FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

SUSTAINABLE BUILDING MAINTENANCE: HOW FEASIBLE?

By

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Professor of Architecture

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Courtesies

The Vice-Chancellor, the Deputy Vice-Chancellor (Academic), the Deputy Vice-Chancellor (Administration), the Registrar, the Bursar, the Librarian, Deans of School, past Vice-Chancellors, past Deputy Vice-Chancellors, distinguished Professors, Directors, Heads of Department and other members of the Senate, my Lords Spiritual and Temporal, Eminent Invited Guests, Colleagues, my friends and family, Students, Ladies and Gentlemen, good afternoon.

It is with a deep sense of humility, fulfillment and great joy that I stand before you here to deliver the 79th Inaugural lecture of the Federal University of Technology, Minna, the 9th in the series from School of Environmental Technology (SET) and the 2nd of its kind from Department of Architecture. It is interesting to note that the lecture is as well to be delivered by the 1st PhD product of Architecture Department in this University, the 1st SET Chairman of the Lower House and the 1st SET PhD product to become Professor and Dean of the School. I give God **who is always in absolute control**, all the glory and adoration.

1. Introduction

Building as a shelter, a dwelling place or a house, is generally viewed as the most basic human need playing a very important role in the welfare and productivity of individuals. Housing is one of the three basic needs of man and it is the most important for the physical survival of man after the provision of food. Adequate

housing contributes to the attainment of physical and moral health of a nation and stimulates the social stability, the work efficiency and the development of the individuals. It is also one of the best indicators of a person's standard of living and of his place in the society (Olayiwola *et al.,* 2005).

To the individuals, owning a home has always been a cherished dream and life ambition most especially in a developing country like Nigeria. In spite of the importance of housing to mankind, there is however, a universal shortage of needed descent dwelling units especially in developing countries including Nigeria where population growth and urbanization are rapidly on the increase and where the gap between housing supply and housing demand is so wide (Ayedun & Oluwatobi, 2011). Meaning that in reality, housing situation in Nigeria is far from the new target of Sustainable Development Goal (SDG) of housing for all by year 2030, if nothing is done about the

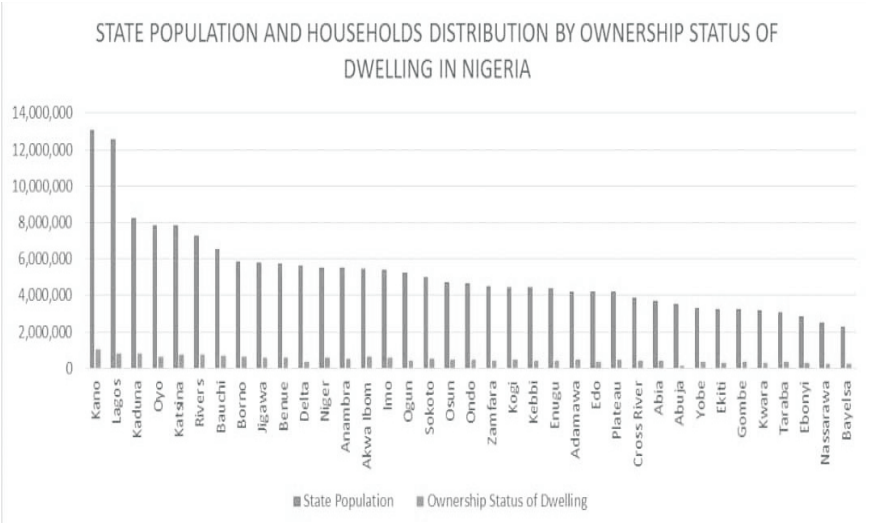

Figure 1a: State Population and Households Distribution by Ownership Status of Dwelling Nigeria

sustainable maintenance of the existing housing stock. According to the National Population Census report, 2006, the ownership status of dwelling in the 36 states of Nigeria including Abuja is 11.81 percent highest at Akwa Ibom and 6.38 percent at Lagos when population of the state is compared with the ownership status of dwelling in each of the states {Figures 1(a & b)}.

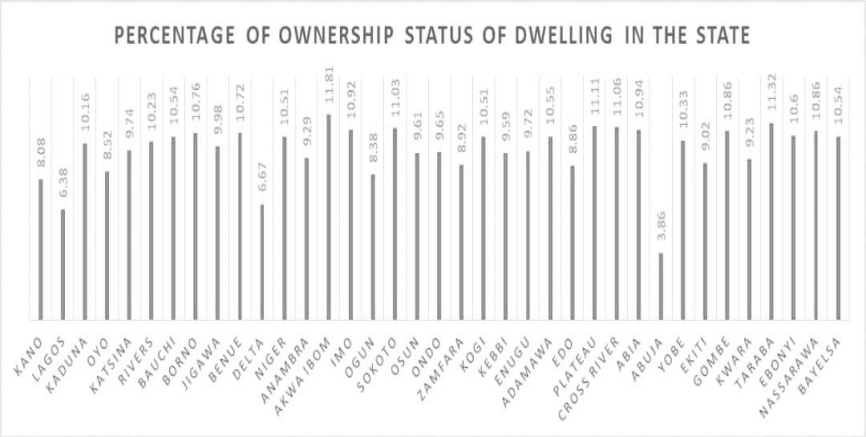

Figure 1b: Percentage of Ownership Status of Dwelling in the State

Source: *National Population Commission (2006)*

In Morenikeji, *et al*. (2017) assessment, states like Lagos, Rivers, Kano, Oyo, Ogun, Kaduna and Anambra have a high housing quality with Lagos having the highest among them. He further affirmed that these states are more populous, the economic, administrative activities and socioeconomic level of the inhabitants are also higher unlike the remaining states that have a low housing quality with high poverty level, high cost of building materials due to high inflation rate and poor enforcement of buildings bye-laws and regulations. These negative effects have contributed immensely to the great need for decent and high quality shelter that ensures welfare and

productivity of the individual and the need to increase the ownership status of dwellings in the states. The **nature and types of shelter** since man's existence till date depends largely on the time, available materials and functional requirements.

Today due to the progressive degradation of our built heritage and the high costs associated with their construction, maintenance and repair and most especially the acute shortage of descent and high quality buildings for all, the need for this lecture to educate the populace on maintenance culture and the possibility of sustainable building maintenance in Nigeria is highly overdue. This necessity is due to several factors, including:

(a) The worries of individual building owners, corporate bodies and government on how to establish requirements for the service life of structures during the design stage.

(b) Awareness of the stakeholders in the construction sector that the quality and total costs of buildings comprise both the construction costs and the maintenance and repair costs.

(c) The knowledge that durability is a key part of the quality and performance of the construction elements.

(d) The awareness that the visual appearance and the ageing of the structures contribute to their loss of performance (Silva *et al*., 2016).

(e) Awareness of the stakeholders in the building industry about sustainability which requires a change in human thinking and activities towards our buildings and the environment in order to better care for it i.e. t**hinking in a sustainable way to reduce waste of materials, time and fund all through maintenance processes/building lifecycle**.

1.1 Maintenance Culture

People that have maintenance culture or think in a sustainable way would have the attitude to maintain, preserve and protect the public facilities. According to Florence (2011), maintenance culture is not universal in nature. It is usually derived or learned through a person making maintenance a natural daily practice that can be followed and emulated by others. Maintenance culture is therefore the values, way of thinking, behaviour, perception and the underlying assumptions of any person or group or society that considers maintenance as a matter that is important (priority) and practises it in their life, (Suwaibatul *et al*., 2012). Iyagba (2005) opined that one of the greatest economic and social problems of Nigeria as a nation is the general absence of a maintenance culture. In same vein, Anele (2010) and Abigo *et al*. (2015) stated that Nigeria will continue to waste scarce financial resources on building new infrastructure which cannot be sustained, if urgent steps are not taken to embrace maintenance culture (see Plate I).

Plate I: 1004 Housing Estate, Eti-Osa, Lekki, Lagos in 2017, due to lack of maintenance culture.

Source: *SAHARA Reporters (2017).*

The United Nations Development Programme (UNDP) is one of the leading organisations working to fulfil the Sustainable Development Goal - SDGs by the year 2030. SDG with set of 17 goals imagines a future of just nine (9) years off that would be rid of poverty and hunger, and safe from the worst effects of climate change. With the situation of decay of built environment in Nigeria presently, it needs urgent attention if the country must achieve a pass mark in the Sustainable Development Goal (SDG) by 2030. Each aspect of the built environment needs sufficient maintenance if it must achieve the goal for which it is established. According to Mark *et al*. (2006) and Tijani *et al*. (2016), developing and embracing maintenance culture through effective leadership, sound policy and attitudinal development among others would not only enhance national development but also enlist our country among the committee of developed nations.

Mr. Vice-Chancellor, Sir, it is pertinent to note here that buildings will always need to be maintained, because as soon as they are built, they begin to decay. The reason is that materials deteriorate with time and consequently with a need to recover the fading glory. Thus, effective leadership, good maintenance culture and adequate knowledge about how to overcome issues of incessant collapse of our new buildings under construction and newly completed ones (sustainable development) and how to sustainably maintain our existing building stocks is therefore urgently needed.

2.0 Sustainability

The word "sustain" comes from the Latin **'sustenare'** meaning "to hold up or support". From thence it evolved to mean – to maintain something or keep something going or extended its possible life span (Maude, 2014). However, the World Commission on Environment and Development (WCED, 1987)

referred to sustainability as 'meeting the needs of the present generation without compromising the needs of the future generation.' According to Dillard *et al*. (2009), sustainability is often thought of as comprising three overlapping goals: (a) to live in a way that is environmentally sustainable or viable over the long term; (b) to live in a way that is economically sustainable, maintaining living standards over the long term; and (c) to live in a way that is socially sustainable, now and in the future.

In summary, sustainability requires a change in human thinking and activities towards the environment in order to better care for it. In other words, sustainability is an attitude. It is a way you can choose to live your life. Thus, sustainability in many facets of life can simply be described as a response to numerous contemporary concerns about the effects of human activity. It involves effective planning to reduce overuse or waste and protect the environment. Sustainability issue thus arises when a valued system, process, objects or attribute faces the risk of not being maintained or fall under threat.

2.1 Sustainable Development

Sustainable development is the development/growth that meets the needs of the present without compromising the ability of future generations to meet their own needs (WECD, 1987). It also means that human activity is only environmentally sustainable when it can be performed or maintained indefinitely without depleting natural environment. Sustainable development is a concept that integrates various criteria including energy efficiency, durability, waste minimisation, social impacts, good indoor environment, pollution control, life-cost, user-friendliness, user comfort and others (Zainul, 2006; Khamidi, *et al*., 2010).

The proper maintenance of buildings is an important

programme for sustainable development, and plays a major role towards national prosperity and a healthy environment (Zulkarnain *et al*, 2011). That is, in addition to the production of new buildings, sustainable building maintenance will serve as a key role and an answer to the Sustainable Development Goal 11, which demands to "Make cities and human settlements inclusive, safe, resilient and sustainable" (i.e. **Sustainable cities and communities**).

2.2 Sustainable Development Goals (SDGs)

The Sustainable Development Goals are made up of 17 goals and 169 targets. The spirit and agenda of the SDGs are commendable as they combine efforts to eradicate poverty and increase the development of poor countries. The 17 Sustainable Development Goals are as stated and shown below (see Plate II):

Plate II: The SDGs In Summary

Source: *Sustainable Development Goals - 2015 (https:www.undp.org)*

Currently, it is just nine years into 2030, the new target of Sustainable Development Goal (SDG). Thus, emphasis should be laid on integration among the substantive goals and targets, so that acting in one area will affect outcomes in others, and that

development must balance social, economic and environmental sustainability. As such, there is the need for similar attention to be devoted to principles associated with Goal 11, a primary concern to today's lecture, “Thinking in a sustainable way.”

In an attempt to achieve the aim of this lecture in realization of most of the goal 11 targets, such as make cities and human settlements inclusive, safe, resilient and sustainable, there is the need to discuss and bring to fore the principles of sustainable development (3 R's of sustainable development i.e. Reduce, Reuse & Recycle), sustainable Architecture, Lean Concept and Sustainable development of building stock.

2.3 The Three Principles of Sustainable Development

1. Reduce

To make a building sustainable, one must be able to reduce the energy consumption of the building either through active or passive design approach. Applying active approach involves making use of specific hardware to reduce the rate at which the building consumes energy and passive approach involves tending to build with some building materials which are effective in energy conservation. Reducing the amount of hard surface landscape elements by landscaping with more grasses, shrubs, and trees also reduces the effect of solar radiation on a building which can cause unnecessary heating of the building.

2. Reuse

Reuse refers to making sure that nothing is wasted in the building either in terms of materials or energy. Sustainable buildings make use of renewable sources of energy like solar, wind, etc.

3. Recycle

The use of recyclable materials like bricks, wood, paper, plastic, glass, etc., makes a building sustainable.

2.4 Sustainable Architecture

Sustainable architecture is design and construction of the built environment that carefully allocates appropriate levels of critical resources to address the primary needs of distinct regions. It is an effort to minimize the negative environmental impact of the buildings by using specific materials, energy and development space through strict moderation and efficiency. That is, sustainable architecture is a process of creating buildings to help preserve the future. Generally, there are two methods for sustainable architecture: new "green" building and preservation/reuse ("green" retrofitted into the existing building stocks). The two methods involve careful application of the 10 Principles of Sustainable Architecture that guarantee the well-being and coexistence of ECO elements.

These principles are (Faraz, 2019):

1. Think Small: Small homes are more affordable, use fewer resources, have less of environmental impacts and require less energy to heat and cool (see Figure 2).

Figure 2: Eco – Concept (Melyan, 2019).

2. Heat with the Sun: Correct orientation of building with the use of green building material that absorbs the sun's energy during

the day and then dispatches it slowly at night can reduce energy requirement considerably (see Figure 3).

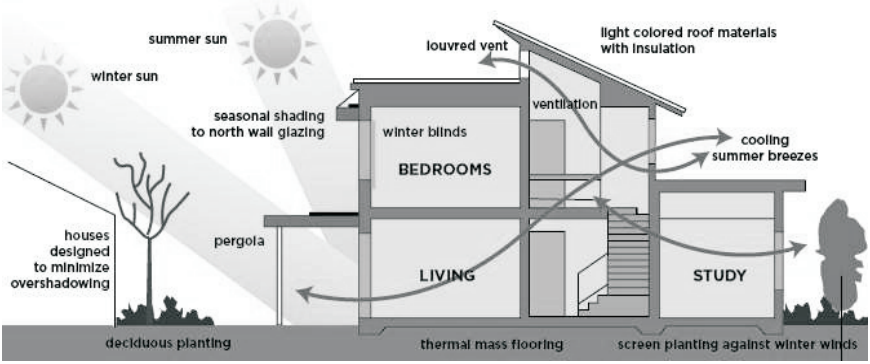

Figure 3: Section through Eco-Friendly Building (Faraz, 2019)

3. Use Renewable Energy: Use of solar panels as source of energy in building is good. Although it is expensive in the short term but will pay off in the long run (see Figure 4).

Figure 4: Renewable Energy (Photovoltaic System)
Source: *(Youth Leadership Summit, 2012)*

4. Keep Your Cool: Passive design and insulating a home well will work wonders and reduce energy requirements (see Plate III).

Plate III: Fallingwater (Kaufman House, 1938), Pennsylvania, USA by Frank Lloyd Wright

5. Conserve Water: Water conservation in homes, especially in dry regions is essential and achievable through harvest rainwater, recycle gray water and consideration for planting of indigenous plants that don't require a lot of water to flourish (see Plate IV).

Plate IV: Eco – House (Melyan, 2019)

6. Use Local Materials: Use of local materials will reduce stress over acquisition and benefits local economy rather than the use of materials harvested in some distant land, which involved travelling a long distance to acquire (see Plate V).

Plate V: Local Available Materials (Faraz, 2019)

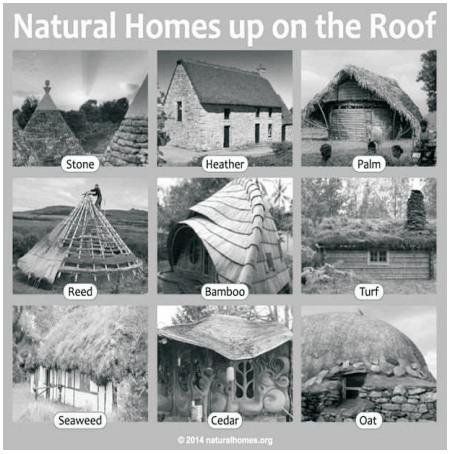

Plate VI: Natural Building Materials (Faraz, 2019)

7. Use Natural Materials: Buildings constructed with natural material such as mud, stone, lime, palm, or bamboo do not only promote natural circulation but with more aesthetic appeal in the structure. Natural materials also promote day lighting and superior acoustics whereas all kinds of interventions are required in more artificial surroundings (see Plate VI).

8. Save The Forests: Forest preservation aids sucking of the globe's carbon. Thus, considering the escalating levels of greenhouse gases in our atmosphere and issue of global warming, protecting our trees is more important than ever (see Plate VII).

Plate VII: Eco Friendly Buildings (CSV Architects, 2019)

9. Recycle Materials: Use of recycled materials reduces wastage. Recycling materials not only gives new life to something discarded or disused, but also provides an opportunity to be creative and resourceful (see Plate VIII).

Plate VIII: Byblock (Conversion of All Types of Plastic Wastes into 0.4 x 0.2 x 0.2m Block at 10kg Weight) (Fusion, 2020)

10. Build to Last: Despite stringent new building codes, many materials used in contemporary architecture are designed NOT to last so that the supplier can prolong their business opportunities. This makes absolutely no sense. **Build to last as much as possible and save the earth while you're at it** needs to be encouraged (see Plate IX).

Plate IX: The First Storey Building in Nigeria, Badagry (Dimeji-Ajayi, 2018)

Sustainable Architecture Worldwide

In developed countries most new building design and construction integrates sustainable methods. Examples include:

i. Bahrain World Trade Center with wind turbines that provide alternative energy (see Plate X).

Plate X: Bahrain World Trade Center (Youth Leadership Summit, 2012)

ii. Sustainable Building: Residential development, a mix-used 18,000 m^2 residential tower and 190m high skyscraper designed by Santiago Calatrava, an Architect, Engineer and Sculptor in 2005 (see Plate XI).

Pate XI: The Turning Torso Tower (Twisting Skyscraper), Malmo, Sweden (Gupta *et al.* (2016)

ii. Sustainable Building: Office Building Africa Commercial Property, known as 'The Heritage Place' at Ikoyi – Lagos. It comprises 15,300 sqm of office over eight floors, 390 car parking spaces over six floors, and a ground floor lobby with meeting rooms and café, designed by Capita Symonds Architects in 2012 and certified by Leadership in Energy and Environmental Design (LEED), see Plate XII.

Plate XII: The Heritage Place, Ikoyi – Lagos, Nigeria (Uroko & Ayetoto, 2019)

Mr. Vice-Chancellor sir, to make a new building sustainable, the building must also holistically balance and integrate all the 3 principles of sustainable design i.e. Economy of material/resources, Life cycle design (i.e. design, construction, operation and maintenance, and recycling and reuse of architectural resources) and Human Design. These principles comprise a conceptual framework for sustainable architectural design.

2.5 Principles of Sustainable Design

According to Akadiri *et al.* (2012) there are three major

objectives for implementing sustainable building design and construction and possibly maintenance. These objectives are:
1. Resource Conservation
2. Life Cycle Design and
3. Design for Human adaptation.

In addition, to enhance environmental sustainability, the following three principles of sustainability and their respective strategies must be strictly adhered to (Pradhan, 2014); namely:

i. Principle 1 (Economy of Resources): Is concerned with the reduction, reuse, and recycling of the natural resources that are input to a building. That is, in a well-designed Sustainable building, no material is wasted as they are either recycled or converted for use in other areas (see Figure 5).

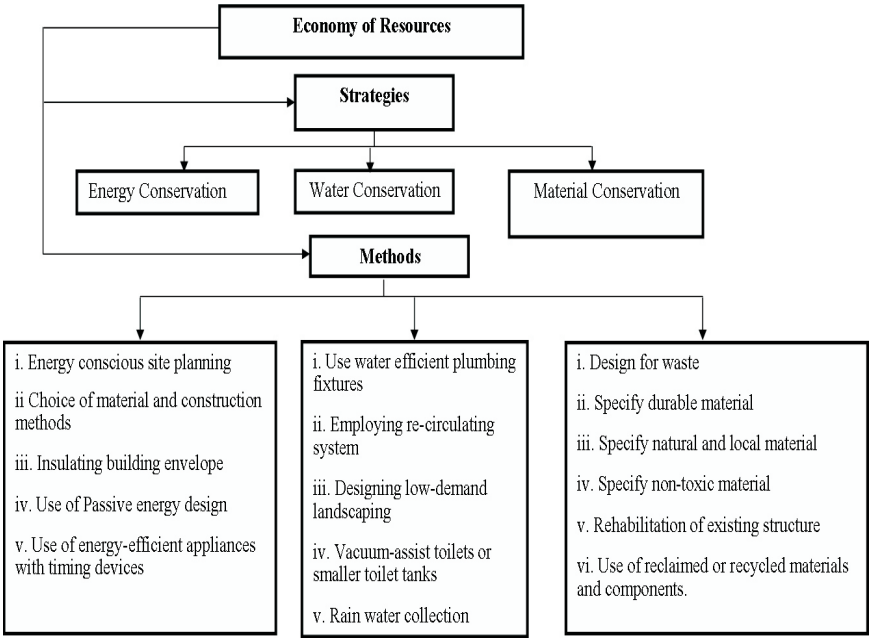

Figure 5: Economy of Resources and methods of application

Source: *Adapted from Akadiri, et al., 2012 and Pradhan, 2014.*

ii. Principle 2 (Life Cycle Design): It provides a methodology for analyzing the building process and its impact on the environment. That is, to make a building sustainable, it must be able to fulfil life cycle principle in such a way that materials can be used, recycled and be reused again. Energy can also be renewed and a continuous cycle of building life can be maintained (see Figure 6).

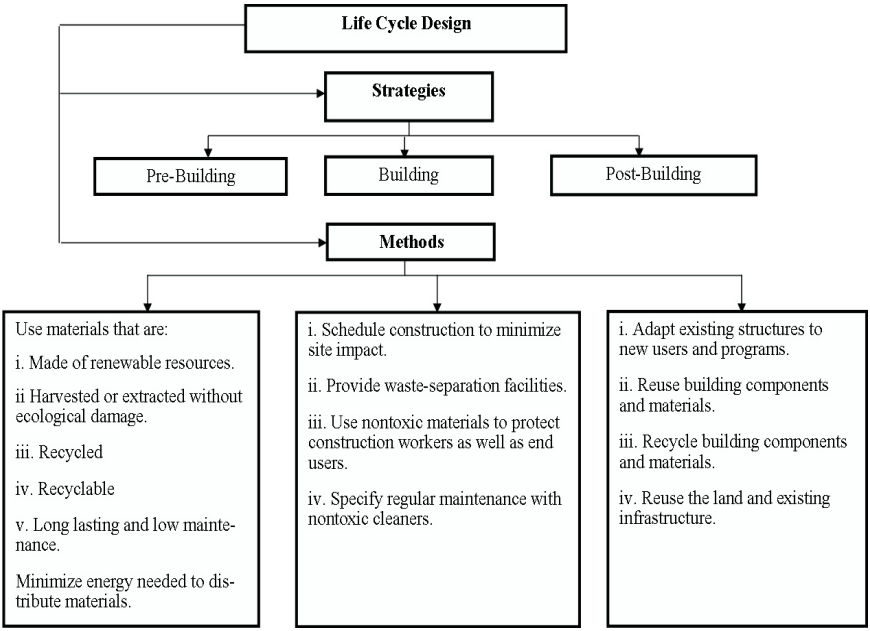

Figure 6: Life Cycle Design and methods of application.

Source: *Pradhan, 2014.*

iii. Principle 3 (Humane Design): It focuses on the interactions between humans and the natural world. That is, any sustainable building must aim at creating a liveable and workable environment for humans and the nature around. It must create an ecosystem where all organisms live in harmony (see below Figure 7).

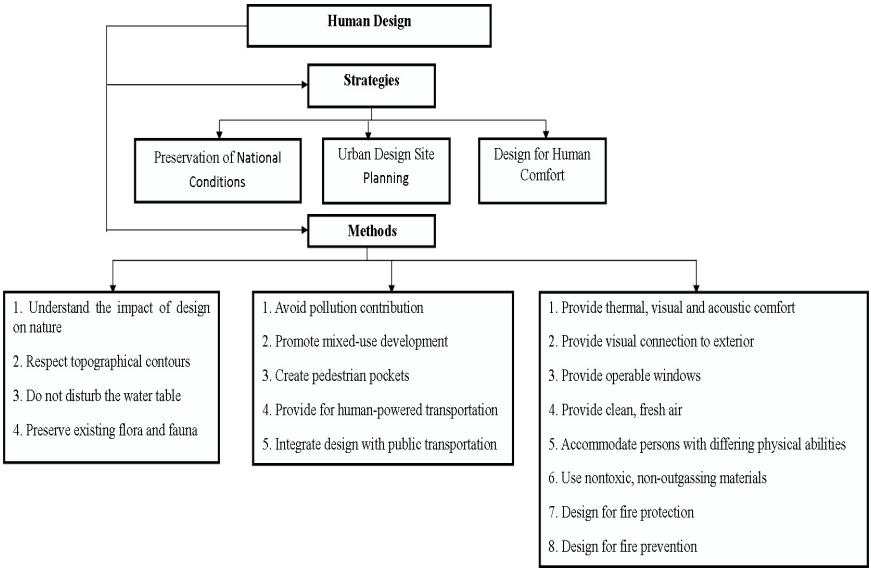

Figure 7: Humane Design and methods of application.
Source: *Adapted from Pradhan, 2014 and Akadiri, et al., 2012.*

These principles can provide a broad awareness of the environmental impact, both local and global, of architectural consumption. The strategies and methods are also to provide more insight into how a building interacts with the internal, local, and global environments.

3.0 Maintenance of the Existing Building Stocks with Lean Principles

3.1 Lean Principles

3.1.1 Lean Concept

Lean means efficient use of the available resources by cutting the non-value added (NVA) activities (Carrasqueira & Machado, 2008; Mostafa *et al.*, 2015). Lean has to do with designing, operating in continuous process flow or working with the right

process and having it right the first time. Essentially, lean is about removal of waste. Waste is seen as activities and processes that consume resources yet do not add value, thus, any non-value added activity or process is considered as waste. Waste involves anything that adds no value from the clients' perspective. Lean concept rest on five (5) principal principles that when followed will reduce waste and maximize profit. These principles are (Ansah *et al*., 2016):

(i) Value specification: Precisely specify what creates value from the client's perspective;

(ii) Value stream identification: Clearly identify all the steps in the processes (value stream) that deliver exactly what the customer values and remove everything that do not add value to the customer;

(iii) Flow: Take actions that ensure continuous flow in the value stream;

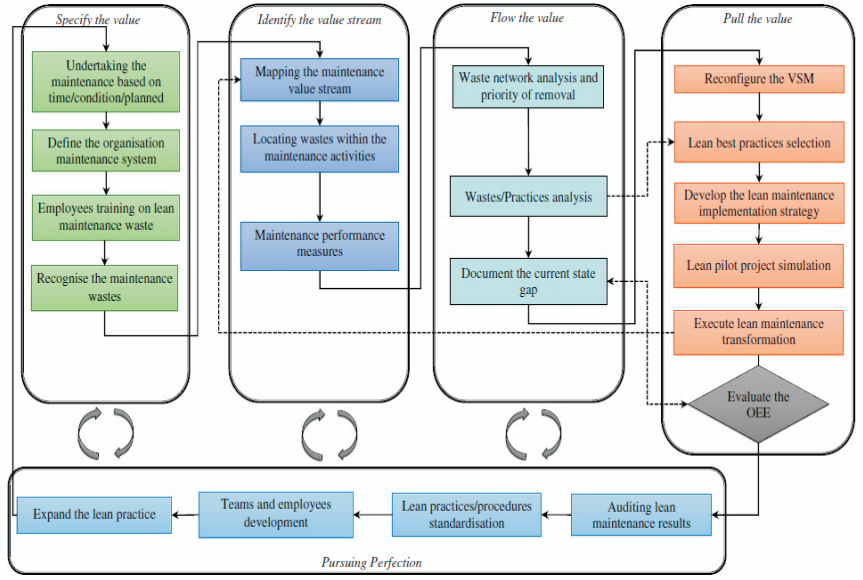

Figure 8: Lean Principles in the Implementation Process

Source: *Mostaf et al. (2015)*

(iv) Pull: This means to produce only what the customer wants just in time; and

(v) Perfection: Always strive for perfection by delivering what the customer wants and expects through a continuous removal of waste (see Figure 8).

According to Womack and Jones (2003) lean principles can be deployed to all organisations. This is known as lean thinking which refers to the thinking process of lean or **thinking in sustainable way.**

3.1.2 Lean Construction

Lean construction is a concept that involves the application of lean manufacturing principles or lean thinking into the construction industry. Lean construction shares same objectives as lean production; waste elimination, reduction of cycle time, continuous improvements, reduction of variability, continuous flow, pull production control, among others (Aziz & Hafez, 2013).

The main aim of lean construction is to reduce waste, increase productivity and health and safety in order to fulfil client's requirements. In addition, it makes work much easier to understand, perform and manage with remarkable processes' waste reduction and with emphasis on things that add value to the customer.

The adoption of the five lean principles in construction with green construction techniques will lead to improved delivery systems and processes through the elimination of wastes, which in turns improve project and financial performance of the construction industry (Ansah *et al.*, 2016).

3.2 **Building Maintenance**

Maintenance is often defined as the series of activities

undertaken to take care of the building structure and services to ensure the intended functions and optimal performance of a building life cycle. According to Tan *et al*. (2014), it is a chain of activities carried out to sustain the building's performance, usage and value by keeping, repairing, retrofitting, or upgrading building's elements, services and grounds, to an up-to-date standard. In real sense, building maintenance constantly affects everyone's life because people's comfort and productivity is relative to the performance of the building they live, learn, conduct research and work in (e.g. home, offices, schools, university and not to mention the impact it has on social fabric and economic growth (Khamidi *et al.*, 2010). Thus, a building not well maintained will certainly affect the user's quality and productivity.

Furthermore, maintenance contemplates taking steps to hinder collapse of the building and its systems by preventative and reformative measures (Thomson, 2012; Aghili & Mohammed, 2017). Indeed, adequate and correct maintenance leads to decreasing negative effects on the environment, occupants, and finally improving the residents' quality of life (Oliveira *et al.*, 2014). Its performance aspects also include the following five attributes, namely:

I. **Safety**: Safety recognizes safe and harmless situation for building tenants. In addition, safety is one of the crucial apprehensions of an architect, engineer, facilities and building managers.

ii. **Comfort**: One of the considerable phases of building performance is the comfort of the building residents. It addresses internal environment, thermal comfort, visual comfort, ergonomics, acoustics and noise comfort.

iii. **Health and Hygiene**: The health and hygiene items are the

most important factors for building occupation. Sick Building Syndrome (SBS) is one of the symptoms that show lack of health and hygiene items.

iv. **Durability**: Durability covers up the durability of building materials and structure.

v. **Sustainability**: Performing sustainability plan in buildings leads to saving energy resources, reducing CO2 emissions, and decreasing bill each month, (Hitchcock, 2002; Foliente & Becker, 2001; Aghili & Mohammed, 2017).

vi.

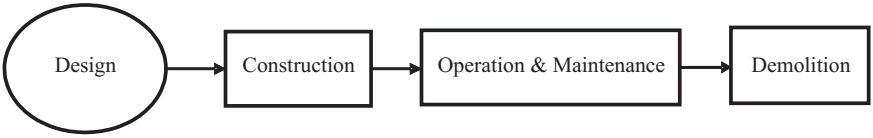

Figure 9: Conventional model of the building life cycle (Kim, 1998)

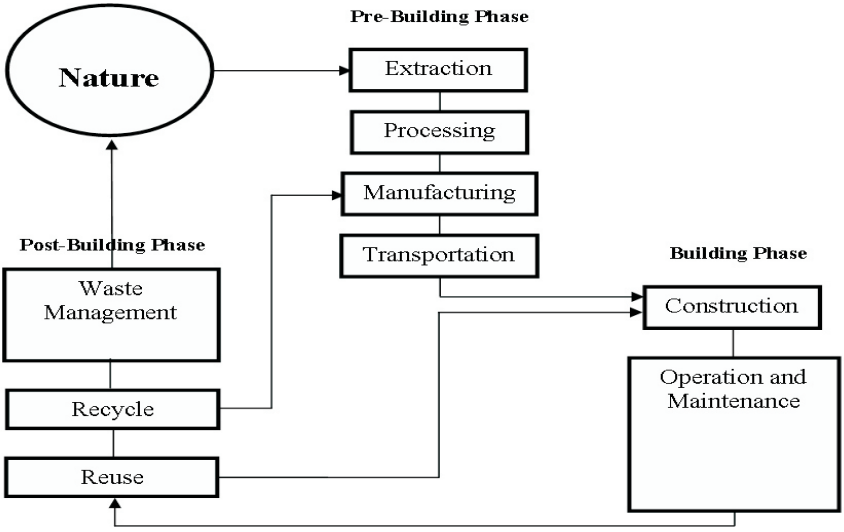

Figure 10: The sustainable building life cycle (Kim, 1998)

From Figure 9, it is obvious that maintenance of building actually starts right from the feasibility study, planning and design stages of a new building's construction, operation and maintenance, and up to preservation/demolition stage. Figure10 further shed light on the extraction of raw materials from the nature, processing, manufacturing and transportation of materials to construction site (Pre-building phase).

3.3 Sustainable Building Maintenance with Lean Principles

Sustainable building maintenance basically involves the reduction of unnecessary maintenance. It is a maintenance system that meets the value system of the present users without compromising the ability of meeting the value system of the future users (Olanrewaju & Kafayah, 2008; Khamidi *et al.*, 2010). It also requires selection of an appropriate and cost-effective maintenance strategy for items in a building. It also requires identification of the best combination of maintenance strategies for a building by selecting the optimum maintenance strategy for each individual item in the building, taking into consideration health, safety and satisfaction of the user and the costs of maintenance tasks (Abd-Rania *et al*., 2014).

Lean maintenance is a proactive maintenance operation employing planned and scheduled maintenance activities through total productive maintenance (TPM) practices using maintenance strategies developed through application of reliability centered maintenance (RCM) decision logic and practiced by empowered (self-directed) action teams (Smith, 2004, Mostafa *et al.*, 2015).

Sustainable building maintenance with lean thinking is therefore an activity that involves a careful planning; design, construction, operation; repair and maintenance of building up to demolition with focus on reduction of unnecessary waste and adequately meeting the clients' requirements (see Figures 9 and 10). In

other words, it is a technical set of operations required for building maintenance and preservation of usable condition, as well as functionally required for the maintenance of the structure, its services and the surrounding environment. Thus, sustainable building maintenance enhances keeping a building in a condition in which it continues to fulfil its purpose and making sure it presents an attractive exterior.

A maintenance strategy with Lean Thinking is an integrated system that is needed by corporate management to highlight the significance of a particular piece of equipment that impacts particular types of maintenance work (Lahiri *et al.*, 2008; Abd-Rania *et al.*, 2014), with emphasis on reduction of unnecessary waste and adequately meeting the clients' requirements. It is a new maintenance management approach aimed at reducing the maintenance costs of existing building stock and usually developed based on the user value system consideration, corporate business objectives, and strategy and maintenance objectives.

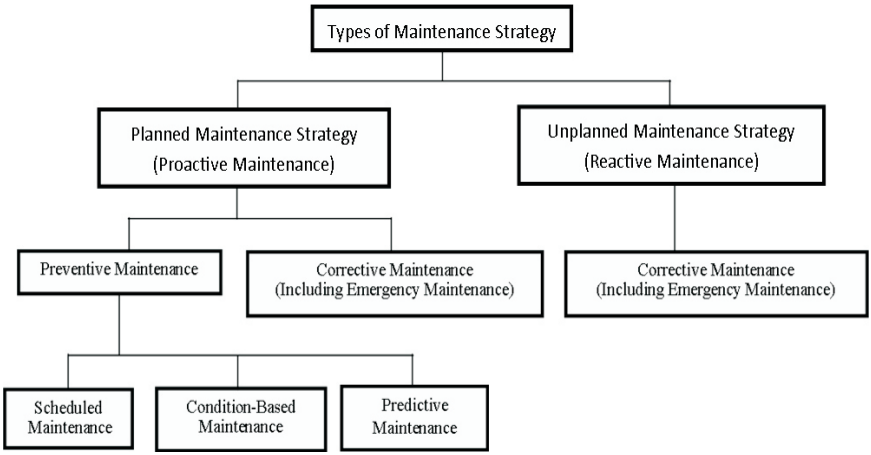

Figure 11: Types of Maintenance Strategy

Sources: *Adapted from BS 3811 (1985 as cited Nik Elyna, 2010 and Abd-Rania et al., 2014).*

There are two types of maintenance strategy, namely planned and unplanned strategy and some other sub-parts as it was found to be characterised by nature of work done (planned/proactive and unplanned/reactive maintenance), point of intervention (preventive and corrective maintenance) and time schedule (scheduled, condition-based and predictive maintenance), as shown Figure 11:

3.3.1 Types of Maintenance Strategy

(a) **Planned Maintenance Strategy (Proactive maintenance):** Maintenance organized and carried out with forethought, control and the use of records to a predetermined schedule. According to Hisham (2003) proactive maintenance is one type of maintenance that detects the failure from the source of the failure. It can lead to extending the life of building/equipment and enhancing production capacity. It is designed to extend the useful age of the building to wear-out/demolition stage by adopting a high level of mastery with respect to operating precision/building manual.

(b) **Unplanned Maintenance Strategy (Reactive Maintenance)**: Is the maintenance carried out without predetermined schedule or maintenance carried out when performance deteriorates to a point when it is no longer acceptable. That is the maintenance carried out after a failure has occurred and intended to restore an item to a state in which it can perform its required function. It is maintenance with respect to emergency/unexpected cases and leads to high maintenance cost.

3.4. Sustainable Building Maintenance Objectives and Methods with Lean Principles

Mr. Vice-Chancellor Sir, it is also noteworthy at this juncture that the connection of a healthy living environment with proper social values is of paramount importance to human wellbeing. That is,

maintaining a sustaining culture of keeping the resources represented by building for human decent and befitting habitation is highly desirable for the workforce. It is therefore clear that the maintenance of buildings ought to be a vigorous exercise within the building industry, organisations and society in general. Building maintenance objective goals can simply be spelt out as follows (Adenuga *et al*., 2010 and Magutu & Kamweru, 2015), to:

i. Ensure continued adherence to the building regulations and legal standards.
ii. Reduce the total cost of building operation.
iii. Retain the value of investment during the expected lifetime.
iv. Maintain the useful qualities of the building at a level chosen beforehand.
v. Preserve the aesthetic qualities of the building at a level chosen beforehand and
vi. Ensure safety of the users/occupants (see Figure 12).

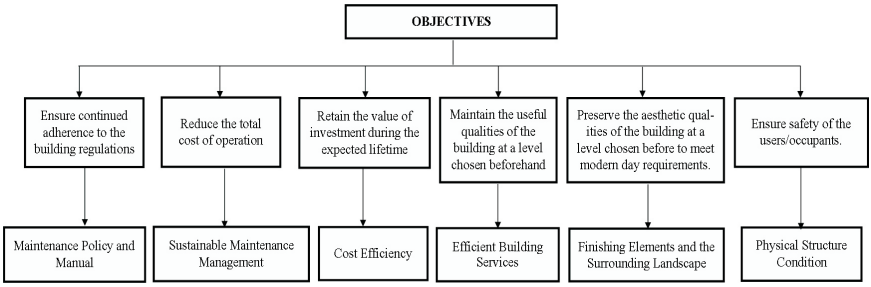

Figure 12: Sustainable Building Maintenance Objectives

3.4.1 Sustainable Building Maintenance: Strategies and methods

There are many ways in which the current nature of building activity can be controlled and improved to make it less environmentally damaging, without reducing the useful output of building activities by thinking in a sustainable way. Thus, to

create a competitive advantage using lean maintenance approach, the whole life-cycle of buildings should therefore, be the setting under which the following practices are carried out.

i. Strategies and methods to ensure continuous adherence to the maintenance legislation and legal standards.
ii. Strategies and methods to achieve sustainable maintenance management.
iii. Strategies and methods to achieve sustainable cost efficiency.
iv. Strategies and methods to achieve efficient building services.
v. Strategies and methods to achieve attractive finishing elements and the surrounding landscape.

3.4.2 Building Condition Indicator

Building condition assessment can be defined as the technical assessment of the physical condition of a building, using systematic method designed to produce consistent, relevant and useful information. Usually, the objective of the assessment and the type of asset will determine the approach to be employed and the items that need to be inspected. Where funds are limited an indicative assessment is required, a survey of an asset can yield quick results without a detailed inspection of individual components (Department of Public Works, 2002).

In addition, it is more manageable when an asset is sub-divided into reasonable parts, such as, physical building structure**,** namely,

i. the primary elements (structure and fabric)
ii. the secondary elements (interior)
iii. the service elements (ventilation)
iv. building services (electrical and plumbing), and related infrastructure services.

3.4.3 Building Condition Evaluation Criteria

Building condition evaluation scale usually provides an

indication of the gap between actual asset condition and that which has been specified or as-new condition. Table 1 is the building condition rating and index used for building condition evaluation in some foreign countries.

Table 1: Condition Rating: Scale of Asset Condition and Definitions

CONDITION STATUS	GENERAL DESCRIPTION	BUILDING CONDITION	CONDITION RATING (C)
Very poor	Asset has deteriorated badly; serious structural problems; general appearance is poor with eroded protective coatings; elements are broken, services are not performing; significant number of major defects exists.	0.00 to 0.19	1
Poor	Asset is in poor condition; deteriorated surfaces require significant attention; services are functional but failing often; significant backlog maintenance work exists.	0.20 to 0.49	2
Fair	Asset is in average condition; deteriorated surfaces require attention; services are functional, but require attention; backlog maintenance work exists.	0.50 to 0.74	3
Good	Asset exhibits superficial wear and tear, minor defects, minor signs of deterioration to surface finishes; but does not require major maintenance; no major defects exist.	0.75 to 0.94	4
Excellent	Asset has no defect; appearance is as new.	0.95 to 1.00	5

Source: *AAPPA - Australasian Association of Higher Education Facilities Officers, 2000, and Olagunju, 2011*

NOTE:

Facility/Building Condition Index: The Building Condition Index (BCI) is an index number that indicates the current condition of the asset measured relative to its 'as-new' condition.

$$\textbf{BCI} = \frac{\text{Asset Current Condition}}{\text{As-new Condition}}$$

The above condition status rating (Scale of Asset Condition and Definitions) is a widely accepted and used strategic asset management tool by some foreign countries, published by AAPPA-Australasian Association of Higher Education Facilities Officers (2000) and titled Guidelines for Strategic Asset Management: How to Undertake Facility Audit. Strategic Asset Management (SAM) wide acceptance is attested to by its successful use in countries such as England, Scotland, Wales and three consecutive times by the Northern Ireland Housing Executive for Northern Ireland House Condition Survey in 2001, 2004 and 2006, the reports of which are widely available on the internet.

In addition, the United States (U. S.) Department of Labour (DOL) also used the method since 2003 in condition assessment estimates of their buildings and structures. It was used to calculate Facility Condition Index (FCI) score for the entire portfolio of Job Corps centre constructed assets, which is used to evaluate the overall asset condition of the portfolio and ranking of individual asset condition based on FCI Scores. The building condition evaluation scale is of high relevance to physical building condition studies. It is useful for the evaluation of the overall residential buildings and their premises condition, and ranking of residential building condition based on facility/building condition index scores. Thus, it aimed to provide a minimum standard of building conditions (Decent Homes Standards) for all those who are housed in both public and private sectors.

4.0 My Contributions

In modern society, more than 70% of a person's lifespan is spent indoors. An essential role of architecture is to provide built environments that sustain occupants' safety, health, physiological comfort, psychological well-being, and productivity.

Mr. Vice-Chancellor, Sir, my contribution in today's lecture and to the existing knowledge here is based on my research works done on Development of Mathematical Models for The Maintenance of Residential Buildings in Niger State, Nigeria and its application. It is an attempt to ascertain how feasible it is with buildings' care in Niger State, while thinking in a sustainable way with emphasis on waste reduction or things that do not add value to building owners and also to give back to Niger State where my whole lot has been made till date.

4.1 The research work

The study covered two selected local government areas (LGA) headquarters in Niger State and the state capital, which include Bida LGA, Kontagora LGA and Minna metropolis. One local government councils' headquarter was selected from each of the three Senatorial districts, based on the hierarchy of settlements in the state (100 km radius influence) and population density (highest). Based on the nature of the study, a combination of descriptive and inferential methods was employed for physical assessment, using audit inspection approach.

Probability sampling method was used for the research. Probability sampling method was adopted so as to allow equal opportunity of being selected to every data collected, and also to allow selection of every data independently without influencing each other. Systematic sampling method was used for the selection of neighbourhood centres available in each of the urban

centres. Systematic sampling method was also adopted for the selection of the private residential building units in each town (sample). Based on the population size, sampling frame of 1216, which is (2%) of the research population (60,800) was used. The sampling frame of 1216 buildings was further distributed on pro-data basis among Bida (370), Minna (581) and Kontagora (265) for the data to be fully representative.

The questionnaire was designed to reflect on the research problems, which was administered in each of the 1216 buildings selected at random. The copies of questionnaire were retrieved from a respondent in each of the buildings immediately after completion and collated for analysis. Table 2 shows that building/component condition can be rated ranging from very poor to excellent. All the building/component conditions itemised are well defined, with corresponding condition rating and building condition index.

Table 2: Condition Rating: Scale of Asset Condition and Definitions

BUILDING/ COMPONENT CONDITION	GENERAL DESCRIPTION (Definition of rating/condition of building asset)	CONDITION RATING (C)	BUILDING CONDITION INDEX
Very poor	▪ Building has failed ▪ Not operational ▪ Not viable ▪ Unfit for occupancy ▪ Environmental/contamination/ pollution issues exist	1	0.00 to 0.19
Poor	▪ Badly deteriorated ▪ Potential structural problems (e.g. structural cracks) ▪ Inferior appearance ▪ Major defects ▪ Components fail frequently	2	0.20 to 0.49
Fair	▪ Average condition ▪ Significant defects are evident (e.g. non–structural cracks) ▪ Worn finishes require maintenance ▪ Services are functional but need attention ▪ Deferred maintenance work exists	3	0.50 to 0.74

Good	▪ Minor defects (e.g. hairline cracks) ▪ Superficial wear and tear ▪ Some deterioration to finishes ▪ Major maintenance not required	4	0.75 to 0.94
Excellent	▪ Asset has no defects ▪ As new condition and appearance	5	0.95 to 1.00

Source: *Olagunju, 2011*

NOTE:

Facility/Building Condition Index: The Building Condition Index (BCI) is an index number that indicates the current condition of the asset measured relative to its 'as-new' condition.

BCI = Asset Current Condition
As-new Condition

4.2. Research findings:

Niger State (Bida, Minna and Kontagora) Model Development

(i) Multiple regression model was used to establish relationships between dependent variable (Physical condition of buildings) and other 25 predictor variables (Post Occupancy Evaluation, POE variables for buildings' condition), **using forced entry method**. The forced entry method was adopted so as to detect the strongest variables among the twenty five (25) predictor variables. The result is as follows:

(i) The regression coefficient table reveals that all the predictor variables are significant.

(ii) The multiple correlation coefficient 'r' is 0.996. This means that there is strong and positive relationship between physical condition of buildings (dependent variable) and predictor variables.

(iii) The coefficient of determination 'r^2' is 0.992. This means that the predictor variables can give about 99.6% explanation for residual variation in physical condition of buildings.

(iv) However, the strongest variables among the twenty five (25) predictor variables could not be detected.

(v) Multiple regression model was again used to establish relationships between dependent variable (Physical condition of buildings) and other 25 predictor variables (Post Occupancy Evaluation, POE variables for buildings' condition), **using stepwise method**. The stepwise method was adopted so as to detect the strongest variables among the twenty five (25) predictor variables and to get the equation of best regression that can describe the relationship and be used for prediction. The result is as follows:

The multiple regression analysis for dependent variable, physical condition actual percentage yielded twenty five (25) models. From the Model Summary of Physical Condition and Other Variables - Bida, Minna and Kontagora table, only the first eight models are significant, with R Square Change not less than 0.01. Thus, the eighth stepwise regression model has eight variables which are the following (see Table 3):

Table 3: Model's Variables

S/N	CODE	PARTICULARS
1	STRUCT	Structural components' condition
2	ROOFCO	Roof's condition
3	TOILFAC	Toilet facilities' condition
4	WASTEW	Discharge of waste water's condition
5	EXTWAL	Exterior walls' condition
6	WAKWAY	Walkways within the building premises' condition
7	ELECTW	Electrical wires & switches' condition
8	INTWSU	Interior walls' surface condition

Source: *Olagunju, 2011*

From the Model Summary of Physical Condition and Other Variables - Bida, Minna and Kontagora table again:

(i) The multiple correlation coefficient 'r' is 0.970. This means that there is strong and positive relationship between physical condition of buildings (dependent variable) and predictor variables.

(ii) The coefficient of determination 'r^2' is 0.940. This means that the predictor variables can give about 94% explanation for residual variation in physical condition of buildings (dependent variable). Others may be as a result of chance effect which may not be measurable (i.e. the remaining 6%).

(iii) Therefore, Model (1) equation is,

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + l$ (1)

Where:

Y = Physical condition of buildings (dependable variable, PHYCON)

X_1 = Structural components' condition (STRUCT)

X_2 = Roof's condition (ROOFCO)

X_3 = Toilet facilities' condition (TOILFAC)

X_4 = Discharge of waste water's condition (WASTEWT)

X_5 = Exterior walls' condition (EXTWAL)

X_6 = Walkways within the building premise condition (WAKWAY)

X_7 = Electrical wires & switches' condition (ELECTWR)

X_8 = Interior walls' surface condition (INTWALS)

Table 4: Regression Model's Coefficient and the Corresponding Beta Values

S/No	Regression Model Coefficients Particulars	Value	Beta Value
1	Constant β_0	4.368	
2	β_1	2.305	0.164
3	β_2	2.555	0.184
4	β_3	2.699	0.186
5	β_4	2.096	0.170
6	β_5	2.295	0.158
7	β_6	1.805	0.135
8	β_7	2.031	0.142
9	β_8	1.853	0.128

Source: *Olagunju, 2011*

Table 4 shows the emerging model equation's regression coefficients estimates, Therefore, Model equation is, Y = 4.368 + 2.305X1 + 2.555X2 + 2.699X3 + 2.096X4 + 2.295X5 + 1.805X6 + 2.031X7 + 1.853X8 (1).

All the above eight listed building maintenance factors as physical condition of buildings' predictor in the equation can give about 94% explanation for residual variation in physical condition of buildings in Niger State. Thus, they have the best building maintenance factors with 94% predictive value for assessments of physical condition of buildings in Niger State and Nigeria with some assumptions in place.

5.0 Conclusion and Recommendations

5.1 Conclusion

Mr. Vice Chancellor, distinguished Ladies and Gentlemen, in the course of the lecture, I have taken you through the landmark

events of my involvement in the care of buildings. I have carefully studied how to care for buildings in a sustainable way right from the planning stage all through to demolition/preservation stage with focus on waste reduction of materials, time and fund.

Having had all these experiences, most especially with buildings, I have come to the conclusion that there is the need to address as the crisis of maintenance of the building stocks through a well-established system. Crucial to this assertion is recognition by the necessary authorities that a crisis does indeed exist, and that an urgent solution is required by **thinking in a sustainable way all through our buildings' lifecycle maintenance/care processes.** The effect on our economy emanating from dilapidation of our building structures is high and cannot be ignored in the calculations of our wasting wealth. It is high time to change our mentality in Nigeria that once a project (housing, public building or road) is commissioned, it is believed to last forever and therefore need not to be maintained. As a result of this mentality, most of the buildings in our higher institution campuses, public and privately-owned housing estates and roads owned by the Federal, State and Local Government Authorities are in deplorable conditions. However, **Sustainable Building Maintenance is feasible**, but depends largely on the leadership and users thinking and activities towards the environment in order to better care for it. I therefore call on the Government at all levels, Unions and Agencies for infrastructure provision and maintenance to wake up and embrace the opportunities derivable from **'Sustainable Building Maintenance with Lean Principles'** as presented here today.

5.2 Recommendations

Mr. Vice Chancellor Sir, for full utilization of the accrued benefits derivable from this inaugural lecture, the building maintenance stakeholders have to take the following into consideration while

thinking in a sustainable way with focus on waste reduction of materials, time and fund.

(i) Re-introduction of the Buildings and Building Premises Inspection Programme (BBPIP) in the state, whereby the developed maintenance model will be used for quick assessment of residential buildings' physical condition. The mathematical models' adoption will eliminate doubts and drastic reduction of waste resources, time and fund on the part of the government officials and the house owners or housing agents or tenants, most especially in Investigative Post-Occupancy Evaluation decision making which may later demand for Diagnostic Post-Occupancy Evaluation.

(ii) The physical condition assessment model developed, Y = 4.368 + 2.305 STRUCT + 2.555 ROOFCO + 2.699 TOILFAC + 2.096 WASTEWT + 2.295 EXTWAL + 1.805 WAKWAY + 2.031 ELECTWR + 1.853 INTWALS should be adopted with emphasis on thinking in a sustainable way and be used by Government at all levels for quick assessment of residential buildings within their jurisdictions.

(iii) Government at all levels should formulate policy and strategy for planning and development permit and control with focus on thinking in a sustainable way in order to set minimum maintenance standards for buildings within their jurisdictions. This may be through renovation permit such as:
a. Minor repair works,
b. Major repair works and
c. Total redevelopment, decoration and improvement notice.

(iv) Government should formulate maintenance policy and strategy in view to achieving the Millennium Development Goal 11 (MDG 11) targets with less waste of materials, time and fund.

(v) Government at all levels should educate the residents on the need for building structures and buildings' premises maintenance and the implications for failure to maintain building structures and building's premises through radio and television announcement and discussions. In addition, strategic placement of posters and effective distribution of hand bills can also be employed for the enlightenment campaign.

(vi) Use of the developed model for the prediction of residential buildings' physical condition should be enforced and used for quick assessment of buildings' physical condition by the Buildings and Building Premise Inspection Programme (BBPIP) agents at all levels in Niger State and Nigeria at large.

(vii) Maintenance department that is well equipped and funded should be domiciled in every government and private establishment with explicit maintenance policy based on lean concept.

(viii) Private individuals and organisations should include yearly maintenance cost of building and declaration of maintenance on the building construction plan before approval by Urban Development Authority. This will help to hold responsible or initiate litigation, if the individual or organisation fails to maintain their building structure.

(ix) An Independent Maintenance Enforcement Commission (IMEC) should be established to oversee the role of maintenance departments of government infrastructure and private established assets. Members of the Commission can be co-opted from appropriate existing institutions or associations.

(x) Maintenance culture based on lean principles, as a course of

instruction, should be introduced into all levels of Nigeria Education Curriculum.

(xi) Re-adapting or reusing of existing buildings rather than starting new construction projects that will consume more resources and time should be encouraged.

(xii) New construction should have some sustainable aspects through renewable or recycled materials, alternative energy sources, and orienting the building in order to make use of cross winds and sun for natural temperature regulation.

(xiii) Intensive training and seminars must be organised for all cadres of staff of various establishments on the benefits of good maintenance culture. Users of facilities should also be brought up to date in the use and care of equipment with emphasis on lean thinking.

(xiv) It should be required that the designer give some guidance as to maintenance needs in form of building maintenance manual with lean principles.

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REFERENCES

AAPPA - Australasian Association of Higher Education Facilities Officers (2000). *Guideline for Strategic Asset Management, SAM – How to Undertake A Facility Audit*, 1st Edition, ISBN 1740520351

Abd-Rani, N. A., Baharum, M. R., Akbar, A. R. N., & Nawawi, A. H. (2014). Perception of Maintenance Management Strategy on Healthcare Facilities, *Asian Conference on Environment-Behaviour Studies, Proceeding Social and Behavioral Sciences*, 170, 272 – 281, www.sciencedirect.com

Abigo, A., Madgwick, D., Gidado, K., & Okonji, S. (2015). Embedding Sustainable Facilities Management in the Management of Public Buildings in Nigeria. *open access,* https://research.brighton.ac.uk., Accessed 11 May, 2020.

Adenuga, O. A., Olufowobi, M. B., & Raheem, A. A. (2010). Effective Maintenance Policy as a Tool for Sustaining Housing Stock in Downturn Economy. *Journal of Building Performance, 1*(1), 93 – 109. http://pkukmweb.ukm.my/~jsb/jbp/index.html

Aghili, N., & Mohammed, A. H. (2017). Management Key Practices For Improving Green Building Performance. *International Journal of Real Estate Studies, 11*(2), 125 – 130.

Akadiri, P. O., Chinyio E. A., & Olomolaiye, P. O. (2012). Design of a Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. B*uildings, 2*, 126-152, www.mdpi.com/journal/buildings.

Akande, O. K., & **Olagunju, R. E.** (2016). Retrofitting and Greening Existing Buildings: Strategies for Energy Conservation, Resource Management and Sustainability of the Built Environment in Nigeria. *Journal of Sustainable Architecture and Civil Engineering*, 15(2), 5-12.

Alexander, K. (1988). Building Appraisal Research Report, Building Performance Studies Unit, Department of Architecture and Building Science, Strathelyde University, Glasgow.

Al-Hammad, A. M. (1998). Principles of Maintenance, Handout, College of Environmental Design, KFUPM, Saudi Arabia. faculty.kfupm.edu.sa

Amole, O. O. (1997). An Evaluation of Students Residential Facilities in Some Nigerian Universities. Unpublished PhD Thesis, Department of Architecture, Obafemi Awolowo University, Ile-Ife, Nigeria.

Anele, D. (2010). Public Property, Maintenance Culture and the Nigerian. Nigeria: *The Punch,* Cited in Abigo, A., Madgwick, D., Gidado, K., & Okonji, S. (2011). Embedding Sustainable Facilities Management in the Management of Public Buildings in Nigeria. https://cris.brighton.ac.uk

Ansah, R. H., Sorooshian, S., & Mustafa, S. B. (2016). Lean Construction: An Effective Approach for Project Management. *ARPN Journal of Engineering and Applied Sciences, 11*(3), 1607 – 1612, www.arpnjournals.com

Asif, M., Muneer, T., & Kelly, R. (2007). Life Cycle Assessment: A Case Study of a Dwelling Home in Scotland. *Build. Environ*., *42*, 1391–1394.

Asmone A. S., & Chew M. Y. L. (2016). Sustainable Facilities Management and the Requisite for Green Maintainability, Conference Paper, SMART Facilities Management Solutions Regional Focus Group Session Challenges & Opportunities for Facilities Management in AEC, Sands Expo & Convention Center, Singapore, 1 – 19.

Atamewan, E. E., & **Olagunju, R. E.** (2017). Sustainable Low-Income Housing and Practicable Minimum Design Standards In Bayelsa State Nigeria. *Journal of Sustainable Architecture and Civil Engineering,* 3(20), 14-24.

Ayedun, C. A., & Oluwatobi A. O. (2011). Issues and Challenges

Militating Against the Sustainability of Affordable Housing Provision in Nigeria. *Business Management Dynamics, 1(*4), 1-8, www.bmdynamics.comm

Aziz, F. R., & Hafez, M. S. (2013). Applying Lean Thinking in Construction and Performance Improvement. *Alexandria Engineering Journal, 52*(4), 679–695.

British Standards, BS 3811 (1985). *Glossary of General Terms Used in Maintenance Organisation*, Britain, British Standard Institution.

Burcu, G. (2015). Sustainability Education by Sustainable School Design, Department of Architecture, Dokuz Eylul University, *Turkey Procedia - Social and Behavioral Sciences, 186,* 868 – 873.

Carrasqueira, M., & Machado, V. C. (2008). Strategic logistics: Re-designing companies in accordance with Lean Principles. *International Journal of Management Science and Engineering Management, 3*, 294-302.

Chan, E. (2014). Building Maintenance Strategy: A Sustainable Refurbishment Perspective. *Universal Journal of Management, 2*(1), 19-25. http://www.hrpub.org

CSV Architects (2019, May 5). Sustainable Architecture: Eco-Smart Designs. http://www.csv.ca/

Department of Public Works (2002). Strategic Asset Management: Condition Assessment, Online HTML document, *open access,* http*://www.build.gld.gov.au/sam*, retrieved on 22nd January 2008

Dillard, J., Dujon, V., & King, M. C. (2009). *Understanding the Social Dimension of Sustainability*, 1-12. New York: Routledge.

Dimeji-Ajayi, D. (2018). The First Storey Building in Nigeria. Real Estate News, Prestige Magazine. www.propertypro.ng

Exceptional Consults (2019, July 26). History of 1004 Estates? *facebook.com.* Retrieved September 26, 2020.

Faraz, M. T. (2019, May 5). Sustainable Architecture, Eqyptian E-Learning University, Course Hero Homework Help, Sustainable-151106164040-lva1-app6891. www.coursehero.com

Florence, F. A. (2011). An Empirical Analysis of Asset Replacement Decisions and Maintenance Culture in Some Government Organisations Located in Ogbomoso and Ilorin Metropolis as Case Study. *Journal of Management and Society, 1* (3), 01-09.

Foliente, G. C., & Becker, R. (2001). CIB PBBCS Proactive Programme–Task 1. Compendium of Building Performance Models: *CSIRO Building,* Construction and Engineering, Victoria, Australia.

Fusion (2020, June 13). Byblock Build Demonstration. YouTube.

Gupta, D., Sharma, P., Aggarwal, R., & Malik, S. (2016). Neo-futurism, Tropical Modernism, Sustainable Architecture. *Slideshare*, HOA- VI

Hitchcock, R. J. (2002). High Performance Commercial Building Systems Program, Element 2 Project 2.1-Task 2.1. 2, Standardized Building Performance Metrics.

Horner, R. M. W., El-Haram, M. A., & Munns, A. K. (1997). Building maintenance strategy: A New Management Approach. *Journal of Quality in Maintenance, 3*(4), 273–280.

Hui, S. C. M. (2002). Sustainable Architecture and Building Design (SABD). http://www.arch.hku.hk/research/BEER/sustain.htm

Iyagba, R. O. A. (2005). The Menace of Sick Buildings – A Challenge to all for its Prevention and Treatment. An Inaugural lecture delivered at University of Lagos, Lagos.

James, D. B. (1972). The Maintenance Manager and Maintenance Policy. *Building Maintenance.* Britain. Cited in Zubairu, S. N. (2010). The National Building Maintenance Policy for Nigeria – the Architects' Perspective, Conference Paper, The Architects' Colloquium of the Architect Registration Council of Nigeria at

Yaradua Conference Centre, Abuja, Nigeria.
https://www.researchgate.net/publication/311101471

Khamidi, M. F., Lateef, O. A., & Idrus, A. (2010). Building Maintenance: A Path Towards Sustainability. *Malaysian Construction Research Journal, 7*(2), 47 – 59, https://www.researchgate.net/publication/279468572

Kim, J. J. (1998). Sustainable Architecture Module: Introduction to Sustainable Design, National Pollution Prevention Center for Higher Education, www.umich.edu/~nppcpub/

Lahiri, R. N., Sinha, A., Chowdhury, S., Chowdhury, S. P., & Crossley, P. A. (2008). Importance of strategic maintenance management for Indian utility industry. 2008 IEEE Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 1–5. doi:10.1109/PES.2008.4596368

Landman, M., (1999). Breaking through the Barriers to Sustainable Building: Insights from Building Professionals on Government Initiatives to Promote Environmentally Sound Practices, MSc in Urban and Environmental Policy, Tufts University.

Lee, R. (1998). *Building Maintenance Management*, Third Edition. Cornwall: Blackwell Science.

Li, F., Yan, T., Liu, J., Lai, Y., Uthes, S., Lu, Y., & Long, Y. (2014). Research on Social and Humanistic Needs in Planning and Construction of Green Buildings. *Sustainable Cities and Society 12*, 102–109. doi:10.1016/j.scs.2014.03.003.

Lozano, E. (1990). *Community Design and the Culture of Cities*. New York: Cambridge University Press.

Magutu, J., & Kamweru, K. (2015). The Phenomenon of Building Maintenance Culture: Need for Enabling Systems, *Global Journal of Engineering, Design and Technology, 4(*5*), 8-12,* www.gifre.org

Mark, C. E., Ogaji, S. O. T & Probert, S. D. (2006). Strategic Maintenance Management in Nigerian Industries. *Journal of Applied Energy, 83*(3) 211-277, Malaysia: Mc-Graw Hill.

Maude, A. (2014). Challenging Assumptions: A Sustainable View of Sustainability? *Geography*, *99*, Part 1, Spring, 47 – 50. https://www.researchgate.net/publication/265845217

McDonough, W., & Braungart, M. (2012). The Hannover Principles: Design for Sustainability, Germany. www.mcdonoughpartners.com

Mendler, S. F., & Odell, W. (2000). *The HOK Guidebook to Sustainable Design*. New York: John Wiley & Sons.

Melyan, N. H. (2019, April 24). Sustainable Architecture, Career Ready Professionals, Tanri Abeng University, finalsustainablearchi, 150831163646, Iva1-app6891

Morenikeji, W., Umaru, E., Pai, H., Jiya, S., Idowu, O., & Adeleye, B. M. (2017). Spatial Analysis of Housing Quality in Nigeria. *International Journal of Sustainable Built Environment,* 6, 309–316.

Mostafa, S, Dumrak, J., & Soltan, H. (2013). A Framework for Lean Manufacturing Implementation. *Production & Manufacturing Research, 1*, 44-64.

Mostafa, S., Dumrak, J., & Soltan, H. (2015). Lean Maintenance Roadmap. *2nd International Materials, Industrial, and Manufacturing Engineering Conference, Bali Indonesia, Procedia Manufacturing, 2*, 434 – 444, www.sciencedirect.com

Muehleisen, R. T. (2011). Acoustics of Green Buildings. *Journal of the Acoustical Society of America,* 130(4), 2350, ResearchGate. https://www.researchgate.net/publication/51693917

Namesh, K. I., & Shridhar, A. B. (2014). Integrated Study of Measures & Techniques in Green Building Construction, *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 11* (6), 70-79, www.iosrjournals.org

National Association of Home Builders, NAHB (2007). Study of Life Expectancy of Home Components. Online document, retrieved on 7th May 2020. www.interstatebrick.com

National Population Commission (2006). State Population and Households Distribution by Ownership Status of Dwelling Tables. www.nationalpopulation.gov.ng

NBA Construction Consultants (1985). *Maintenance Cycles and Life Expectancies of Building Components and materials: A guide to data and sources*, London.

Nik-Elyna, M. N. M. (2010). Performance measurement of office buildings maintenance management. University, Malaya.

Oguntola, S. (2013, November 17). Thrills, frills of living in 1004 Estate. *The Nation,* Retrieved September 25, 2020.

Okosun, B., & **Olagunju, R. E.** (2017). Assessment of Factors Contributing to Maintenance Problems in Higher Institutions in Niger State, Nigeria. *Journal of Building Performance*, 8(1), PP. 47-57.

Okwemba, R. A. (1981). Building Maintenance Manuals and their Application to Building Maintenance Management, Dissertation for MSc Course in Building Maintenance Management, University of Reading.

Olagunju, R. E. (2011). Development of Mathematical Models for the Maintenance of Residential Buildings in Niger State, PhD Thesis, Federal University of Technology, Minna, Nigeria.

Olagunju, R. E. (2012). Predictive Modelling for Sustainable Residential building Maintenance in Developing Countries: A Nigerian Case. *Interdisciplinary Journal of Contemporary Research in Business.* 4(6); 1237-1283.

Olagunju, R. E., Adedayo, O. F., Ayuba, P., & Abiodun, O. (2013). Maintenance of the Federal Secretariat Complex Minna, Niger State: A Post Occupancy Evaluation Approach. *Journal of Developing Country Studies,* 3(4), 106-115.

Olagunju, R. E., Adedayo, O. F., Ayuba, P., & Abdulsalam, B. (2012). An Assessment of Users Opinion as a Tool for Generation of Maintenance Process in Shiroro Hotel Minna, Niger State.

Journal of Economics and Sustainable Development (JESD), 3(13), 108-118.

Olagunju, R. E., & Zubairu, S. N. (2016). Post Occupancy Evaluation of Students' Hostel Accommodation in Federal University of Technology, Minna. *Journal of Building Performance,* 7(1), 105-115.

Olagunju, R. E. (2012). Sustainability of Residential Buildings in Nigeria: An Appraisal of the Factors that Influence Maintenance of Residential Buildings' Standards. *Journal of Civil and Environmental Research,* 2(4), 20-29.

Olanrewaju A. A., & Kafayah, S. T. (2008). The Need to Maintain our Buildings: Sustainable Development. *In Proceedings of PSIS Enviro (The 1st National Seminar on Environment, Development and Sustainability*. Politeknik Sultan Idris Shah, PSIS, Sabak Bernam, Selangor, Malaysia.

Olayiwola, L. M., Adeleye, O., & Ogunshakin, L. (2005). Public Housing Delivery in Nigeria: Problems and Challenges, World Congress on Housing Transforming Housing Environments through the Design, Pretoria South Africa, pp. XXXIII IAHS

Oliveira, A. M., Lopes, I. D. S., & Figueiredo, D. (2014). Maintenance Management Practices of Companies of the Industrial Pole of Manaus. Proceedings of the World Congress on Engineering and Computer Science (WCECS), (2), 22-24, San Francisco, USA

Pradhan, D. (2014). Expressionist Architecture: Expressionism, Modernism and Sustainable Architecture, Contemporary Architecture. https://www.slideshare.net

Residents of 1004 Estates Sack Management Committee Over Decaying Infrastructure. (2017, February 12). New York: Sahara Reporters. Retrieved September 25, 2020.

Roaf, S, Fuentes, M., & Thomas, S. (2007). *Ecohouse: A Design Guide, Third Edition,* Jordan Hill, Oxford. Elsevier Ltd.

Royal Institute of Chartered Surveyors (1990). *Planned Building*

Maintenance, A Guidance Note, Free pdf download books, Building Services Division, Royal Institute of Chartered Surveyors (RICS).

Sameh A. M., Mohamadien M. A., Ahmed S., Eisawy A. S., & El-Arabi I. A. (2015). Sustainability Factors Affecting Maintenance of Residential Buildings. *International Journal of Management (IIJM), 3*(11), 15-30.

Seeley I. V. (1987). *Building Maintenance*, Second Edition, London: Macmillan Publishers Ltd.

Silva, A., Gaspar, P. L., & Jorge de, B. (2016). Methodologies for Service Life Prediction of Buildings With a Focus on Façade Claddings. *Green Energy and Technology*, International Publishing Switzerland, Springer.

Smith, R. (2004). What is Lean maintenance? Elements that need to be in place for success. *Maintenance Technology,* 15-21.

Spedding, A. Holmes, R., & Shen, G. (1995). Managing Major Items of Maintenance in Large Organisation. *Chartered Surveyor Monthly*, England, April, p. 27

Stone, P. A. (1970). The Application of Design Evaluation Techniques, *Building*, Britain, 20th March.

Suwaibatul-Islamiah, A. S., Abdul-Hakim, M., Syazwina, F. A. S., & Eizzatul, A. S. (2012). *An Overview Development of Maintenance Culture*, Proceedings from 3rd International Conference on Business and Economic Research, 2206 - 2217.

Tan, Y., Shen, L., Langston, C., Lu, W., C.H., & Yam, M., (2014). Critical Success Factors for Building Maintenance Business: A Hong Kong Case Study. *Facilities, 32*, 208–225. doi:10.1108/F-08-2012-0062.

Thomson, M. (2012). Repair and maintenance obligations under the commercial lease.

Tijani, S. A., Adeyemi, A. O., & Omotehinshe, O. J. (2016). Lack of

Maintenance Culture in Nigeria: The Bane of National Development. *Civil and Environmental Research, 8*(8), 23 – 30.

United Nations Development Programme (2015). Sustainable Development Goals. https:www.undp.org

Van-Wagenberg, A. F. (1989). Post Occupancy Evaluation for General Hospitals and Other Buildings, *Paper presented at First International Symposium on Facility Management*, Washington D. C. May, 10 – 12.

Womack, J. P., & Jones, D. T. (2003). *Lean Thinking: Banish Waste and Create Wealth In Your Corporation,* Second Ed., New York: Free Press, Simon & Schuster Inc.

World Commission on Environment and Development – WCED, (1987). *Our Common Future*, Oxford, UK: Oxford University Press.

Youth Leadership Summit (2012). Sustainable Architecture, Sustainable Hawaii Youth Leadership Initiative, sustainablearchitectureallie, 130202125903, phpapp.

Zainul. N. A. (2006). Challenges in Integrating Sustainable Issues into Value Management. *International conference in the Built Environment in the 21st century.*

Zimring, C. M., & Reizenstein, J. E. (1980). Post Occupancy Evaluation: An Overview, *Environmental and Behaviour*, *12*(4), 429 – 450.

Zubairu, S. N. (1999). Maintenance of Government Office Buildings in Nigeria: A Post-occupancy Evaluation Approach. Unpublished PhD. Thesis, Department of Building, University of Lagos, Nigeria.

Zubairu, S. N. (2010). The National Building Maintenance Policy for Nigeria – the Architects' Perspective, Conference Paper, The Architects' Colloquium of the Architect Registration Council of Nigeria at Yar'adua Conference Centre, Abuja, Nigeria. https://www.researchgate.net/publication/311101471

Zubairu, S. N., & **Olagunju, R. E**. (2012). Post Occupancy Evaluation of some selected Secondary Schools in Minna. *Journal of Economics and Sustainable Development*, 3(7), 112-119.

Zulkarnain, S. H., Zawani, E. M. A., Rahman, M. Y. A., & Mustafa, N. K. F. (2011). A Review of Critical Success factor in Building Maintenance Management Practice for University Sector. *World Academy of Science, Engineering and Technology*, *53*, 195-199.

PROFILE OF THE INAUGURAL LECTURER

Architect Professor Remi Ebenezer Olagunju was born on 1st October, 1963 to the family of Late Pa Daniel Oladele Olagunju and Late Mrs. Mary Folorunsho Olagunju of Oluawo's Compound, Inisa, Osun State.

He started his educational career at the St. Peter's Anglican Primary School, Inisa in 1970. He later transferred to St. Michael Primary School, Ikirun where he competed his primary education in 1975. He proceeded to St. Michael Commercial Modern School, Ikirun and graduated in 1978. With his Modern School qualification, he gained admission into Form II at Ajasse-Ipo Comprehensive High School, Ajasse-Ipo, Kwara State in 1978. He later transferred to Inisa Grammar School, Inisa, Osun State (Oyo State then) in 1979 and graduated in 1982. He furthered his educational career to Osogbo Grammar School (HSC) for his Higher School Certificate and completed in 1984.

He later got admission to Ahmadu Bello University, Zaria, Nigeria where he obtained B.Sc. (Hons.) Architecture and M.Sc. Architecture in 1988 and 1990, respectively.

Architect Prof. Olagunju took up appointment with the Kwara State Polytechnic, Ilorin between 1992 and 1995. He later joined the services of Federal University of Technology, Minna, Nigeria in 1995 as Lecturer II in the Department of Architecture. While on the job, he embarked on his PhD Architecture programme in the same Department as one of the ten pioneer PhD students and later graduated as the only rigor survival of the 1st set and the 1st PhD product of Architecture Department in 2011. He progressed

steadily from September 1995 as a Lecturer II to the rank of a Professor in 2017.

Prof. Olagunju was appointed among others as the Sub-Dean, School of Environmental Technology between 2010 and 2011, Head of Architecture Department between 2011 and 2016, and as the current Dean, School of Environmental Technology. He has served as Chairman of various Committees at the Department, School and University levels; Professional Association, Nigerian Institute of Architects, Niger State Chapter and Religious body, Living Faith Church, Bosso – Minna. He has also served as External Examiner to many Polytechnics and Universities, and as well as NUC Accreditation Team member to some Universities.

He is a member of the Architects Registration Council of Nigeria (ARCON), Nigerian Institute of Architects (NIA), Association of Architectural Educators in Nigeria (AARCHES), SERVICOM Marshal, Federal University of Technology, Minna and Special Marshal, Unit 5, Federal Road Safety Corp 7.2, Minna, Niger State.

Prof. Olagunju has successfully supervised and graduated many PhD and Master Students. He is happily married with children.