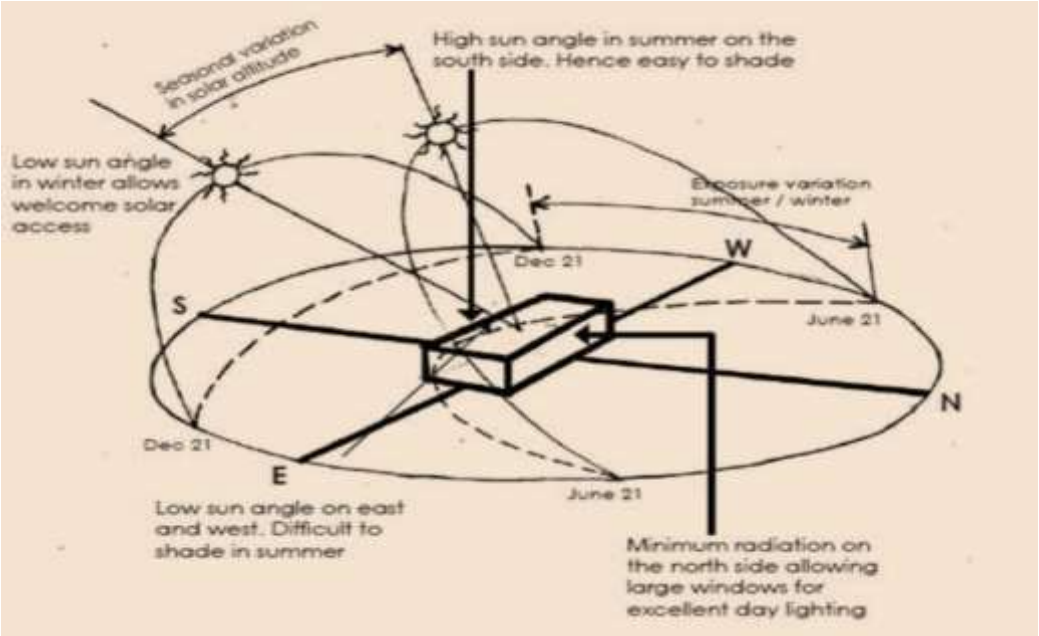

Figure 2.12: Orientations of buildings for Hot Arid Climate
Source: Huelat (2008)

In conclusion, the building elements should be an integral part of the environment that supports healing; sick people need to have a sense of the exterior surrounding. There should be active participation of outdoor activity to have a feel of the natural scenery (Huelat, 2008).

2.7.3 Natural ventilation

Natural ventilation helps to eliminate the use of mechanical equipment for cooling and brings about opening in windows of a room which ensures that the climatic condition of the indoor environment is comfortable. It has a couple of benefit as well as criteria for optimum effectivity. The subject has been back dated in existence and in use for providing comfort for the internal part of the building (Hyde, 2000). The use of the appropriate window type enables good views and good day lighting; it also natural ventilation enables sufficient cooling when the internal temperatures are higher than the external temperature leading to thermal comfortability. There will be the need for mechanical cooling when natural ventilation is insufficient for providing adequate

indoor thermal comfort.

This system is referred to as mixed mode ventilation, because it combines both methods (Kellert *et al*., 2011). The contribution of natural ventilation into a building is great, it decreases pollutants both indoor, provided pollutants that are outdoor are not more than indoor pollution, brings about thermal comfort in an interior space, and reduces consumption of energy from the use of air conditions.

Natural ventilation is achieved through

i. Driven wind: The wind generates pressure at the external part of the building resulting in driven wind ventilation (Kellert *et al*., 2011).

ii. Buoyancy driven (Thermal buoyancy): Thermal buoyancy relates to the disparity between cool air and warm air in the internal and external part of the environment (Kellert *et al*., 2011). However, in a design, there can be the combination of buoyancy and wind driven as well as natures force (Joseph *et al.*, 2007).

2.7.3.1 Natural ventilation strategies

The strategies for natural ventilation include Single sided ventilation, Cross ventilation, Stack Ventilation.

I. Single-Sided-Ventilation: Single-sided ventilation is by varying wind. Exchange of air in a space occur such that air is allowed into a space from an opening and also exit from an opening at the same side (Ghiaus *et al*., 2005). Figure 7.8 gives an illustration of single sided window opening. Air flows into a building moves at different speed near openings like windows (Ubbing *et al*., 2011). It is mostly used and enables indoor comfort when used to ventilate different spaces, but to a depth limit which is two times the height of the room (Ghiaus *et al*., 2005). Figure 2.13 shows single-sided ventilation air flow.

Figure 2.13: Single Sided ventilation air flow
Source: Ghiaus *et al*. (2005)

a) Driving Forces Affecting Single-Sided Ventilation;

i. Wind driven

ii. Buoyancy driven

There is an effect produced at the opening of the window due to wind fluctuating. For difference in temperature between the interior and exterior environment, buoyancy enables heated air to flow out of the top part of the building and for cooler air to enter close to the window sill (Ghiaus *et al*., 2005). Figure 2.14 below explains these.

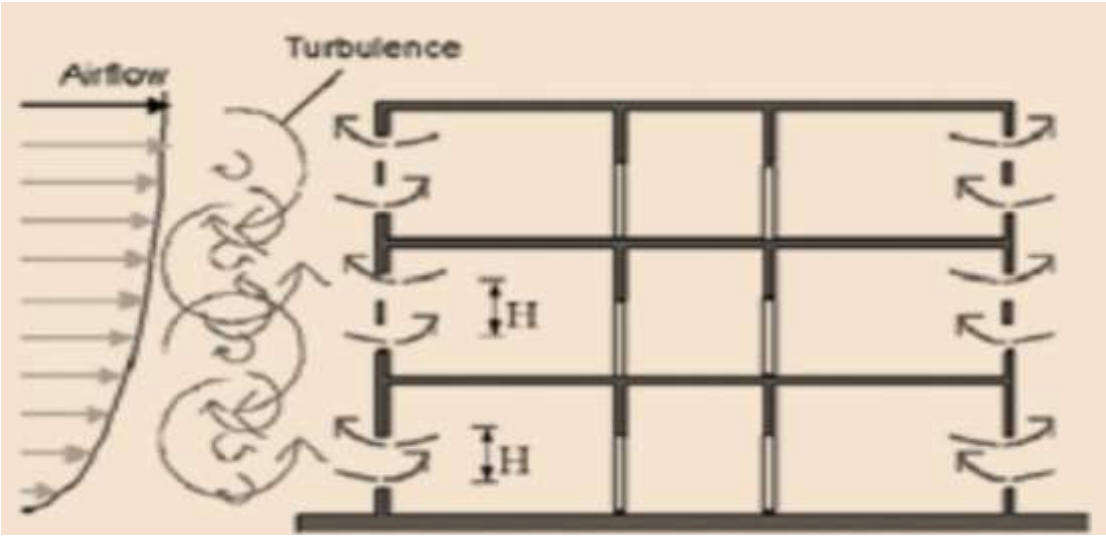

Figure 2.14: Wind Driven – Single Sided Ventilation
Source: Ghiaus *et al*. (2005)

b) Strategies of Single-Sided ventilation;

i. Maximum depth of the room = 2.5metres much more than the height.

ii. Height of window = 1.5metres

iii. Area of Window = 1/20 of the area of the floor

c) Wing Walls Pressure: Adding wing walls creates wing wall pressure in order to advance circulation of wind foe single sided ventilation method (Ubbing *et al*., 2011).

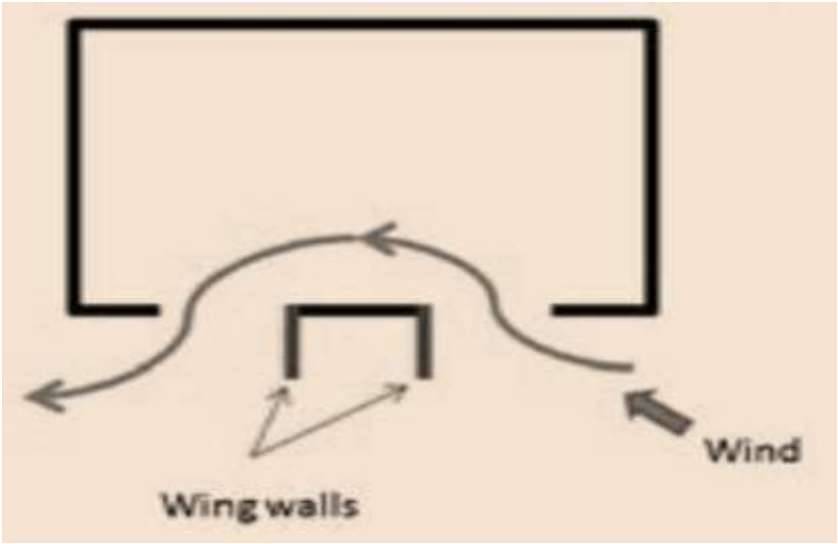

Figure 2.15: Wing Walls with Wind Penetration
Source: Ubbing *et al*. (2011)

II. Cross Ventilation

Cross ventilation refers to flow of air into different openings; air enters from an opening and exits through a second opening. Openings can be a door or a window, and are positioned indifferent ways (Ubbing *et al*., 2011). This type of ventilation is as a result of pressure difference. Wind flow at the wind ward area brings about positive pressure, and the leeward area brings about negative pressure; therefore, difference in pressure is made because there is movement of air from a high pressure to a low pressure (Ghiaus *et al*., 2005). The limitation of this type of ventilation is that there is likelihood of spreading of pollutant in the area receiving ventilation because there is transfer of air from one place to place. Cross-Ventilation depends on:

i. Building form

ii. Urban environment

Figure 2.16, Figure 2.17 and Figure 2.18 explains the concept of cross ventilation.

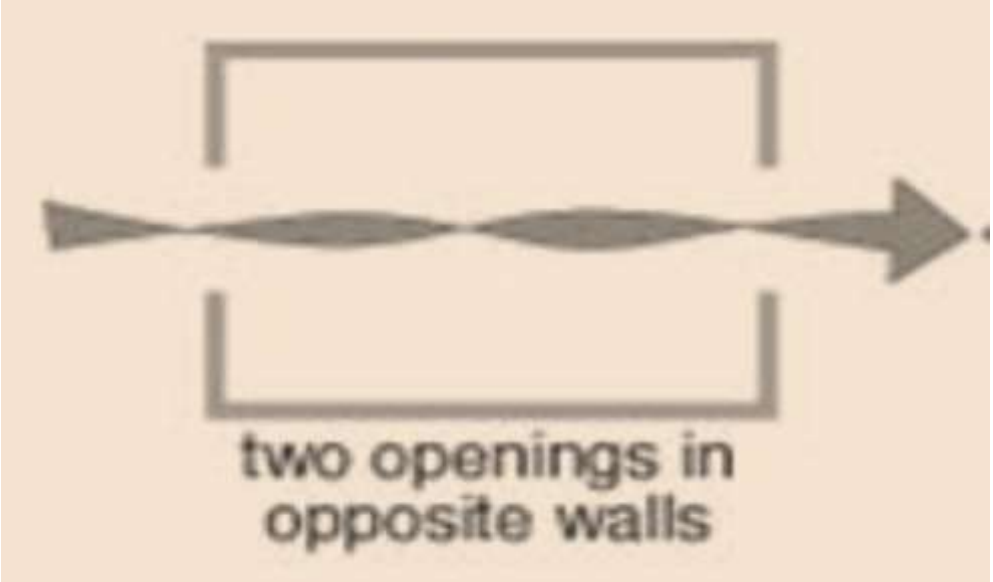

Figure 2.16: Cross Ventilation Air flow
Source: Ghiaus *et al*., 2005

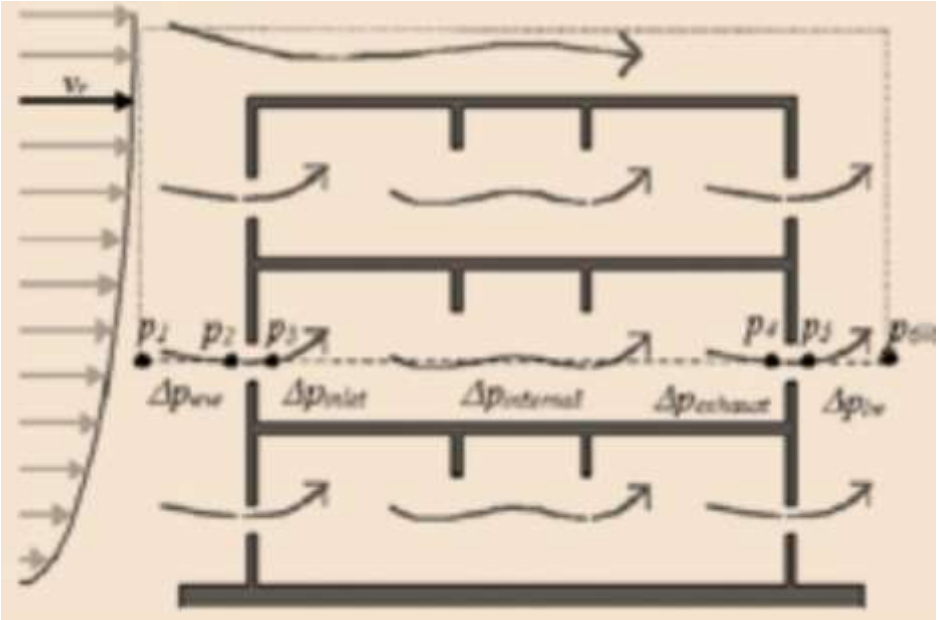

Figure 2.17: Wind Driven- Cross Ventilation
Source: Ghaius *et al*., 2005

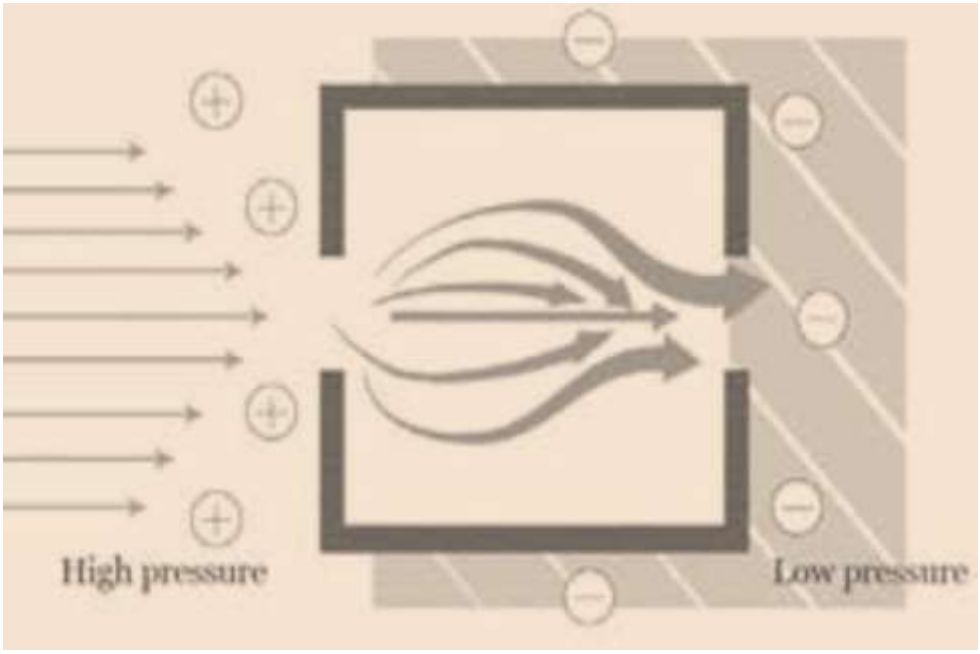

Figure 2.18: Flow of Cross Ventilation
Source: Ghiaus *et al*., 2005

III. Stack-Ventilation

Stack ventilation is a chimney like method creating convection current without the requirement of fan; air circulates the building's interior (Ghiaus *et al.*, 2005). Cooler air comes into a room via bottom opening and warmer air goes out of the room via opening at the upper part of a building. Any opening can be used for this type of ventilation. The rate of airflow is increased when the distance between the upper and lower opening is large enough. The upper openings are positioned at the façade with low pressure so that the stack and the wind pressure can function in the path (Ghiaus *et al*., 2005). The appropriate stack ventilation design is dependent on the Neutral Pressure Level; this level is helps to balance the rate of air flow entering and leaving the building, and is close to the larger opening. It is dependent on the size and the positioning of the opening, as well as the indoor and outdoor temperatures. The neutral pressure level will be high if the upper openings are high, this fresher air will reach the building's upper area (Ghiaus *et al*., 2005). Stack ventilation and cross ventilation are faced with a

limitation of privacy which is necessity for healthcare; however, single sided ventilation is more effective (Ubbing *et. al*., 2011). These concepts are being expressed in Figure 2.19 and 2.20 below also dependent on building form and internal layout.

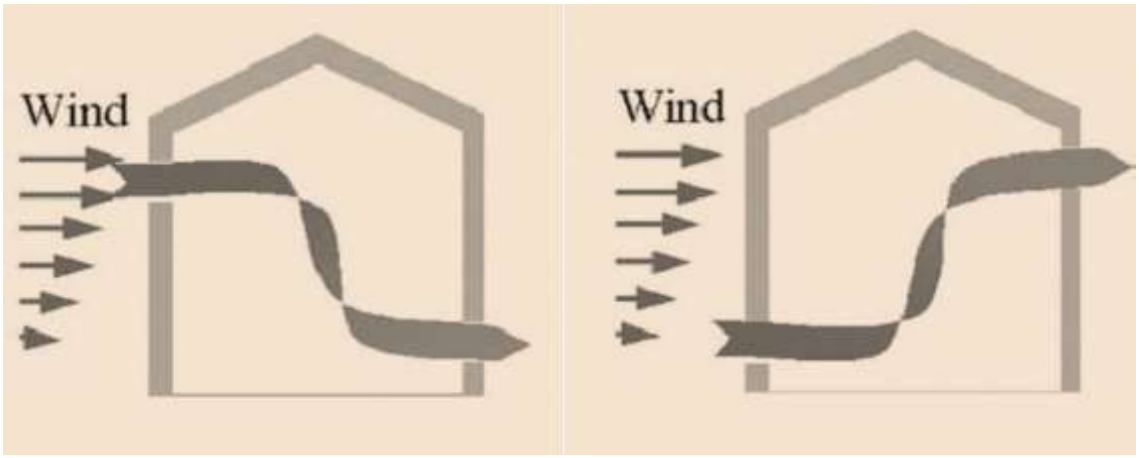

Figure 2.19: Opposite effect of stack and wind
Source: Ghiaus *et al*. (2005)

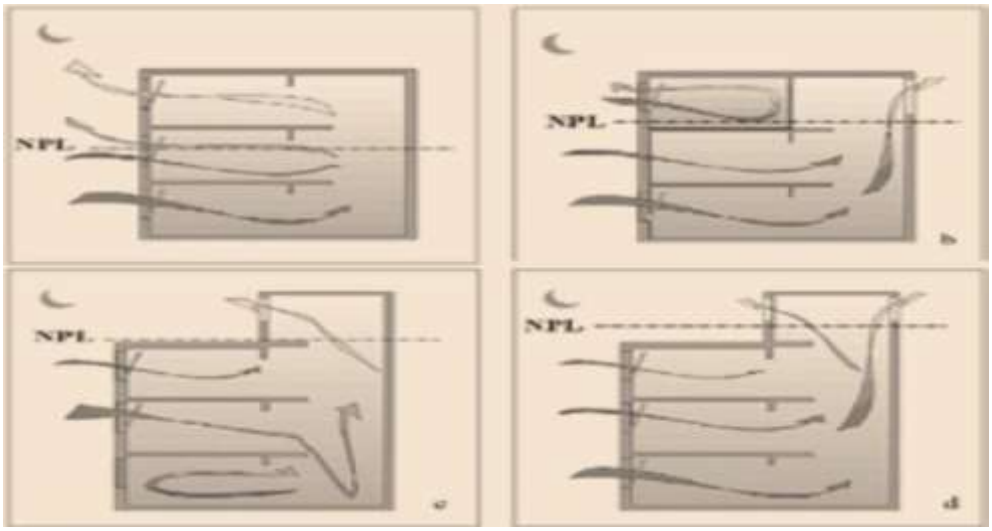

Figure 2.20: Stack Effect- Different ways to cool upper level.
Source: Ghiaus *et al*. (2005)

2.7.3.2 Quantification of Natural ventilation

a. Rate of air flow

The rate of airflow is the opening area multiplied by the speed of air; measurement is in cubic metre per seconds. According to Givoni (1998), the equation below is used to

calculate the rate of air flow:

Q = 0.02 * Vspeed * an opening (2.5)

V= Wind speed (m/s)

Q= Air flow rate (m^3/s)

A= Area of openings (m^2)

b. Factors affecting airflow via opening.

i. Speed of wind.

ii. Direction of wind

iii. Fluctuation of wind

iv. Size of openings, location and shape of openings

v. Context and geometry of building

c. Rate of ventilation

The measurement of the rate of ventilation is in measured in litres per second per person or Ach (Air change rate per hour). Air change rate is the quantity of air volume per hour produced by the speed of wind and by constant move of air due to window openings (Ubbing *et al.*, 2011). The calculation of the rate of air change is by using the following equation (Givoni, 1998);

$$ACh = \frac{Q * 3600}{V}$$

d. The parameter affecting the air change rate:

i. Velocity of wind

ii. Direction of wind

iii. Wind fluctuation

iv. Opening Shape

v. Opening Position

vi. Opening size

vii. Building shape

As opined by the Building and Construction Authority, the speed of wind for health centres should not be 0.6m/s; while the lowest speed of wind as recommended by British standard hospitals is 6 air change per hour (Li *et al.*, 2014).

2.7.4. Biodiversity and Landscape

2.7.4.1 Biodiversity

Humans are taken on a high esteem because there is a vast knowledge of other creatures which in turn exalts the design of life (Wilson, 1994). Biodiversity can be referred to different species of whether plants and animals, as illustrated in Plate III. The processes of nature are understood through biodiversity. Curation is enhanced by nature's element through biodiversity; basically forming the basis of health of humans. Variations of biodiversity creates a healthy ecosystem by helping to balance gases in the atmosphere for absorbing greenhouse gas. It offers a lot of benefits to human needs such as production of food, air and water quality maintenance, security and treatment of illness. Unfortunately, they are devalued and downgraded within communities (Wilson, 1994).

However, it is important medicinal drug production which come from plants in a bio diverse ecosystem. Besides, it plays a role in the control and regulation of contagious disease and has social, cultural and spiritual importance within communities. However, diversity of species evolves before human existence, then humans evolve with them, their limits may not be fathomed; therefore, the world in habitation is a domain for the paradoxical aspects of human's spirit (Wilson, 1994). A typical example of biodiversity

is seen in Plate XII.

Plate XII: Biodiversity in an Interior Space of a Hospital
Source: Molthrop (2011)

2.7.4.2 Landscape

Landscape is referred to as a land area with natures element having the capability to minimize stress and enhance the comfort of humans (Molthrop, 2011). It brings together different elements and scenery, allowing users to interact with nature. A garden is an area of land with different colours of element, which usually serves as a resource for designing healing environments (Huelat, 2008). Plate IV gives a picture of a natural environment. Early around the middle age, variety of garden were developed in order to transmit an image of calm to sick people (Ulrich, 2002). According to Huelat (2008), it is of advantage to health in the following ways:

i. Eliminate depression and stress

ii. Adds value to an environment

iii. Minimizes pain.

iv. Enhances content in patients

iv. Enhances productiveness for health workers

Pollutants like gases in the atmosphere are eliminated, and the surrounding is filtered and purified because of the existence of plants and trees in landscape configurations. They also release oxygen, have psychological benefits on humans and serves as a prevent a dry environment. (Mazuch *et al*., 2005). Natural landscape elements are shown in Plate XIII, Plate XIV and Plate XV.

Plate XIII: Landscape Elements Allowing Exposure to Nature
Source: Huelat (2008)

Plate XIV: Landscape allowing for Mingling with Nature.
Source: Huelat (2008)

Plate XV: Landscape Element in the Outdoor and Indoor Spaces
Source: Huelat (2008)

2.8 User Perception and Satisfaction in Hospitals

Studies has shown a fundamental connection between the environment where a person resides or where a person is treated to the health situation (Gesler *et al*., 2004). Therefore, in recent times, there has been focus on the design of health centres (Reiling, 2007). Consequently, Sime (1986) opined that there should be a keen interest on providing an optimal fit between the wellbeing of people and their immediate environment, which is referred to as Placemaking. It involves drifting away from basic geometry in designing to wholly considering the user's behavior as relates to the surrounding. This is also synonymous with the design of sense sensitive. There arose the need to take into cognizance the user's preference and satisfaction of their physical environment when designing, this is due past evaluations and studies carried out, this will overall enhance the indoor comfort (De Dear, 2004).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

This chapter explains the Research method adopted in the cause of the study, the research design, Sampling technique as well as the methods and instruments of data collection with the use of variables derived from literature sources from the previous chapter.

3.1 Research Method

This research adopted the quantitative and qualitative method of data collection as it is focused on gathering mainly verbal, images or objects, and it focuses on a small sample size which is purposely selected. Qualitative method entails character description, makes use interview, observation and review of document as a data source (Sime, 1996). The research method used for research work was the descriptive research method. The researcher carried out physical observations to determine and identify the design consideration of green architecture present in selected specialized hospitals. The study was conducted in Abuja, Minna and Lagos respectively.

3.2 Research Design.

Case study approach is adopted whereby cases are examined, analyzed, categorized and tabulated. Wilson (1994) highlighted past studies which mentioned the fact that case study research permits understanding and seeks to explore complex situations and that it can be well thought out to be a straight forward method of research categorically when it requires an all-inclusive and in-depth investigation. As stated by O'Shaughnessy (2011), case study application types that are relevant to architectural research include; illustrative, exploratory, explanatory, evaluative and critical instance. For this research the evaluative and explorative case study is appropriate because it involves an in-depth

description, understanding and analysis of a particular instance or aspect of a program, project, or other development activity and cases being studied.

Case studies: Case studies are basically empirical inquiries that aim to investigate phenomena as relates to reality (Mitchell, 2007). It involves careful analysis and systematic gathering of information about a particular person, event, group or social setting. In a more a more scientific point of view it involves studying an existing phenomenon in order to get a better understanding. Three case studies were carried out based on purposive sampling of Nursing homes and identification of facilities in which green architecture principles were applied. Out of the case studies, three were local case studies and three were international case studies.

3.3 Sample and Sampling Techniques

For this research, the purposive sampling method is adopted and this involves the purposive selection of specialized health facilities locally and internationally. According to Given (2008), purposive sampling among others, is suitable sampling techniques when it comes to evaluation research, as it identifies “who the major respondents are, and are involved in planning and administering the service that is assessed”.

3.4 Data Collection

The major sources of data are categorized into two:

3.4.1. Primary source

The primary source refers to personal observation and study of existing senior's facilities by the author. This also refers to the author's visit to the selected sites for their peculiar characteristics and features as relative to sustainability such as Old people’s home, Minna, Rock garden home, Lagos as well as Old peoples’ home, Abuja; the information was analyzed descriptively and used to produce the primary data presented

in tables and charts.

3.4.2. Secondary source

The Secondary data were gotten from sources, such as articles and websites. Secondary source implies the collection of information from the following:

i. Published Literature: Research into existing literature that has been written on the subject under study was carried out making up the majority of chapter two of this dissertation. This was done to identify the most relevant issues to be discussed and added to, if need be. This primarily serves as background information from which useful suggestion and/or solutions could be applied to address some of the questions raised in this dissertation. This was also done to highlight specific issues and back up the theoretical framework as well as the working hypothesis of this dissertation. Library research was done by consulting books, online documents, journals and articles in periodicals. Distinct works and discovery form previous researchers in the field were used in the course of the research.

ii. Maps: Geographic maps, base maps and Google Earth imagery maps were used to collate information, current and historic, regarding the site, its location, size and other existing relevant physical features required.

iii. Images and illustrative references: These were useful in providing graphical illustrations and tangible descriptions.

iv. Archival collections (reviews): Review of previous and existing cases of relevant works was carried out. This was done mainly by carrying out an intensive study and analysis of the architectural drawings of existing cases, especially the foreign cases, with relevant points highlighted to establish the background information on requirements of the concluding design product.

v. Media: The media was useful in carrying out this research work. The internet was helpful in sourcing of data. Information about the design analysis were gathered mostly from the internet and reviewed to establish features and approaches used in the design aspect of the research. Information about the foreign cases were also gotten from the internet and analyzed for the design synthesis.

3.5 Instrument of Data Collection

The following data collection instruments and techniques were applied:

3.5.1 Observations schedules

A list of variables used to observe indoor air quality design considerations in Senior's facilities was itemed based on deductions from literature sources.

3.5.2 Interviews: Care givers like the nurses and other stake holders had their opinions sampled through personal conversations. Vital information was collected from interacting with the health workers which were used for the research work.

3.6 Selected Design Considerations and Variables used for the Study.

3.6.1 Design considerations;

i Natural ventilation and Lighting.

ii Shading devices

iii. Biodiversity and landscape.

3.6.2 Observed variables

i. Types of natural lighting medium available.

ii. Different ventilation types available.

iii. Types of windows available.

iv. Height of windows available.

v. Sizes of windows available.

vi. Types of shading device available.

vii. Orientation of the building.

viii. Shape of buildings.

ix. Types of trees available.

x. Types of shrubs available.

xi. Function of outdoor landscape available.

xii. Location of indoor landscape available.

3.7. Data analysis method and Presentation

The data collected was sorted for analysis purpose and results were presented in tables and charts. The research questions that were selected as well as the objectives was upon which the recommendations of the research would be based.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

This chapter presents and discussed findings from the survey stating inferences based on the results, objectives and as present in the case study of buildings that were evaluated.

4.1 Data Analysis

Data was collected manually in the course of the field exercise from participants as relates to the study. The data was analyzed of which the objectives of the research enumerated in chapter one of this thesis were discussed accordingly. In addition, the descriptive results were interpreted using the Microsoft Excel Spreadsheet Program by generating charts, plates and descriptions. This section also discusses the proposed design and the considerations incorporated. Analysis of data was done based on the following objectives;

i. To identify the principles of green/sustainable architecture.

ii. To examine the design requirement for indoor air quality as one of the principles of sustainable architecture.

iii. To assess indoor air quality design consideration in the design of existing senior's housing facilities and its effects on the residence.

iv. To propose a design of a senior housing facility using principles of Indoor Air Quality that enhances indoor thermal performance in order to provide a safe and self-healing environment for older adults.

4.2. The Design requirements of Sustainable Architecture

The first of objective of this research work is to identify the principles of green/sustainable architecture. A senior's residential facility is very important for a self-healing environment; therefore, it is of great need to identify how relevant sustainable architecture is to the older adult's environment. According to White (2006), there are seven (7) basic principles of Green/Sustainable Architecture. Which includes;

i. Site and its surroundings.
ii. Energy Efficiency.
iii. Material Efficiency
iv. Indoor air quality
v. Waste reduction
vi. Low maintenance cost

4.3. Assessing the design consideration for indoor air quality sustainable design principle in the design of existing facilities and its effects on the patients.

The different ways in which indoor organic architecture can be experienced in the healthcare settings are as follows:

1. Naturals lighting in interiors spaces.
2. Natural ventilation in interior spaces.
3. Adequate shading devices.
4. Therapeutic environment.

Three (3) Nursing homes in three (3) zones across Nigeria were examined.

Variables for Indoor Air Quality in Old people's home, Minna: The surrounding is imperative for the enhancement of the curative process, for this reason, there should be the identification of how indoor air quality design consideration is to the environment of old people. The different ways in which these considerations can be experienced in the

facility are as follows: natural lighting interiors spaces, natural ventilation in interior spaces, shading devices and a therapeutic environment.

4.3.1 Natural lighting in interiors spaces

The users of buildings are isolated from their natural environment due to the dependence on man-made lightning. All through ancient times, humans have been depending on the sun for living; assuring that light from the sun is a major element associated with the health of man (Huelat, 2008). The settings of the outdoor is received via openings into a building, connecting the surrounding outside and the indoor (Joseph *et al*., 2007). Older adults would naturally react positively to bright environment than a dark and dull one.

Daylighting is categorized into direct component and diffused component. The former involves light that gets to the surface of the earth from the sun directly, while the latter is light from the sky in the atmosphere. Excess light from the sun can cause glare and poor vision, if not properly managed by building elements in a building (Joseph *et al*., 2007).

In the Older Adult's facility visited, various types of natural lighting media were available. As seen in plate X, windows and courtyard were the most common media. The figure gives an illustration of the most common media used for admitting light to interior spaces in healthcare facility.

4.3.2. Natural ventilation in interiors spaces of senior's facilities

The need for constant air exchange within the interior spaces of the facility due to different activities ongoing. Therefore, the relevance of natural ventilation in the senior's apartment spaces is seen in, decrease in concentration of indoor, provision of

indoor thermal comfort through temperature cooling/heating and pleasure smells, and a decrease energy consumption of air condition devices in the buildings. The media through which air is admitted into the building include: windows- Cross ventilation air flow and courtyard. Plate XV below highlights the various media of natural ventilation in a chart form.

Plate XVI: Courtyard serving as medium for lighting and ventilation in Old People's Home, Minna

Plate XVII: Window serving as medium for lighting and ventilation in Old People's Home, Minna

Plate XVIII: Window serving as medium for lighting and ventilation in Old People's Home, Abuja

From the data obtained the windows and courtyard are readily available for ventilation in the facility. The windows are cross ventilated with sizes, 1800mm x 1500mm in the bedrooms and 1800mm x 2400mm in the Lounge. Air vents and clerestory windows are

not very common in Nigeria as seen from the area study. Although they are very effective for stack ventilation as hot air rises to the top, hence they provide a medium through which foul air is channeled out of the building, and must be integrated for effective natural ventilation of indoor spaces.

Plate XIX: Window serving as medium for lighting and ventilation in Rock gardens Home.

4.3.3. Shading devices

Exterior shading device is regarded to be a more effective shading devices used on the interior in obstructing unwanted solar heat. The type of shading devices used are vertical fins as seen in Plate XX below.

Plate XX: Vertical fins serving as shading device

4.3.4 Biodiversity and Landscape.

Biodiversity is referred to as a land area with natures element having the capability to minimize stress and enhance the comfort of humans (Molthrop, 2011). It brings together different elements and scenery, allowing users to interact with nature. It is very necessary for a check spelling heterogeneous environment which helps in balancing atmospheric gases and water quality, provision of variety of food (fruits), provision of spices and herbs to aid the healing process.

i. Outdoor Landscaping: Landscape forms a basis on which biodiversity can be achieved. It features such as land and water provide a plate-form for plants and animals to exit. Landscape configurations exist as healing gardens, viewing gardens, edible gardens, roof garden, vertical gardens and indoor plant as seen in reviewed literatures. Observation shows that biodiversity and landscape configuration were not put into proper consideration in the planning of the facility as seen in Plate XXI and XXII, only trees as the biodiversity component of the environment was found.

Therefore, it is very relevant for the integration of landscape configurations to health

facilities due to its benefits such as curtailing stress and depression to residence, decreasing pain, boosting up patient contentment and improving staff work output including purification and filtration, releasing moistures and preventing dryness as seen in literature reviewed. Plate XXI shows sparsely dense landscape element in the facility.

Plate XXI: Trees provided as the only landscape element on the outdoor of the building in Old People's Home, Minna

Plate XXII: Trees provided as the only landscape element on the outdoor of the building

ii. Indoor landscaping: Indoor landscape plays a very important role in communicating the relevance of indoor air quality, they are achieved when natural elements such as plants, water, reliefs, and geological formations are incorporated in the indoor spaces of a residential premises. Indoor landscape stimulates good emotions and instigates a pleasant psychological state of mind hence curtailing stress. Stress reduction and progress in clinical outcomes emphasizes its relevance in the residence for the elderly. In the old people's home visited, there are only trees at some points outside the property with no defined parking spaces hence the therapeutic effect is not achieved by the residence and care givers.

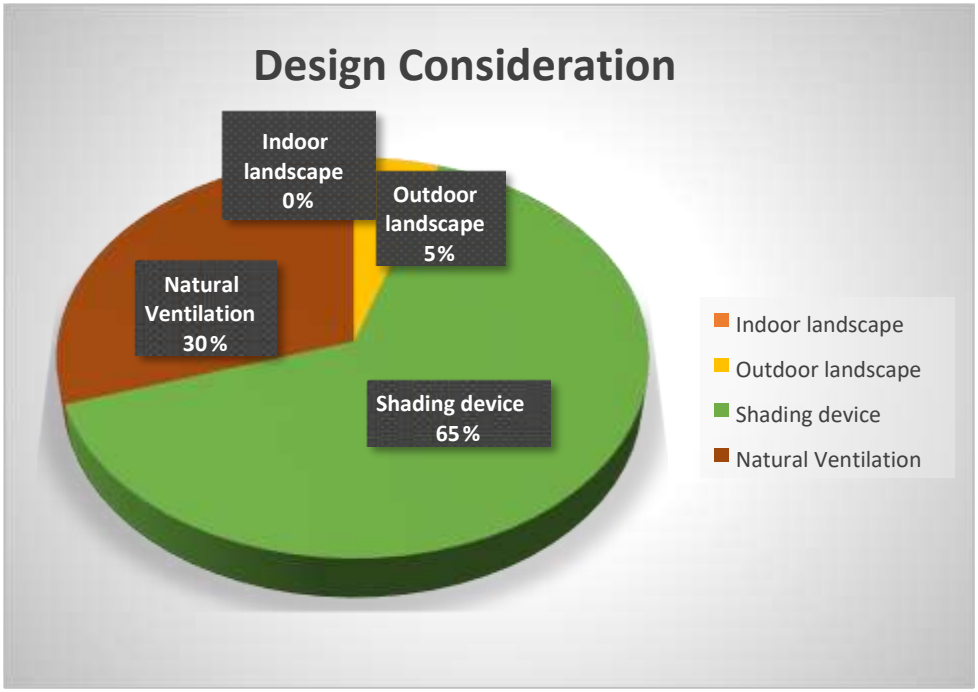

Figure 4.1: Design Consideration for Indoor Air Quality
Source: Fieldwork (2019)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1. CONCLUSION

The study demonstrates association between certain building characteristics (i.e. the building orientation, wall and floor materials, housing type and number of rooms) as potential risk factors for certain diseases. Indoor thermal comfort has been viewed as being highly dependent on the occupants and the way they see the environment. The issues of comfort and thermal delight is as important to building design, therefore, indoor thermal comfort must be understood as a far more holistic experience dependent upon the interaction of many considerations, including the variability and options that the environment offers and the ability of the occupant to have an effect of these options.

The research opines that the state and condition of the Old people's home as regards indoor air quality is generally not satisfactory. This is due to a significantly low level of attention paid toward organic indoor air quality design consideration, as regards natural ventilation, lighting therapeutic views, biodiversity and landscape element. The findings should be presented in a format that would be useful for architects to design climate sensitive residential buildings that will provide comfort for the senior populace. Specific categories of landscape elements should be designed to create an appealing environment.

5.2. RECOMMENDATIONS

Researchers have focused on sustainability as it relates to other health care facilities with minimal contextualization of seniors housing facilities which is central to this study. Based on the forgoing, therefore, it is recommended that further studies be carried out on some of the existing facilities for the older adults to provide a safe and self-healing environment.

The government in Nigeria should developed grants for people to build nursing homes that provided better health care services equipped for longer days than what seniors would receive in the hospital. It is also important that government through the management of facilities for geriatric care and provide space with adequate integration of natural elements in and around the senior's residential environment, to meet the aspirations of the users because the nature of environment a patient is exposed to have an effect on the prevention of illness and recovery process.

Intervention studies have proved that poor air quality in an indoor environment for the elderly can be improved significantly by using different strategies including,

I. Improved ventilation such as installing chimneys and smoke hoods.

II. Enlarged windows (Awning windows) is recommended as a window type that should be used, 1800mm x 1800mm should be adopted as a minimum standard for window design.

III. There should be existence of landscape configurations such healing gardens, therapeutic gardens, edible gardens, viewing gardens, roof garden, vertical gardens and indoor plant as reviewed from literatures.

IV. Vertical and horizontal fins should be well designed as part of the building form to serve as shading devices, projecting outward from the façade effectively adding refined detailing to square frames of curtain walling systems or an array of shapes and profiles

having the ability to provide solar shading and also provide visual appeal.