THE IMPACT OF CLIMATE CHANGE ON BUILDING DESIGNS

BY

IZEGAEGBE OVERCOMER PRINCESS

MAT. NO: ENV1805737

DEPARTMENT OF ARCHITECTURE,

FACULTY OF ENVIRONMENTAL SCIENCES

UNIVERSITY OF BENIN,

BENIN CITY, EDO STATE.

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A RESEARCH PROJECT PROPOSAL SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE,

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DECLARATION

I **IZEGAEGBE OVERCOMER PRINCESS**, humbly declare that, this project is based on a study entitled: **THE IMPACT OF CLIMATE ON BUILDING DESIGNS** undertaken by me in the department of Architecture, University of Benin, under the supervision of **Arc. Osesenaga Okieimen**. The information derived from the literature has been dully acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

IZEGAEGBE OVERCOMER PRINCESS

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Signature & Date

CERTIFICATION

This dissertation titled: THE IMPACT OF CLIMATE ON BUILDING DESIGNS by **IZEGAEGBE OVERCOMER PRINCESS**, is hereby certified to have met the regulations governing the award of Bachelor's degree in Architecture of the Department of Architecture, Faculty of Environmental science, University of Benin, Benin City, Edo State, Nigeria and it's approved for its contribution to knowledge and literary presentation.

……..	……..……..
ARC. OSESENAGA OKIEIMEN	**ARC. FELIX IGHODALO OMOBUDE**
Project Supervisor.	Head of Department.

DEDICATION

This study is dedicated to the Master Architect of the universe; God almighty, who in spite all hurdles saw me through my undergraduate program.

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My sincere gratitude goes to my parents Mr. & Mrs. Izegaegbe Overcomer Princess for their support and unending love, also to all my siblings, thank you for your support and love through the years.

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ABSTRACT

A sustainable design guide has a huge potential to enhance the sustainability of the built environment. This project work investigates the impact of climate change on building designs using two prominent areas in Benin City as case studies; The Centenary Celebration of Egedege N' Okaro and National Museum, Benin City Edo State. The design and method of this study which is mostly observation and conclusion drawn. The population of the study are basically conventional buildings methods, materials, and design concepts used in Benin City's historical architectural style. The findings of this study shows that; Climate change is no longer a myth or subject for debate but rather a subject for action, there is a two way relationship between climate change and buildings, there is huge evidence of the negative impacts of climate change globally and particularly in Nigeria and there is very little research activities in the subject of climate and buildings in the sub-Saharan region of Africa. Concluding that Nigeria to take up such challenges and embark on more research studies and as a result provide data as tangible evidence to argue for more government actions for the overall good of sustainable development in Nigeria. Thus, the research aim is achieved with the formulation of a sustainable residential design framework. Also, all the research objectives and research questions were addressed as stated at different sections of this thesis, therefore recommending that it is necessary for the government to encourage active participation of the built environment professionals (stakeholders) on its policy formulation teams in order to encourage interactions and collaborations, also there is the need for the Nigerian government to encourage institutionalised climate change initiatives at all tiers of government. In order to ensure effective monitoring, evaluation, control mechanism and implementation of climate change initiatives and lastly, there is the need to facilitate and quicken the actualization of the seemingly 'comatose' climate change policy draft and thereafter, to carry out an immediate review in conjunction with professional representatives and other relevant stakeholders.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Climate change has been defined as the variation over time in weather elements, due to the factors of human activities or natural vulnerabilities (Stott et al, 2004; IPCC, 2007; Odjubo, 2010). Climate change has become a global concern and its impact have continued to affect, threaten human life and to a large extent influenced the livelihood of most people across the globe. Expectedly, this development has attracted the attention of world political organization, like the United Nations Organization (UNO), hence has found its way at the top of global environmental agenda, especially in the twenty-first century (Evelyn, 2014). In response to this, most national governments have pointedly domesticated environmentally friendly laws (Evelyn, 2014). The global concern over climate change has been highly acknowledged in literatures and increasingly, researchers have often argued that climate change has the capacity to impact all human activities in every region of the world (Adger et al, 2005; Welch, 2005; McLachlan et al, 2007; Prato, 2007; Bond, 2010; Cole, 2011; Lawler, 2009; Steidl et al, 2009) and they have therefore suggested proactive and sustained action to tackling its effects across countries.

Arguably, the global awareness about climate change has encouraged the evolvement of deliberate policies to reducing its impacts across all countries (Dimondi and Tompa, 2008; Sozen and Api, 2009; Wilby, 2007; Senitkova and Culakova, 2011). This development have further seen various national governments across Africa been informed about the potential vulnerability of the continent to climate change impacts, if sustained concrete actions are not taken to correct this anomaly (Magadza, 2000; Hulme et al, 2001; Callaway, 2004; Hulme et

al, 2005; Christensen et al, 2007; Onyekuru and Marchant, 2011), following the negative impact that has been observed already across the continent in recent years (Conway, 2008).

This owes mainly to the lack of capacity to contain the adverse consequences of climate change, which by implication makes Africa the worst for it (Evelyn, 2014). Despite this unfortunate unfolding disaster, very little research activity and data are available on climate change baseline scenario, forecast, trends and magnitude of it impacts across the African continents (Conway, 2008; Onyekuru and Marchant, 2011) and particularly in the academia.

According to Durant et al. (2011) carbon dioxide (C02) dominates the greenhouse gas (GHG) emissions contributing around 80% of all ghg emissions (Lashof and Ahuja, 1990) hence, it is vital to have a deeper understanding on their sources. Conversely, other studies suggests that buildings are the major sources of emissions (CIBSE, 2005; UNEP, 2009; Cole, 2011; Janda, 2011) particularly in developing nations, arguably because of the substantial lack of relevant technical knowledge required in building design, materials and processes.

Firstly, because the lack of technical knowledge reflects on building design, materials and processes employed (Evelyn, 2014). Secondly, available evidence point to the fact that solutions to climate change induced problems are not solely technical problems requiring technical solutions, rather it is more to do with human behaviour and how they relate to the larger environment (Evelyn, 2014). Although much research is currently being focused on energy efficiency in buildings (Senitkova and Culakova, 2011; Marino et al, 2012) however, energy efficiency requires good knowledge of scientific tools, shortage of skills, and other technical complexities that may not be readily available or an immediate option for any developing economy like Nigeria (Morton, 2007; Arif et al, 2012a).

It is therefore necessary to know what knowledge is available for design options in poorer countries that may not be able to afford additional cost in the life of a building already being faced with impacts of a changing climate (Evelyn, 2014).

Generally, buildings have great impact and influences on the natural environment (Evelyn, 2014). Some researchers have been noted that buildings contribute about 50 percent of the world's carbon emissions into the environment (Stern, 2007; Altomonte, 2008; Robert and Kummert, 2012). Other researchers also observed that around 90 percent of people spend about 90 percent of their daily time inside buildings (Dimondi and Tompa, 2008; Essig et al, 2011; Robert and Kummert, 2012).

It is therefore, necessary to minimise problems that occupants may face in terms of comfort and climatic risks (Evelyn, 2014). Zubairu (2012) argues that in order to minimise the problems faced by occupants of buildings a sustainable building design is required. While other similar literature suggests that there is an inter-relationship between climate change and buildings (Wilby, 2007; Berrang-Ford et al, 2011; Bond, 2011; Simon 2011; Janda, 2011). Hence buildings contribute significantly to climatic changes and its impacts on the natural environment as such making a study such as this important (Evelyn, 2014).

Although buildings may contribute to climate change, obviously buildings themselves are equally vulnerable to the impacts of climate change themselves (Evelyn, 2014). According to UN Habitat report (2009) buildings are most vulnerable to climate change, because all the indicators of climate change such as flood, hurricane, bush fires and other adverse effects have huge consequences for the effective functionality of buildings. What this emphases is an intertwined interface between buildings and the natural environment and climate change (Parry et al, 1998; Cole, 2011; Mortimore, 2010; William et al, 2012). Furthermore, it is the interface between a building's outdoor environment affected by climate change with its

interior environment and the comfort required by its occupants that makes it significant (Zubairu, 2012).

It is important to understand the effects and impacts climate change has on the environment in order to determine the processes of designing new buildings that will mitigate and adapt to the climatic changes (Audin, 2001; Roberts, 2008; Apay, 2011; De Wilde, 2012). Buildings have a long life span and throughout their life span, buildings continue to consume energy and release greenhouse gases (American Institute of Architects (AIA) 2011; De Wilde and Coley, 2012). Thus, any action taken to render buildings sustainable now will prove effective for today and for the future (Evelyn, 2014).

The ability to make buildings sustainable means that the buildings are able to mitigate and adapt to climatic changes (Evelyn, 2014). Sustainable buildings are also cost effective and achievable through sustainable design and especially when the commitments of stakeholders to ensure the sustainability of buildings is assured (Guan et al, 2005a; Guan et al, 2005b; Guan, 2009; Radhi, 2009; Beak, 2011; Bond, 2011). By implication, building designs would require specific inputs from current climatic indices to make them mitigate and adapt to a changing climate (Evelyn, 2014).

This preceding discourse lays the background for this research project to include inputs from the built environment professionals, through primary data sourcing using questionnaires and semi-structured interviews (Evelyn, 2014). This will ascertain what mitigation and adaptation considerations and options are available to inform suitable choices for a design guideline for residential buildings for a changing climate in Nigeria (Evelyn, 2014).

The importance of sustainable building design solutions is widely acknowledged (Evelyn, 2014). Hence, the general arguments suggest that potential capacities for curbing climate change should be sustainable (Commission for Architects and the Built Environment (CABE),

2007; Colker, 2006; Hales et al, 2007; Altomonte, 2008). Sustainable building design reduces man-made negative influences on a building's life time, from the design stage to when a building becomes functional (Wang et al, 2009).

Furthermore, the relevance and importance of understanding the need for sustainable buildings is rarely seen in Africa's built environment design (Dixon et al, 1996; Twumasi et al, 2005; Oluwatayo, 2011; Onyekuru and Marchant, 2012). One of the most effective channels by which strategies are used to tackle climate change occurrences in the built environment are through sustainable design particularly for buildings (Evelyn, 2014). The resilient strategies that are foremost are those which allow structures to accommodate disturbances without losing their components and functionality (Abidin, 2010; Beak, 2010; Larsen et al, 2011). It is deducible to suggest that research relating to sustainable design processes that will allow buildings to mitigate and adapt to climate change impacts is lacking in most developing countries, particularly Sub- Saharan African countries (Evelyn, 2014). This again gives this research project relevance because; it will seek to bridge the gap with sustainable design guidelines in Nigeria, which would be a novelty for the country (Evelyn, 2014).

The Kyoto Protocol generally recognises two approaches to climate change alongside the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) which was created to promote the UN's human development goals through the activities of IPCC in providing assessments on scientific findings, technology, socio-cultural resource that will serve the global communities in understanding the risks of anthropogenic (humaninduced) climate change as well as making projections of impacts and the integration options of mitigation and adaptation (IPCC, 1990; IPCC website, 2010).

Therefore, to have a fuller understanding about the implications of climate change in an area or certain activities would require a comprehensive and thorough investigation (Evelyn, 2014). Such investigations should be directed at exploring the perceptions and reactions of the sector's stakeholders and professionals at local levels (Yohe et al, 2007; Conway, 2009; Ebohon et al, 2013). The differences in climate change impacts are dependent on key natural peculiarities inherent in an area, location or region where the impacts are being felt (Heller and Zavalera, 2009; Perez, 2009; Dudley et al, 2010). This research supports the preceding argument and consequently, adopts a combination of methods to gauge the perceptions of professionals in the building sector on climate change and its effects on buildings (Evelyn, 2014) designs. Hence it will be vital to drill down on some of those key natural peculiarities inherent across the three climate regions in Nigeria while developing the new framework that would guide the design of residential buildings (Evelyn, 2014).

Also, Greenwood et al. (2011) observed that the challenges associated with technological expertise, geographical requirements and increasing attempts of modifications by other countries are some of the reasons why there are country variations in design guides. The key research rationale is therefore drawn from the observations of Larsen et al. (2011) who argued that the focus of research on sustainable building practices, especially in the United States are mainly on the reduction of greenhouse gas emissions, however, their study also suggests the inclusion of sustainable twin- strategy.

Also, is the lack of academic materials, including data on climate change, especially in relation to buildings in Africa (Conway, 2008; Laryea, 2011).

1.2 STATEMENT OF RESEARCH PROBLEM

This research suggests the use of sustainable design guide for Nigeria in order to ameliorate the challenges facing design professionals in Nigeria in response to climate change (Evelyn, 2014). Nigeria is the most populated country in Africa and obviously one of the most populated in the world (World Bank, 2003). In 2012 Nigeria's population stood at 167 million (National Population Commission, 2012) with an annual growth rate of 3 per cent (Mu'azu, 2011). Despite potential economic value of having a sizable population, Nigeria like most other African countries appears not to be putting proactive measures in place to check Climate Change (Christensen et al, 2007; USAID, 2009; Onyekuru and Marchant, 2012; Pat-Mbano et al, 2012). Thus, exposing its population to high risks and vulnerabilities associated with climate change (Evelyn, 2014).

Furthermore, the challenges of climate change are likely to accumulate based on two reasons (Evelyn, 2014). Firstly, Nigeria is projected to require about 40 million houses to meet its housing demands or deficit by 2020 (Ademiluyi and Raji, 2008; Ademiluyi, 2010; Ogu and Ogbuozobe, 2011). Secondly, giving the impact of the built environment on climate change, unless these houses are sustainably designed, the impact of such a scale of housing building on the larger environment would be quite severe (Evelyn, 2014).

Furthermore, the lack of identified regional design parameters for Nigeria and the importance of such indicators at the design stage of building are significant to building performance and the production of sustainable buildings (Eromobor and Das, 2013). Thus, if the design of the expected new residential buildings is left unsustainable, Nigeria would become a potentially high carbon emitter in the near future (Evelyn, 2014).

Unfortunately, this Figure suggest that developing countries has progressively accounted for a much higher proportion of global CO2 emissions since 2000 and has presently surpass the

Kyoto commitment level (Evelyn, 2014). This clearly has a huge implication for the natural environment considering the carbon emissions expected if no action is taken especially at the early design stage of new buildings across developing countries, particularly in Nigeria which is the context of study (Evelyn, 2014).

Firstly, at the early design stage of buildings it is important that the right decisions are taken (Evelyn, 2014). Bogenstätter (2000) had noted that 20% of any building design decision at the early phase of design has 80% consequences on the overall design. As such, early building design decisions are of great significance to design outcomes (Allu et al, 2013). Earlier studies have suggested that, it is not an easy task for the design professionals (architects) to make these decisions without some form of guide (Anthienitis, 2010; Morszal, 2011). Conversely, other scholars argued that quite a number of available decision tools for building performance do not always address early considerations for the architect thus are unable to accommodate the environmental conditions of hot climate regions (Attia et al, 2009; Doe, 2011). In addition, these tools are noted to only (Evelyn, 2014) "focus on addressing the building geometry and envelopes" (Attia, 2012. p.7).

Secondly, the conclusions drawn by Arif et al. (2009) which is also supported by Mu'azu (2011) observed that developing countries like Nigeria have had a big leap in their construction activities in recent years due to their rapid population. Arif et al. (2009) further observed that, increased construction activities are synonymous with increased concern for environmental sustainability. Unfortunately, the current Nigerian Building Code (NBC) only focuses on basic building standards Mu'azu (2011). The NBC also fails to address some relevant themes like sustainable standards, features for design consideration and climate change strategies to mention but a few (Evelyn, 2014).

Thirdly, Emuzie et al. (2013) expressed their concern by questioning the knowledge of the built environment professionals in Africa and their ability to apply the sustainable concepts in their practices. Furthermore, Eromobor and Das (2013) have observed that identifying design parameters, has high potentials for achieving sustainable building and enhancing their performance (Eromobor and Das, 2013). Furthermore, Attia (2012) noted that architects are constantly in search of decision tools that would aid and promote design decisions (Attia, 2012).

The combination of these problems (large population, housing deficit, vibrant construction sector, lack of sustainable guiding standards, low level of knowledge on sustainable concepts and application by professionals and the lack of identified design parameter and decision tools) poses significant challenges to Nigeria (Evelyn, 2014). Hence, the attempt by this researcher to identify the potential strategies for the development of sustainable design guide through the creation of a framework that will serve as a decision tool for residential buildings in Nigeria (Evelyn, 2014).

1.3 JUSTIFICATION OF STUDY

The evidence of climate change is overwhelming globally and chapter three of this thesis provides evidence for the Nigerian context (Evelyn, 2014). According to Obioha (2008) and Building Nigeria's Response to Climate Change (BNRCC) (2011), climate change has had destructive effects in Nigeria. One possible explanation for climatic variations in Nigeria is its latitude and longitudinal location (Evelyn, 2014). This also accounts for the differences in the magnitude of the impacts of climate change across the three regions in Nigeria (Evelyn, 2014). It is further argued that, the Nigeria's sub-Saharan region have become poorer in the last generation making it quite difficult to cope as well as adapt to the challenges posed by climate change variability (Washington et al, 2006; World Bank, 2010c; Ogbo et al, 2013).

Hence, increasing poverty levels and exposing its citizens to vulnerability to climate change impacts (Evelyn, 2014).

These differences associated with the magnitude and impacts across the different climatic regions have not been adequately established (Evelyn, 2014). Regrettably also and on the larger scale, available global climate models have also failed to simulate the West African sub-region climate correctly (Cook and Vizy, 2006; IPCC, 2007 AR4; Ruti et al, 2010) due to lack of expert information and data in this critical area. Other reasons for this include but not necessarily limited to inadequate knowledge in this area, poor funding by relevant government, weak institutions and perhaps underdevelopment (Leary et al, 2008; Thabrew and Ries, 2009; Ford et al, 2013) across this sub-region. However, Holmes (2003) concluded that poverty and environmental challenges go hand-in-hand, hence, it is necessary to pursue strategies that combine mitigation and adaptation if developing countries want to succeed in tackling the menace of climate change (Ayers and Huq, 2009), particularly Nigeria.

The housing sector is very important to climate change studies because of the role buildings play in the activities that lead to climatic change (Evelyn, 2014). Furthermore, following the buildings are noted as the main emitters of GHG carbon emissions due to their high level of energy consumption and residential buildings account for the larger share of total energy consumption (Laustsen et al, 2011). Although there is no known specific data for Nigeria, it is generally believed that the Sub-Saharan Africa residential buildings account for about 96 per cent of the total building sector's energy consumption as against 76 per cent of Europe's total residential building sector's energy consumption (Earth Trends, 2005). It is important to acknowledge what actions or inactions successive government in Nigeria have demonstrated in their attempt to tackle the environmental problems caused by climate change (Evelyn, 2014).

A National Climate Change Commission for Nigeria was approved by its Senate in November, 2010 (Evelyn, 2014). Two years later there seem to be no clear or specific agenda as regards to its strategies for Climate Change (Onyekuru and Marchant, 2012). By implication Nigeria is still amongst nations lagging behind in efforts towards implementing policies aimed at tackling the challenges posed by Climate Change, particularly in the building sector (Evelyn, 2014). Despite the fact that the National Adaptation Strategy and Action Plan on Climate Change for Nigeria (NASPA-CCN) published its draft Report since 2011, it is still awaiting government inputs (at the time of this documentation) (NASPA-CCN, 2011). This delay once again shows the lack of seriousness and the slowpace at which an important issue such as the challenges of climate change are being handled by the Nigerian government (Evelyn, 2014).

Therefore, researchers must stress to Nigeria government, the urgent need to step up its climate change initiatives and building designs implementations (Evelyn, 2014). By way of coordinating and integrating all necessary strategies aimed at stemming the effects and impacts of climate change (Ademiluyi, 2010) and particularly in its housing sector (Dada and Akpadiaha, 2013). Thus, the attempt by this researcher to provide tangible research findings that could add to the basis for arguing for prompt action by the Nigerian government cannot be over emphasized (Evelyn, 2014).

This project work is therefore, mainly an exploratory research that looks at the building design practices in the climate change regions in Nigeria in order to know what is required to provide a sustainable design guide for Nigeria as a way of enhancing the sustainability of the built environment in general (Evelyn, 2014). Robson (2002) explains that an exploratory research offers a value study, undertaken to know what is happening in order to find ways to address issues or problems therein. Thus this project work focuses on exploring and investigating the potentials of incorporating both mitigation and adaptation strategies in order

to produce a framework for a sustainable residential design guide for Nigeria. So new buildings in Nigeria are designed and produced with a high capacity to reduce carbon emissions and are able to adapt to the negative impacts of Climate Change being experienced across the country (Evelyn, 2014). Therefore, the research problems and the research limitations provide the basis to undertake the research and further strengthen the choice for Nigeria for a research in the subject area such as this (Evelyn, 2014).

1.4 RESEARCH QUESTIONS

The researcher will attempt to answer the following research questions in other to synchronize and focus the study. The research questions will play a determining role in understanding the implications of the research findings (Evelyn, 2014). These questions are (Evelyn, 2014);

i. What relationship exists between climate change, buildings and the built environment? (Evelyn, 2014)
ii. What evidence exists on the impacts of climate change on residential buildings in Nigeria? (Evelyn, 2014)
iii. What level of knowledge exists amongst design professionals and how do they reflect such knowledge in their design practices? (Evelyn, 2014)
iv. What design parameters are required for the residential buildings in the different climate regions or zones in Nigeria? (Evelyn, 2014)
v. What are the prospects that the proposed sustainable residential design guide will result in sustainable building designs in Nigeria? (Evelyn, 2014)
vi. What role has the Nigerian government played in the subject of climate change and buildings in Nigeria? (Evelyn, 2014)

1.5 AIM AND OBJECTIVES OF THE STUDY

1.5.1 The Research Aim

The main aim of this research is know the impact of climate change on building design and to develop a framework for its actualization in order to promote the design of sustainable buildings in Nigeria (Evelyn, 2014).

1.5.2 Objectives of Research

This research is specifically focused on achieving the following five objectives (Evelyn, 2014):

a) To conduct a critical literature review and identify research gaps in the area of Climate Change and buildings (Evelyn, 2014).
b) To establish the extent to which residential buildings have been impacted by climate change in Nigeria and globally (Evelyn, 2014).
c) To explore and ascertain the key design parameters that will promote the design of sustainable residential building design for the three climate regions in Nigeria (Evelyn, 2014).
d) To ascertain how the knowledge and information available to design professionals are reflected in their design practices (Evelyn, 2014).
e) To evaluate the perceptions of built environment professionals on collaborations and governance on the issues of climate change and sustainability of the built environment (Evelyn, 2014).
f) To ascertain the usefulness of a design guide as tool for design guidelines (Evelyn, 2014).

1.6 RESEARCH HYPOTHESIS

Hypothetically, there is no known design guide for residential design guide across the three climatic regions in Nigeria. Hence, this research is determined to create a framework which will underpin the development of a sustainable design guide for the built environment across the three climatic regions in Nigeria (Evelyn, 2014). It could be argued that, design guides or tools from other regions of the world with different climates do not cover all aspects of problems associated with buildings (Evelyn, 2014). Since the reduction of ghg emissions is still relevant and vital there is need for research to now focus its attention on the understanding of climate change impacts on the environment and to incorporate appropriate design strategies that are sustainable for Nigeria (Evelyn, 2014). More so, this research is relevant because it will help gather much needed information that could validate findings as it concerns the Nigerian context (Evelyn, 2014). Finally, the findings from this study will present raw empirical data for policy makers that could possibly guide them on climate change policy formulation in Nigeria (Evelyn, 2014). It is also expected therefore, that practicing professionals would find some of the empirical data contained in this study relevant to their subsequent residential designs that mitigate and adapt to climate change in Nigeria (Evelyn, 2014).

1.7 SCOPE OF THE STUDY

Basically, the research scope covers the three climatic regions in Nigeria (Evelyn, 2014) but it is narrowed down to two specific areas in Benin City, Edo State with the key purpose of proposing a potentially sustainable residential design guide for the built environment in the country (Evelyn, 2014). With the anticipation that the suggested strategies in the new framework will help design professionals reduce the impact of climate change on buildings across the three regions of built environment in Nigeria (Evelyn, 2014).

1.8 THE STUDY AREA

The research study area is narrowed to two specific areas in Benin City, Edo State, Nigeria;

1. The Centenary Celebration of Egedege N'okaro , Benin City, Edo State
2. National Museum, Benin City Edo State.

1.9 LIMITATION OF THE RESEARCH

Basically, the researcher perceives that there would be limitations to data gathering, specifically current statistical data, and accessing up-to-date journal articles and relevant literatures that would give the research its academic underpinnings (Evelyn, 2014). However, the researcher will overcome this limitation by carrying out an extensive literature reviews on materials relevant to the research topic, consulting books as well as on-line library sources (Evelyn, 2014). This will help broaden secondary sources of data which will give this research the necessary academic underpinning it requires (Evelyn, 2014). Another limitation is the difficulty in identifying and accessing relevant practicing design professionals in Benin City who would be ready to participate in the interview and questionnaire surveys, in an attempt to gather empirical data (Evelyn, 2014). The researcher was address the above limitation through early contacts, right from the start of the research, with practicing professionals who will be ready to participate in the interviews (Evelyn, 2014). Finally, funding was also a limitation, however, without compromising quality and standards, the researcher was able to engage in cost effective options in the application of available funds (Evelyn, 2014).

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The chapter acknowledges past research efforts in the study of climate change and related issues. It also reviewed existing literatures on climate change and buildings to avoid duplicating past research efforts. This chapter is further structured into sections. Section 2.2 defined some terminologies that will re-occur during the discussion stage of this research. Section 2.3 gives an overview of the general knowledge and arguments on climate change, while 2.4 establishes the evidence of climate change globally. However, section 2.5 relates the impacts of climate change on the built environment, while the relationship between climate change and buildings are discussed in section 2.6. The relevance of sustainability to climate change interventions is discussed in section 2.7, and sustainable design guide with examples from the UK are presented in section 2.8. The twin strategies of mitigation and adaptation, in tackling climate change are discussed in section 2.9 and with a brief chapter summary and the implications for the research project are discussed in 2.10 (Researcher).

2.2 TERMINOLOGIES

The technical terms used in this research are those that resonate with the concept of study that is climate change (Evelyn, 2014). These terms also represent those expressed by intergovernmental Panel on Climate Change (IPCC) and have been recognized by international agencies for climate change issues (Evelyn, 2014).

Adaptation: Refers to the initiatives and measures used as strategies to reduce the vulnerability of natural and human systems against happening or and the potential climate change effects (IPCC, 2007).

Climate Change: Is the change in the state or patterns of the climate that can be proven through statistical data with changes in its mean and/or the variability of its properties, and which are persistent for extended periods that are typically decades or longer (IPCC, 2007).

Factors of design strategies: These include; energy, indoor environmental quality, innovations, materials, site, waste, and water conservation (Center for Sustainable Building Research, 2002).

Greenhouse Gas GHG: This refers to the atmospheric gaseous constituents, from both natural and anthropogenic emissions, that absorbs and emits radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere, and by clouds that result into what is known as greenhouse effect (IPCC, 2007).

Kyoto Protocol: The Kyoto Protocol is the United Nations Framework Convention on Climate Change (UNFCCC) initiative, adopted in 1997 in Kyoto, Japan (IPCC, 2007). It sets the intentional intervention for controlling global warming leading to Climate Change and contains legally binding commitments for emission reduction targets for all signatories, especially developed countries (maintain temperature rise below 5%) (IPCC, 2007). The commitment period spans from 2008 to 2012 (IPCC, 2007). The Kyoto Protocol came into action on 16 February 2005 (IPCC, 2007).

Mitigation: Is the deliberate action or implementation of relevant a policy geared towards slowing down of greenhouse gas emissions levels and enhance sinks (IPCC, 2007).

Resilience: Refers to the ability of a social or ecological system to cope or the capacity to adapt to climatic changes and impacts while maintaining its basic structure and functions (IPCC, 2007).

Sustainable design: Requires the use of sustainable principles to integrate factors of design strategies to produce the best sustainable product or building (U.S. Green Building Council (USGBC), 2003).

Sustainable Building Design Guide: Is the product of the integration of information from different professions in the built environment or stakeholders to produce sustainable durable buildings (World Building Design Guide WBDG, 2012).

Uncertainty: Is the futuristic degree or level to which the climate system is known for certain (IPCC, 2007). It is dependent on information or the lack of information and what is known or knowable (IPCC, 2007). The different sources and level of information may contain quantifiable errors that could give wrong data and result that could affect climatic scenarios (IPCC, 2007).

United Nations Framework Convention on Climate Change (UNFCCC): This convention was adopted on 9 May 1992 in New York and was signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community who are part of the international treaty, to jointly consider what they could do to limit the inevitable average global temperature increases and the resulting climate change, and to adapt to whatever the climatic impacts were. The UNFCCC entered into force on 21 March 1994 (IPCC, 2007; UNFCCC, 2012). Presently, it has near-universal 195 countries membership (IPCC, 2007; UNFCCC, 2012). Members who have ratified the Convention are called Parties to the Convention (IPCC, 2007; UNFCCC, 2012).

Vulnerability: Is viewed as the degree or level to which a system is; susceptible to and unable to cope with; adverse effects of climatic changes, including climate variability and extremes (IPCC, 2007). Vulnerability is also a function of the character or attributes,

magnitude, and rate of climate change variation to which a system is exposed, the sensitivity and the adaptive capacity of that system (IPCC, 2007).

2.3 CLIMATE CHANGE: AN OVERVIEW.

Climate change or global warming is often used interchangeably by academics and in the literature publications, but for the purpose of this research, it will restrict its use to 'climate change' (Evelyn, 2014). The term climate change refers to changes that have occurred in the global climate since the 1900s and the ever increasing GHG emissions leading to the catastrophes associated to a changing climate (Brown and Bhatti, 2002; Tompkin and Adger, 2004; UK Climate Impact Programme (UKCIP), 2006; VijiyaVenkataRaman et al, 2012) (Evelyn, 2014). This has become a serious global environmental problem and is considered to be the most significant challenge facing global communities and therefore, making issues of climate change to be taken more seriously in recent times because of its devastating effects on the environment and its inhabitants (Houghton et al, 2001; UNDP, 2002; Fagre, 2007; Stern, 2007; Tompa, 2008; Dimondi, Sozen and Api, 2009; Dudley et al, 2010; Martins and Ferreira, 2011; VijiyaVenkataRaman et al, 2012).

The rate at which the climate has been changing since 1970s is alarming based on published statistical data which shows an average global temperature rise of 0.2oC and a 2 per cent rise in global precipitation (UNFCCC, 1994; Heller and Zavalera, 2009). The impact of climate change is felt in all areas of physical, ecological and social wellbeing, therefore, could presents potential challenges to researchers and future livelihoods (IPCC, 2007; Costello et al, 2007; Bond, 2010; Nath and Behera, 2011). This thesis is thus a follow up attempt to contribute to the future of buildings in Nigeria and in general terms to enhance environmental sustainability (Evelyn, 2014).

2.3.1 Causes of Climate Change

Climate change in this section is viewed as a problem that basically affects the environment in a significant way, thus, it has to be taken quite seriously (Evelyn, 2014).

However, there are several arguments on the causes of climate change (Lowe, 2003; Lorenzo et al, 2007), which can be drilled down to four main strands.

The first argument suggests that climate change is a natural phenomenon (Evelyn, 2014). Those in agreement argue that the earth`s climate has changed several times in response to natural causes, these natural climatic changes are said to be a reflection of variability over certain time scales (American Meteorology Society, 2006; Karl et al, 2009). These natural causes include; interactions between oceans and the atmosphere, changes in the Earth`s orbit patterns, microcosmic properties of the climate systems, frequencies in weather elements, increase in the degree of variability, and volcanic eruptions of gases which absorb energy that are radiated from the earth's surface (Sanders and Philipson, 2003; Tompkin and Adger, 2004; Karl et al, 2009; UK climate change impacts programme (UKCIP), 2011).

The trapped or absorbed energy concentration in the atmosphere warms the atmosphere and in turn increases the earth surface temperatures globally, as shown in Figure 2.1 (Evelyn, 2014). Therefore, the persistent shift in the mean state of natural climate or in its variability refers to Climate Change (Ziervogel and Zermogllio, 2009). Hence, these arguments support the view that climate change occurs naturally (Evelyn, 2014). If this view holds, actions currently taken to reverse climate change effects are not only superfluous but likely to distort the patterns of the natural environment (Evelyn, 2014).

Conversely, climate change is believed to have been induced by the activities of human beings (Evelyn, 2014). This view is consistent with views held by academic pundits like (Karl and Trenberth, 2003) who argued that climate change is caused by human beings (Anthropogenic). Supporting Karl and Trenberth (2003) therefore, Odjubo (2010), Younger et al. (2008) and Hondula et al. (2014) proceeded to identify some man-made factors like, urbanization, transportation, land use, deforestation, geometric increase in global population,

industrialization and increased release of greenhouse gases which are mainly from buildings. Research has shown that these factors deplete the ozone layer, which has resulted in global climate change. Specific evidence of anthropogenic emissions would include Carbon dioxide (C02), Green House Gases (GHGs), Nitrous Oxide (N20), Methane (ch4), Ozone (O3) and Chlorofluorocarbons (CFCs) have terribly caused global warming, which obviously have resulted in climate change as we know it today (IPCC, 2007; Forster et al, 2007; U.S. Green Building Council (USGBC), 2010; Welch, 2005).

Further to the above, anthropogenic induced climate change affects all sectors of human activities, especially the built environment which is largely made up of buildings that emit greenhouse gases (Levine, 2008; Larsen et al, 2011). However, it is vital to point out that United Nations Framework Convention on Climate Change, (UNFCCC) clearly endorses this argument on how human induced activities contribute to climate change, and as a result, UNFCCC has focused its activities towards tackling the components of human influence over climate change (Washington, 2006). These human factors are linked by processes and mechanism that may be internal or external in nature that occur as a reaction to the activities of man which results in climate change (Parmesan and Yohe, 2003; O'Brien et al, 2004; Adger, 2005; Jentsch et al, 2008). The result of a survey study conducted by the American Geographical Union (2009) saw 82% of Earth Scientist and 97.4% of Climate Scientist agreeing that human activities are actually responsible for climate change.

A similar study by Bray (2010) also showed that 97% of Climate Scientist agreed that there are evidences that suggest climate change is caused by humans. Some of the identified human factors include; burning of fossil fuel, deforestation, agriculture, water pollution, and urbanization (Evelyn, 2014). These reduce the carbon dioxide absorption capacity of the environment and therefore increase the greenhouse gases concentration in the atmosphere, which causes depletion of the ozone layer which in turn causes global warming (or cooling in

some cases) leading to climate change (Odjubo, 2010) see Figure 2.1. To buttress this point, Figure 2.2 shows clearly that the increased temperature being experienced across the world today demonstrates the fact that different forms of human activities, some of which have been mentioned above, has indeed negatively influenced agricultural production and food supplies (Evelyn, 2014).

Figures 2.1, 2.2 and 2.3 show clearly indication of the processes of climate change globally (Evelyn, 2014).

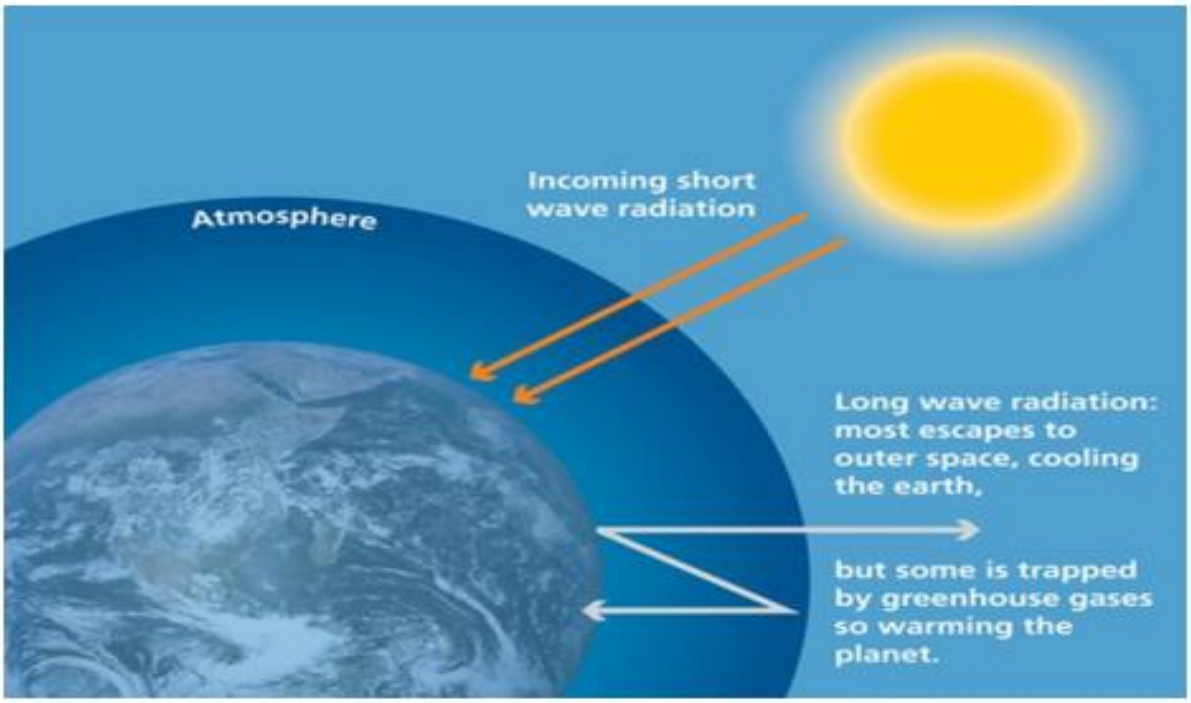

Figure 2.1 Effects of Greenhouse gas emission (Evelyn, 2014).

Source: UK Climate Change Impact Programme (UKCIP) 2011.

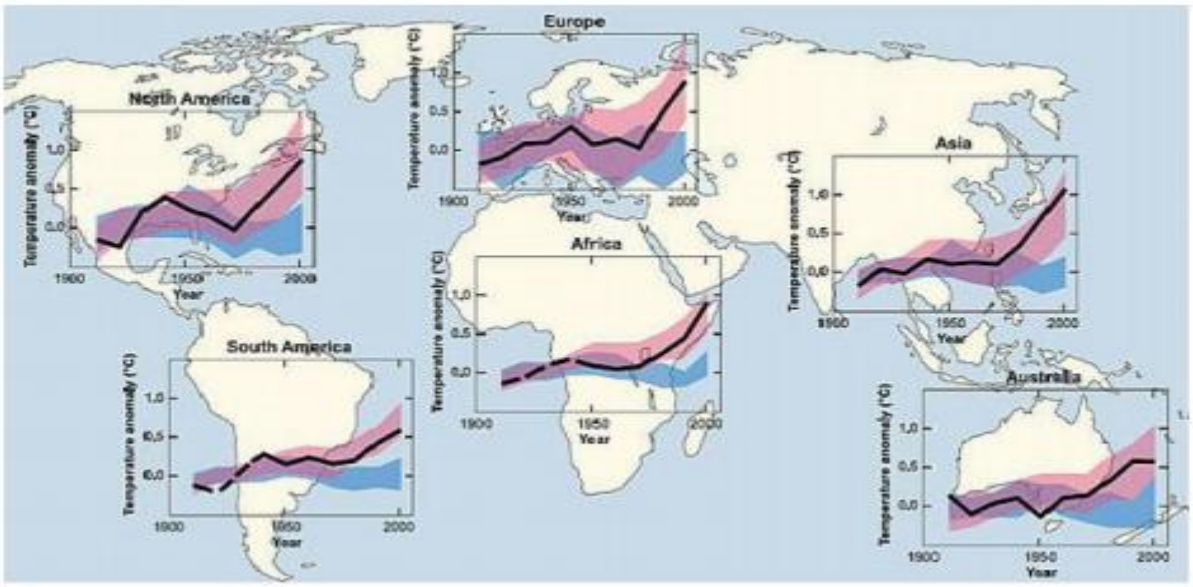

Figure 2.2: Changes in temperatures during 1906-2005 per continent

*(**Blue:** models using only natural forcings. **Red:** models using both natural and anthropogenic forcings -uncertainty margins. **Black:** Decadal averages of observations are shown for the period 1906-2005).*

Source: Pachauri and Reisinger (2007, pp.40).

The third argument suggests that, climate change is caused by both human and natural factors (Stott et al, 2004; IPCC, 2007; Biesbroek et al, 2010; Odjubo, 2010). These combined factors are explained in Figure 2.3, which shows natural factors of biological processes, astronomical and extra-terrestrial factors heating up the earth's surface whilst human-induced activities like; urbanization, deforestation, pollutions continue to emit greenhouse gases into the atmosphere (Evelyn, 2014). Basically, both combined elements are absorbed into the atmosphere apparently leading to global warming which is fundamentally responsible for Climate Change (Evelyn, 2014).

Also, within the context of this strand of argument, evidence shows that climatic change influenced by human activities is of relevance, admittedly, buildings constitutes an aspect of human activity, which forms part of the built environment referred to as

urbanization in Figure 2.3 (Evelyn, 2014). The relationship between climate change and buildings are discussed in sections 2.5 and 2.6 respectively (Evelyn, 2014).

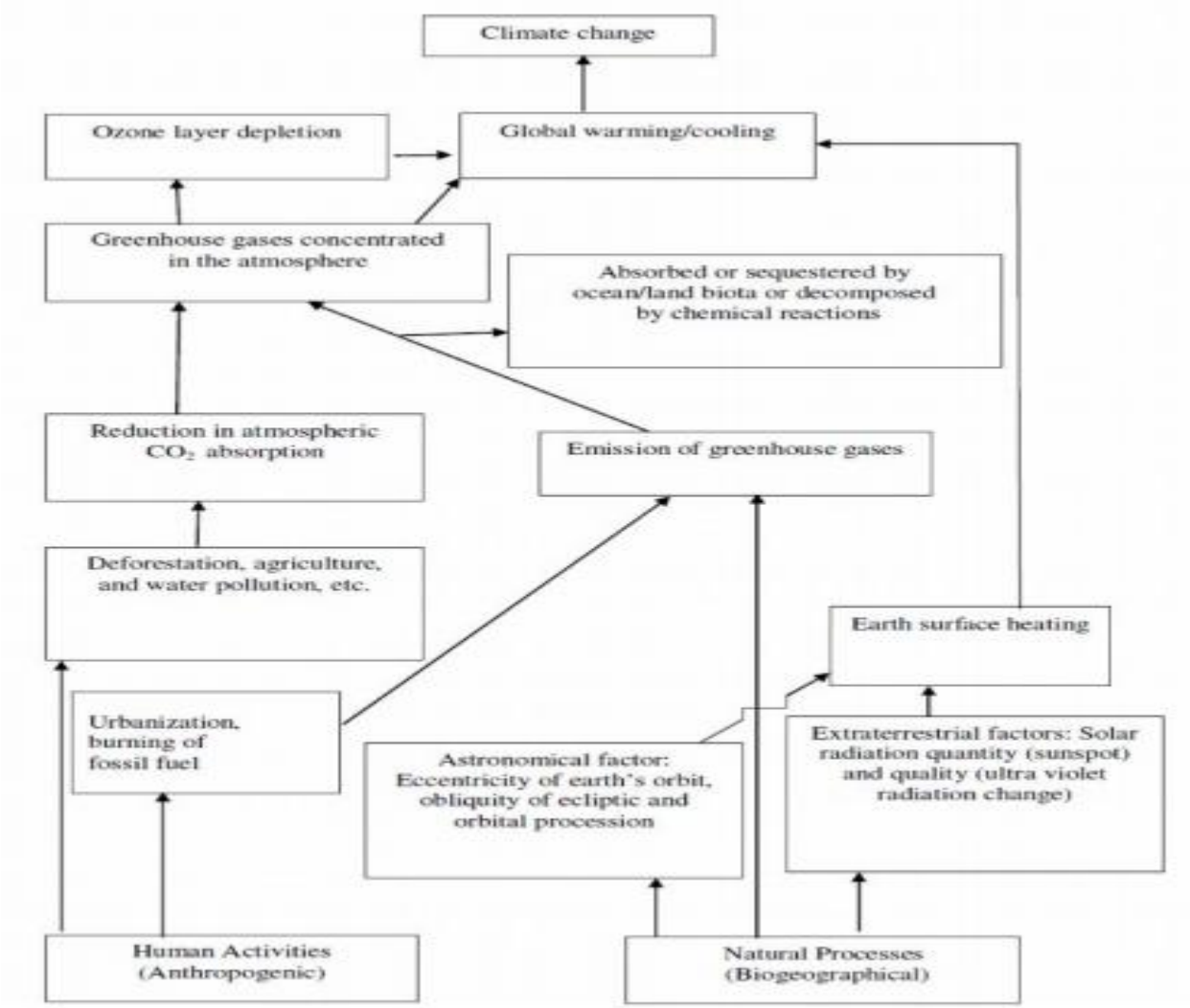

Figure 2.3 Factors of climate change.

Source: Odjubo, 2010, pp.143.

Lastly, the fourth argument suggests that although there are variations in climate change across countries, it is likely caused by the workings of the natural processes, but sees climate change as a myth (Evelyn, 2014). Although this fourth argument does not appear to be popular amongst academics, it is good to discuss it and perhaps use it to gauge the opinion of other commentators in this regard (Evelyn, 2014). Carter (2007) who may be classified as

a strong proponent of this strand of argument believes that IPCC is an alarmist group because its membership is mostly constituted by politicians who may not even understand the workings of the climate when compared to scientists. The research further stressed that IPCC assertion that climate change is real, is nothing but merely circumstantial and part of the workings of natural environment, and that any human causation could only be assessed and examined when all the causes of natural environmental changes have been well understood (Evelyn, 2014). Thus, Carter (2007) also argued that even the media has failed in its role as a public watchdog, accusing them of being a self-interested party in the debate over the existence of climate change (Carter, 2011a and Carter, 2011b) cited in Carter (2007). These views are more of subjectivity than been objective, hence unrealistic of the obvious fact that the global climate has indeed been changing over the years (Evelyn, 2014).

Labohm et al. (2006) however, explained that the 'scare' or state of denial in accepting the reality of climate change may be due to the huge financial burden and its implications on the global economy, but concluded that the views of IPCC on the existence of climate change are mostly one sided which are designed only to favour human induced causes. However, Labohm et al. (2006) has been criticized by Ebohon (2006) who subsequently observed, that their views were quite weakened because it clearly lacked objectivity in an attempt to discredit the anthropogenic activities linked with climate change phenomenon.

The argument on climate change now, is to look for solutions and how to mitigate and adapt to the incidences of climate change (Hamin and Gurran, 2009; UKCIP, 2009; Berrang-Ford et al, 2010). Although there are differences on the perceptions of climate change, but available scientific and empirical evidences seems to have convincingly establish the reality in the existence of climate change

A qualitative study conducted by Lorenzoni et al. (2007) employed the use of questionnaires on respondents with the intention to gauge their opinion on the barriers for individual and social perception to climate change. Their findings suggest that, the key reason why a great percentage of respondents were sceptical and uncertain about climate change was because of lack of knowledge of the subject matter (Evelyn, 2014). The study finally concludes that any targeted and tailored information to the UK public has implication on the reduction of Greenhouse Gas (GHG) emissions (Evelyn, 2014). However, it was observed that their respondents were randomly selected members of the general public, implying that their findings clearly omitted other critical stakeholders within the built environment (Evelyn, 2014).

Few et al. (2007) opined that it is important to have public opinion and participation but caution must be taken not to have only an inclusive exercise and miss out on having a satisfactory participation on specific instrumental targets or goals. This opinion therefore, suggests the need for a specific target group study in order to channel findings of such a study towards a more practical application for desirable outcomes, such as the built environment sector in Nigeria (Evelyn, 2014). Thus, it is important to have professional and stakeholders' opinion on specific research goals and for eventual practical applications in relevant sectors (Few et al., 2007).

Underpinned by the above discussions, it is evident that some gaps in the knowledge of climate change do exist and arguably, this gap has resulted in poor level of awareness amongst people, thus, fuelling the myth associated with Climate Change in the minds of individuals. Although the myth about Climate Change seems more of denial and passing of blames instead of looking for sustainable solution to the problem. This attitude has been observed in advanced economies like the UK, despite been recognised as a leading country in tackling Climate Change (RCEP, 2000; Her Majesty Treasury (HM Treasury), 2006;

Boardman, 2007; Lorenzoni et al, 2007), people are still in denial in the country, arguably. Finally, it is believed that, the government, non-governmental agencies and professional bodies could do more to sensitize and create awareness amongst the public (Lorenzoni et al, 2007). This strategy could raise the self-awareness level of the general public and thus, this research project revalidates the opinion of built environment professionals in Nigeria based on the survey conducted (Evelyn, 2014).

2.4 EVIDENCE OF CLIMATE CHANGE.

There are quite a number of evidences that have proven the negative impacts of climate change across the globe (Evelyn, 2014). Since the fourth IPCC Assessment Report of (2007) declared that climate change is an issue to be taken seriously, stakeholders (government and scientific communities alike) have now generally agreed that, climate change is a reality based on available evidences (Reid and Huq 2007) cited in Chambwera and Stage, (2010). The scientific consensus is that human activities have contributed significantly to climate change, unfortunately, the rate of the current changes suggest that the changes are far more rapid and dangerous than previously thought (Boko et al, 2007; Karl et al, 2009; NASA, 2011).

Figures 2.4 to 2.12 show the manifestations of climate change around the globe (Evelyn, 2014).

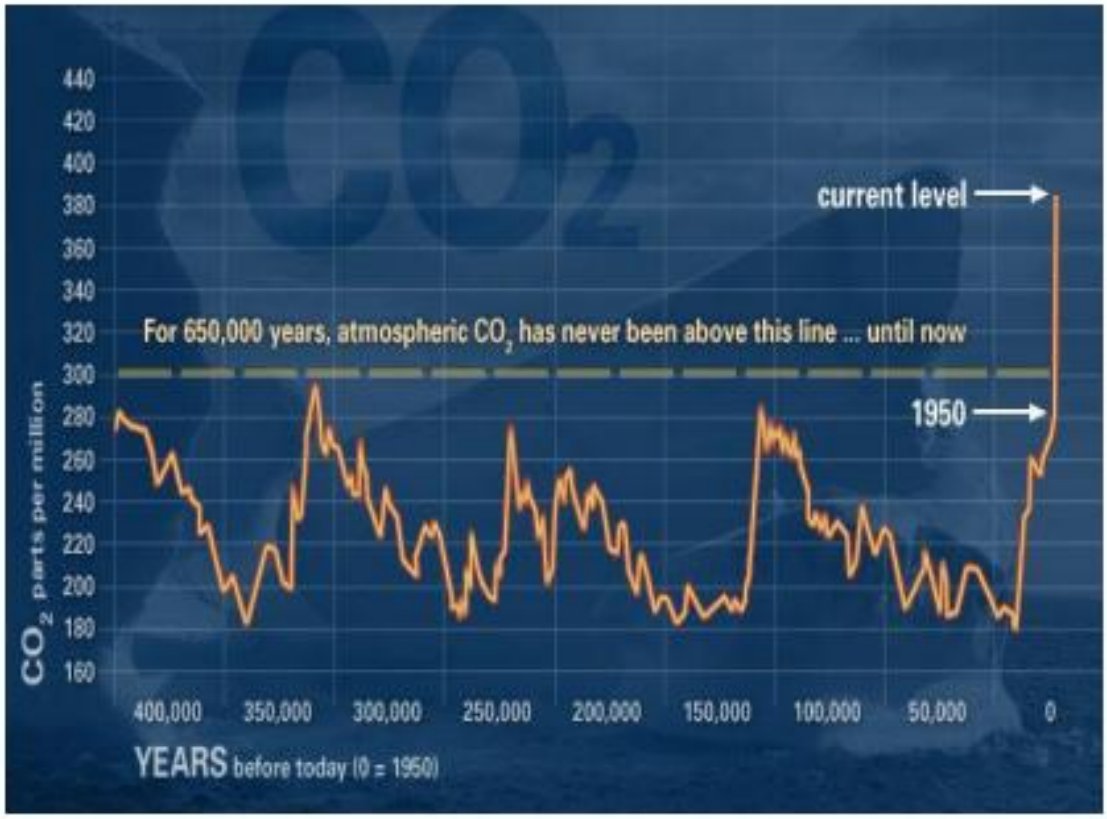

Figure 2.4 Carbon Emission Trends over Years

Source: NASA, 2011 http://climate.nasa.gov/evidence/ (Accessed 1/12/2011).

Figure 2.4 shows the graphic details of the increase in global atmospheric carbon dioxide (CO2), since the 1950s (Evelyn, 2014). Figure 2.5 shows a rise in the sea level in the Maldives and is common to other low level lying communities around the world (Evelyn, 2014). The global sea level has risen by about 17 centimetres in the last century, with the last decade recording nearly double of the last century (IPCC, 2007; Boko et al, 2007; Smith et al, 2009; NASA, 2011).

Figure 2.5 Rising Sea-level (Republic of Maldives)

Source: NASA 2011 http://climate.nasa.gov/evidence/ (Accessed 1/12/2011).

Figure 2.6 Rising Global Temperature

Source: NASA 2011 http://climate.nasa.gov/evidence/ (Accessed 1/12/2011).

Similarly, the global temperature is rising and this is set to continue resulting in the warming of oceans (Evelyn, 2014). The absorption of heat by the oceans precipitates vapour that evaporates into the stratosphere preventing heat loss, and warming the earth (Evelyn, 2014).

Figure 2.7 Warming Oceans

Source: NASA 2011. http://climate.nasa.gov/evidence/ (Accessed 1/12/2011)

Figure 2.8 Warming Ice lands (The Greenland and Antarctic ice sheets)

Source: http://climate.nasa.gov/evidence/ (Accessed 1/12/2011).

Clearly, this shows flowing melting water from Greenland ice sheet resulting in the shrinking of ice sheets (Evelyn, 2014). Also, it shows the continued decline in the Arctic sea level where both the extent and thickness of the Arctic sea has rapidly declined over decades as seen in Figure 2.9 as a result of both natural and man-made activities referred to in Figure 2.2 (Evelyn, 2014).

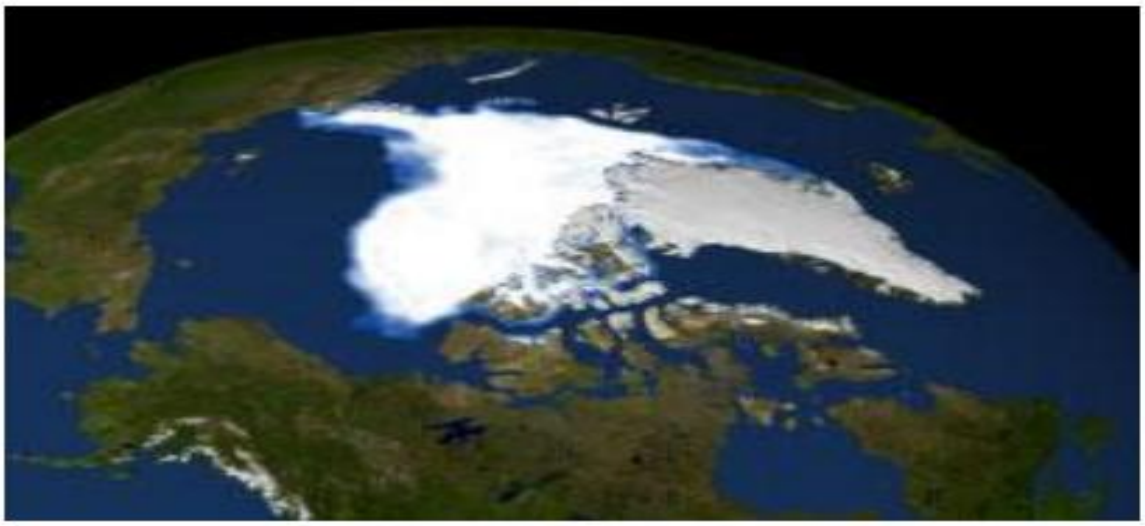

Figure 2.9 Declining Arctic Sea level

Source: http://climate.nasa.gov/eveidence/ (Accessed 1/12/2011).

Figure 2.10 Retreating and Disappearing Kilimanjaro Mountain Snow-cap

Source: NASA 2011 http://climate.nasa.gov/eveidence/ (Accessed 1/12/2011).

Global warming has resulted in the continuous retreating and disappearing mountain snow-cap as demonstrated by the space aerial view of Mount Kilimanjaro in Figure 2.10 (Evelyn, 2014). Figure 2.11 shows how extremely low temperatures lead to extreme snow ice in temperate regions of the world (Evelyn, 2014).

Figure 2.11 Snow -ice Due to Extreme Weather (USA)

Source: NASA, 2011 http://climate.nasa.gov/eveidence/ (Accessed 1/12/2011).

Figure 2.12 Oceanic Acidification

Source: NASA, 2011 http://climate.nasa.gov/evidence/ (Accessed 1/12/2011).

Oceanic acidification shown in Figure 2.12 is seen as an indication that human activities do have an effect on the atmosphere (IPCC, 2007; Kwok and Rajkovich, 2009; NASA, 2011; National Research Council (NRC), 2010; Tompkins and Adger, 2004). This evidence challenges any myth as to the existence of climate change (Evelyn, 2014).

In a nutshell, the above pictorial evidences in Figures 2.4 to 2.12 points to the fact that, human behaviours have quite a significantly negative impact on the environment. Therefore, adverse changes in temperatures have affected built environments around the world (Evelyn, 2014). These facts has further been supported by scientific findings on climate change, following which the UNDP (2008) has called for an end to the debates and encouraged stakeholders to start taking actions necessary to solving the problem (Evelyn, 2014).

2.5 CLIMATE CHANGE IMPACTS ON THE BUILT ENVIRONMENT

The built environment simply means the non-natural surroundings where most human structural activities take place (Evelyn, 2014). Other definitions of the built environment include; the environment created by man to accommodate his activities; all buildings, spaces, infrastructures in cities, towns, and villages (Wilkinson et al, 2009; Otegbulu et al, 2011).

Similarly, Ekins and Lees (2008) described the built environment as consisting of; network of interlocking infrastructure of energy supply, sewage, telecommunications, transport, water and waste management. Other studies identified the built environment as that significant part of manmade environment which shelters human activities; everything made by humans that are arranged (Evelyn, 2014) and maintained to fulfil human purposes, which mediates the overall environment and has impacts on the environment (Evelyn, 2014). It also means that

the transformation and transition of the natural environment into sustainable liveable setting by man for human activities (Aluko, 2011), which include; provision of housing, infrastructure, socio-economic and social facilities and the manipulation of spaces between them (Adebgile, 2011).

However, Jol (2010) suggests the following infrastructures are the most vulnerable to climate change like ecosystems and biodiversity, agriculture and forestry, water resources (flooding and water quality), coastal zones, marine resources and fisheries. Others include tourism, energy (supply and demand), built environment, infrastructure, human health, land management, regional planning (cross-cutting) and finally Insurance services (Evelyn, 2014).

Conversely however, climate change in Nigeria is believed to have a great effect on specific sectors grouped into five different categories by the Nigerian Environmental Study/Action Team (NEST-2004), which they include; human settlements, health and water resources (i.e. wetlands, and freshwater ecosystems), energy (i.e. industry, commerce, and financial services). Others are agriculture (i.e. food security, land degradation, forestry, and biodiversity), coastal zone and marine ecosystems respectively (Evelyn, 2014).

Clearly, the built environment and its infrastructures will be greatly affected by climate change through higher temperatures, erratic and variable precipitation, rise in sea levels and wind actions which have impacts on the surface of the environment and also varying impacts on the built environment (Milly et al, 2002; Meehl and Tebaldi, 2004; UKCIP, 2005; Emmanuel, 2005; Robert, 2008; Kummert and Robert, 2012). These activities from the changing climate are observed to be increasing in frequency and magnitude (Mizra, 2003; Boko et al, 2007).

Furthermore, incidences of climatic change have been tabulated for easy understanding as shown in Table 2.1 (Evelyn, 2014). The Table shows amongst others climate indicators,

surface effect on the environment and the resultant impacts on the built environment (Evelyn, 2014).

Table 2.1 Potential Impacts of Climate Change on the Built Environment

Climate Change Indicator	Surface effect	Key impact on the built environment
Higher temperatures. Lower temperature	-Increased surface temperature -Soil and surface water evaporation and transpiration -Decrease surface temperature -Changes in seasonal flow	-Increase in urban heat islands especially around urban centres with increased demand for commercial energy for air-conditioning -Reduces thermal comfort in the built environment thus reducing productivity. -May also affect the life span and performance of certain building components. -Soil (especially clay) shrinkage causing damage to building foundations and road networks -Increased desertification/drought -Increased mortality
Erratic and variable Precipitation	-Flash floods due to water runoff (storm water) -flooding -Soil erosion and subsidence -Destructive cyclones -Increased Aridity/drought -Soil shrinkage -Reduced Ground water recharge	-Flood risk: damage to buildings, communication, dam and civil works. Structural and non-structural components -Unearthing of underground telecommunication, power and sewage lines -Water supply shortage for industrial and domestic water plants, Hydro power plants and irrigation reservoirs
Accelerated Sea Level Rise (ASLR or SLR)	-Increased inundation Coastal erosion/shoreline retreat -Higher water table runoff and flooding -Storm/wave surge -Land deformation due to extraneous deposits -Ground and surface water salinization	-Significant damage and complete loss of buildings, economic, tourist and civil infrastructure -Temporary and permanent unavailability of road networks due to flooding by running sea water -Substantial damage to drainage, oil pipelines, waste and sewage lines -Destruction of coastline defence structures -Direct adverse effects on the performance of sub-surface structures like building foundations due to soil -subsidence/components integrity breach Water supply quality compromise
Wind events	-Thunderstorms -Hail -Tidal waves -Dust storms	-Destruction of building elements, power lines and communications networks from higher wind speeds and driving rains -Air pollution

Adapted from: (IPCC, 2001; Milly et al, 2002; Meehl and Tebaldi, 2004; Emmanuel, 2005; UKCIP, 2005; IPCC, 2007; Solomon et al, 2007; Wilby, 2007; Robert, 2008; Kummert and Robert, 2012).

The table shows that buildings dominate the built environment as well as connecting the built environment and the surrounding climate and its activities (Evelyn, 2014). Thus, understanding the impact of climate change on the environment would provide a general scenario for studying the impact of climate change on buildings and vice-versa in Nigeria (Evelyn, 2014).

However, these impacts are largely dependent on; design, construction, use and location of buildings and building clusters (Liso et al, 2003). The study by Liso et al (2003) was aimed at providing an overview of the challenges of climate change impacts on the Norwegian built environment and how the country's climate policy can be used practically to confront and prepare for potential impacts. Their study found that technical regulations and standards are effective government tools for ensuring compliance to building design, construction and land-use, building locations and how buildings are clustered. In the case of Norway, they established; Building Research Design (which spells out solution-in-principle) which serves as design guide and must be monitored (Evelyn, 2014). Secondly, there is the need to regulate building locations through landuse planning tools and land management which will help curb the impacts of climate change on the built environment (Evelyn, 2014).

Thus, the importance and scope of this research is to provide a framework for the formulation of a sustainable residential design guide for Nigeria (Evelyn, 2014). Subsequently therefore, this would serve the purpose of advancing a sustainable development in Nigeria and particularly provide a sustainable design guide that will aid design professionals to design buildings that would mitigate and adapt to the vagaries of climate change (Evelyn, 2014).

2.6 CLIMATE CHANGE AND BUILDINGS

Notably, carbon emissions which are mainly from buildings are significant, and have continually attracted global concern on the state of the changing climate and its challenges (Evelyn, 2014). Climate change affects all aspects of life especially the built environment (Keller, 2003; Logan et al, 2003; Philander, 2003; Root et al, 2003; Commission for Architects and the Built Environment (CABE), 2007; Trenberth, 2010; Fagre, 2007) and thus, the need for a critical assessment framework or tool is considered a necessity (VijiyaVenkata Raman et al, 2012).

Buildings also play a major role in the development of every country and form the central part of every daily human activity (Cam, 2012). Lam et al. (2005) argued that buildings are also significant to the environment as depicted in the quote below: "Building acts as a climatic modifier, separating the indoor built environment from the external climate described by the prevailing long-term weather conditions. The climate of a particular location tends to influence the shapes and forms of the local buildings and dictates the types of environmental control required. There is often a distinct correspondence between special architectural features and different climatic zones" Lam et al. (2005, pp. 277)

Lam et al. (2005) argument demonstrates the importance of interrelationship between buildings and climate, because they influence one another, which have a direct and immediate impact on the environment (Lam et al. 2005). This is reflected on the architectural practices and design choices from different of climatic regions globally (Lam et al. 2005).

Although several studies have suggested that buildings contribute to the causes of climate change (Wilby, 2007; Simon 2011; Berrang-Ford et al, 2011; Janda, 2011), they are, without doubt, affected by the impacts of climate change, hence affecting the functionality of

buildings (De Wilde et al, 2008; Wong, et al, 2010; Gething, 2011). This is due to the long life-cycle of buildings (De Wilde et al, 2008).

It has also been argued that building decisions have a long term effects on the environment due to both the physical and economic value of buildings (Ryghaug and Sørensen 2009). However, the magnitude of these effects and impacts on buildings are also dependant on the locations of such buildings (Camilleri and Jaques, 2002; Ashley, 2005; Crawley, 2007; Perez, 2009). Furthermore, Tompkins and Adger (2004) identified the following impact of climate change on buildings, like mean climatic conditions, increased frequencies of weather elements, increase in the degree of variability and shifts in the ecosystem. These effects and the impacts of climate change are enumerated on Tables 2.1 above (Evelyn, 2014).

A number of studies seeking solutions have been carried out due to the global effects and impacts of climate change on buildings (Evelyn, 2014). Quite precisely is the housing sector-based solution approach which was proposed by Schmidt et al. (2008) for developing countries as potential key to climate change mitigation framework. The result of Schmidt et al. (2008) studies on ten highest emitting developing countries with relations to electricity and other energy sectors (see Table 2.2) suggests that these ten countries had their own country based voluntary GHG emission targets, arguably developed to attract incentives from developed countries, overcome barriers of finance and technological transfers, with the principal aim of improving and stabilizing the concentration of atmospheric CO2 in their individual countries, unfortunately, these countries do not seem to have met their individual targets.

Basically, all research findings in the energy sector are quite relevant to the construction sector because a building constitute a larger percentage of construction industry

and tend to consume about 40-50% of energy globally (UNEP, 2009). Sequel to the above, Schmidt et al. (2008) noted some advantages of a sector based solution approach to climate change which includes; the ease of administration, targets emissions in a given sector which is generally simpler and more focused than doing so on an economy-wide basis. This is because of the relatively small number of actors visible in many sectors (Evelyn, 2014). Although, this advantage may not apply to all sectors they are characterized by a high degree of diversity or a large number of players (Evelyn, 2014).

A second advantage suggested by Schmidt et al. (2008) is data availability, where they stressed that in several sectors, emissions inventories or the underlying fuel data are already developed, even in developing countries, thereby facilitating the rapid implementation of a reliable sectorial emissions reduction programme.

Thirdly, Schmidt et al. (2008) argued that greater data availability is another advantage because it also builds confidence, both domestically and internationally, in emissions monitoring and reporting thus, smoothing international negotiations.

The fourth advantage is the creation of greater equity where some internationally competitive sectors in developing countries are equally or more GHG-efficient than those in Annex I countries, as such a sector-based approach may be a 'fairer' way to reducing global GHG emissions, rather than elaborate approaches that differentiate countries according their economy (Schmidt et al, 2008).

Furthermore, they suggested that an increased technology transfer would be an advantage, because sector-based approaches creates focus based environment for global technology transfer and deployment (Schmidt et al, 2008). The final advantage according to Schmidt et al. (2008) is targeting emissions reduction. This is particularly relevant to sectors

that are high energy intensive or low investment turnover which could be specifically targeted, perhaps by giving them tax breaks (Evelyn, 2014).

Despite the advantages discussed above, Schmidt et al. (2008) also outlined some disadvantages that a sector based solution approach to climate change could possibly face, which include; cost-effective loss, where more cost-effective emissions reduction may exist outside a covered sector. This efficiency loss can be minimized by allowing emissions trading across sectors (Evelyn, 2014). Thereby, setting emissions levels or benchmarks within other sectors as well, or using cost-effectiveness criteria to guide the level of emissions reduction established in each targeted sector(s) (Evelyn, 2014).

Secondly, possible limitations may arise due to focusing on a few selected sectors; this is also a disadvantage as observed by Schmidt et al. (2008).This thereby, means the omission of specific energy-intensive or high-growth sectors, which could make achieving global greenhouse stabilization level more difficult to attain (Evelyn, 2014).

The third disadvantage according to Schmidt et al. (2008) is Leakage, this is identified as where emissions could potentially 'leak' into uncovered sectors, depending on how the sectors are defined and the extent to which related products or activities are also simultaneously covered by the set targets.

Unfortunately, Schmidt et al. (2008) studies was limited to only ten developing countries and they left out so many other energy sectors such as housing as observed in Table 2.2 below.

Table 2.2 Top Ten Developing Country GHG Emitters for the Electricity and Major Industrial Sectors

Electricity	Iron & Steel	Chemical & Petrochemical	Aluminium	Cement & Limestone	Paper, Pulp & Printing
China	China	China	China	China	China
India	India	India	Brazil	India	Brazil
South Africa	Brazil	U.A.E.	India	South Korea	South Korea
South Korea	South Africa	South Africa	Venezuela	Brazil	India
Mexico	Mexico	South Korea	Chile	Indonesia	Indonesia
Iran	South Korea	Brazil	Argentina	Mexico	Mexico
Saudi Arabia	Venezuela	Mexico	Bahrain	Thailand	Colombia
Kazakhstan	Indonesia	Iran	Kazakhstan	Pakistan	Thailand
Indonesia	Kazakhstan	Indonesia	South Korea	Egypt	Argentina
Thailand	Iran	Venezuela	Macedonia	Iran	Chile

Source: Schmidt et al. (2008) pp.501

Nigeria is clearly omitted on the table above showing some industrial sectors responsible for emission of GHG into the environment, even though Nigeria is currently leading crude oil producer in Africa and is the third largest exporter of same (Okpe and Abu, 2009; World Bank, 2010b; Peixie, 2011). Arguably, this may be due to unavailability of data and perhaps inaccurateness in the data available on Nigeria (Olotuah and Bobadoye 2009; Ademiluyi, 2010; Onyekuru and Marchant 2011). This clearly suggests that there is knowledge gap in research information, scarcity of data and even documentation in Nigeria (Evelyn, 2014).

Although, studies on the energy sector are relevant to buildings, however, it is the construction industry sector that is directly relevant to this research (Evelyn, 2014). Jagger et al. (2013) argued that the construction industry as a building sector is a key factor to achieving low carbon emissions in buildings. This argument is agreeable because the construction industry determines all the workings of the production of buildings which includes; construction methods, material contents (usage and choice), site management and maintenance and the eventual existence of buildings (Evelyn, 2014). Furthermore, the building sector around the world accounts for about 30 per cent of global emissions and 40 per cent of energy consumption (UNEP, 2009). The extraction of raw materials from the natural environment for building purposes often results in ecological degradation (Williams, 2007). This ecological degradation influences the processes leading to climate change globally (Evelyn, 2014).

2.6.1 Why residential buildings.

Residential buildings in this study refer to all dwellings that include; houses, buildings irrespective of types (flats, bungalow, and duplexes) used as residence (Evelyn, 2014). “In most countries, residential buildings are responsible for a major part of the energy consumption of the building sector…” United Nations Environmental Programme UNEP (2009, pp. 8).The UNEP (2009) quotation has summed up the argument for choosing the residential buildings as the target for this research (UNEP, 2009). However, it is necessary to provide facts that support the summation from the above quotation (UNEP, 2009).

Global scenarios shows that buildings account for a huge amount of house gas emissions for example, in the United States about 50 per cent of its total energy emissions are from buildings, with 21 out of the 50 per cent from residential buildings (Architecture 2030, 2012). While in the UK about 47 per cent of total emissions are from

buildings and of this figure 27 per cent are from residential buildings (DEFRA, 2000; DEFRA, 2006; Kelly, 2009). In China which is a fast developing nation, it has been noted to be leading in global emissions from residential buildings contributing to about 38 per cent of its total emissions (Yutaka et al, 2005) cited in UNEP, 2009. China also contributes about 17 percent of global total GHG emissions, while Europe contributes 13.37 per cent (Evelyn, 2014). This shows that China contributes a larger and more significant percentage of global emissions as compared to Europe (Evelyn, 2014).

This is consistent with the information trend of global emissions in Figure 1.1 (Evelyn, 2014). Furthermore, IPCC (2007) acknowledged that residential buildings contribute hugely to climate change but, also noted that energy efficiency should be ensured in order to curtail GHG emissions from buildings (IPCC, 2007). Thus, this suggests that there lies a huge potential (80%) for stemming climate change through sustainable strategies on residential buildings, which makes this study relevant (IPCC, 2007).

The study of Laryea (2011) conducted between 1985 and 2011 on West Africa (Nigeria's geographical) region, concluded that there are only 23 publications that are related to the built environment. Other research also observed that many climate change studies relating to buildings globally, mainly dealt with public and commercial buildings (De Wilde and Coley 2012). Furthermore, the few climate change studies conducted on African continent were on commercial office buildings in Burkina Faso (De Wilde and Coley 2012). This is an indication that, though buildings and particularly the residential buildings have been identified as key to both carbon emissions and solutions, there is little research focus on the subject in the West African sub-region (Evelyn, 2014). Thus the choice for a residential building research in Nigeria is an exploratory novelty that would be an original contribution to the body of knowledge (Evelyn, 2014).

2.7 CLIMATE CHANGE AND SUSTAINABILITY

The acceptable process identified as preferred the way of growth is sustainable development (Evelyn, 2014). This has been adopted and accepted internationally as a global agenda for all forms of development and has become a key to all activities in the built environment (Najam et al, 2003; Altomonte, 2008).

Sustainable development has become a growing need in the built environment as was established in section 2.2, and basically, it provides today`s generational needs that do not conflict with the ability of future generations to fulfil their developmental needs in all aspects of life (Evelyn, 2014).

This research explores sustainability as a means for achieving the framework for a design guide that conforms to the global agenda enshrined in the UNFCCC and the Kyoto agreement leading to sustainable residential buildings in Nigeria (Evelyn, 2014). The goal and focus herein lies in the strategies that are climate change compliant and within a sustainable framework as a channel to achieving the overall aim of this research project (Evelyn, 2014). Therefore, the historic relevance of sustainability is not within the scope of this research project (Evelyn, 2014).

Basically, sustainability is a deliberate effort geared towards the enhancement of human livelihoods, upgrading or raising the standards for societal economic productivity, without degrading the natural environment for future generations through the concept of sustainable development as shown in Figure 2.13 below (Evelyn, 2014).

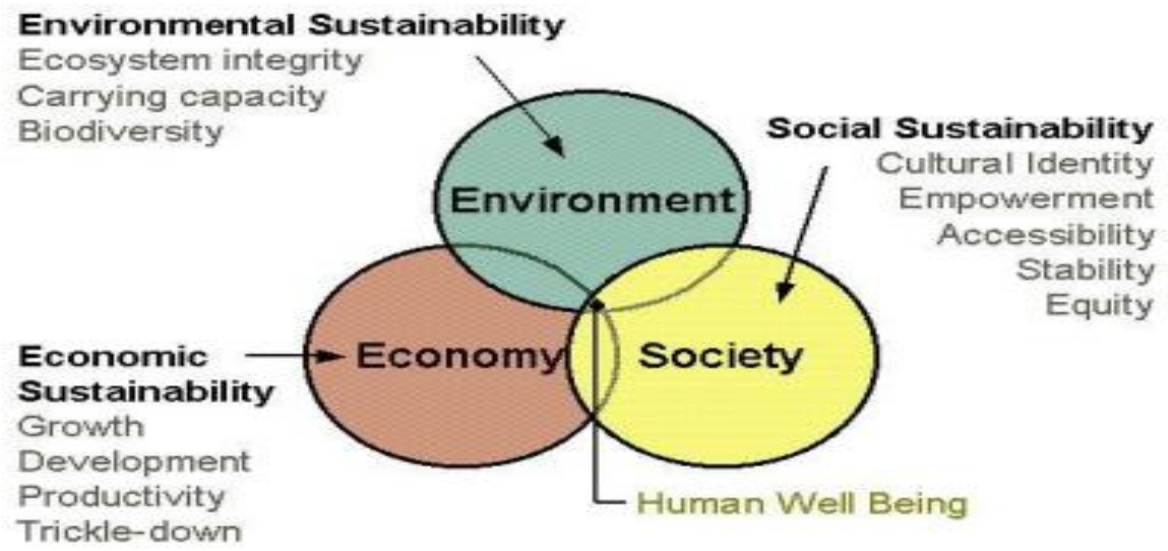

Figure 2.13 Sustainable Development

Source: http://www.arch.hku.hk/research (accessed 02/1/12).

Figure 2.13 above clearly shows that sustainability cuts across environmental, social and economic, all three aspects must synchronize to help any society achieve a meaningful developmental stride (Evelyn, 2014). Hence, complex nature of sustainability and therefore, requiring sustainable actions that, would enhance holistic well-being in the society (Evelyn, 2014). This is consistent with the fact that reducing greenhouse gas emissions and decreasing vulnerability by increasing resilience lies within sustainable options (IPCC, 2007; Lehmann, 2007). Thus to redress and undo the unsustainable environment from the effects of climate change actions can only be achieved through sustainable choices and applications (Najam, 2003; Lark, 2004; UNFCCC, 2010; Akadiri et al, 2012).

Promoting sustainable strategies in the design of the built environment does not only address the challenges of climate change; but serves as a key-factor, and allows for the management of available resources in curbing the effects of climate change (Akadiri et al, 2012). The increase of global effects of climate change and the continuous uncertainty of conventional energy supply make it more demanding to have global sustainable development (Lehmann,

2007; Altomonte, 2009; Ortiz et al, 2009). Furthermore, an earlier opinion expressed by Ebohon et al. (2002) opined that, differences in sustainability lie within the ability of communities to deal with problems that have to do with the environment. The research findings from this project would also seek to identify some of the abilities inherent within the Nigerian communities to deal with problems associated with building design practices (Evelyn, 2014).

Since climate change and sustainable development can be seen as two sides of the same coin, sustainability also offers the most effective action to curb the mitigation question, and all the necessary dimensions of climate change adaptation and impact (Evelyn, 2014). This has become the global challenge for sustainability requiring an intense global intervention and therefore the assertion for it becoming a global agenda (Swart et al, 2009; Doughty and Hammond, 2004; Bond, 2010). To maintain this status quo the developing countries do need to join this development trend by mainstreaming sustainability in all its Climate Change strategies (Evelyn, 2014). In support of this argument Halsnaes et al. (2008) conclude that developing countries would progress and achieve lower GHG gas emission only through sustainable actions. Thus, searching for mitigation and adaptation guidelines for design through sustainable options is the focus for this research project (Evelyn, 2014).

2.7.1 Sustainable design and building

Section 2.7 sets the background to the importance of giving attention to sustainable actions or strategies within the built environment (Evelyn, 2014). In the design of buildings the (Evelyn, 2014) "…Lack of attention to the early design process …has led to an unsustainable built environment" (Loh et al, 2009, p. 2122). Similarly, sustainability has become a global drive for developmental initiative, particularly to climate change related strategies (Evelyn, 2014).

The building sector in every country has a high potential to significantly reduce GHG emissions by about 30-50 percent; it is also the most vulnerable sector to climate change hazards such as flooding, hurricanes, and wild fires (Clark et al, 2003; Hertin et al, 2003; UNEP, 2009). Akadiri et al. (2012) examined how sustainable principles can be implemented in the building sector. Their study was focused on producing a framework based on the triple bottom line principles of; resource conservation, cost efficiency and design for human adaptation through critical literature review (Evelyn, 2014). Findings from their study showed that the way forward for the building industry to advance and develop can only be through holistic sustainability to building design (Evelyn, 2014).

According to Akadiri et al. (2012) a sustainable building approach provides the way forward for the building industry to achieve sustainable development. For them to attain this height, they used different strategies as demonstrated in each of the three objectives reflected in Table 2.3, while Figures 2.13, 2.14 and 2.15 shows the strategies and methods required for the three objectives to become sustainable through the use of the principles of sustainability shown in Table 2.3 (Evelyn, 2014).

Table 2.3 Sustainable Building Issues

Title	Key Theme	Principal Issues
Economic sustainability	**1.0 Maintenance of high and stable levels of local economic growth and employment** 1.1 Improved project delivery 1.2 Increased profitability & productivity	Improved productivity; Consistent profit growth; Employee satisfaction; Supplier satisfaction; Client satisfaction Minimizing defects; Shorter and more predictable completion time; Lower cost projects with increased cost predictability; Delivering services that provide best value to clients and focus on developing client business
Environmental sustainability	**2.0 Effective protection of the environment** 2.1 Avoiding pollution 2.2 Protecting and enhancing biodiversity 2.3 Transport planning	Minimizing polluting emissions; Preventing nuisance from noise and dust by good site and depot management; Waste minimization and elimination; Preventing pollution incidents and breaches of environmental requirements; Habitat creation and environmental improvement; Protection of sensitive ecosystems through good construction practices and supervision; Green transport plan for sites and business activities
	3.0 Prudent use of natural resources 3.1 Improved energy efficiency 3.2 Efficient use of resources	Energy efficient at depots and sites; Reduced energy consumption in business activities; Design for whole-life costs; Use of local supplies and materials with low embodied energy; Lean design and construction avoiding waste; Use of recycled/sustainability sourced products Water and Waste minimization and management
Social sustainability	**4.0 Social progress which recognizes the needs of everyone** 4.1 Respect for staff 4.2 Working with local communities and road users 4.3 Partnership working	Provision of effective training and appraisals; Equitable terms and conditions; Provision of equal opportunities; Health, safety and conducive working environment; Maintaining morale and employee satisfaction; Participation in decision-making; Minimizing local nuisance and disruption; Minimizing traffic disruptions and delays; Building effective channels of communication; Contributing to the local economy through local employment and procurement; Delivering services that enhance the local environment; Building long-term relationships with clients; Building long-term relationships with local suppliers; Corporate citizenship; Delivering services that provide best value to clients and focus on developing client business

Source: Akadiri et al. (2012), pp. 128.

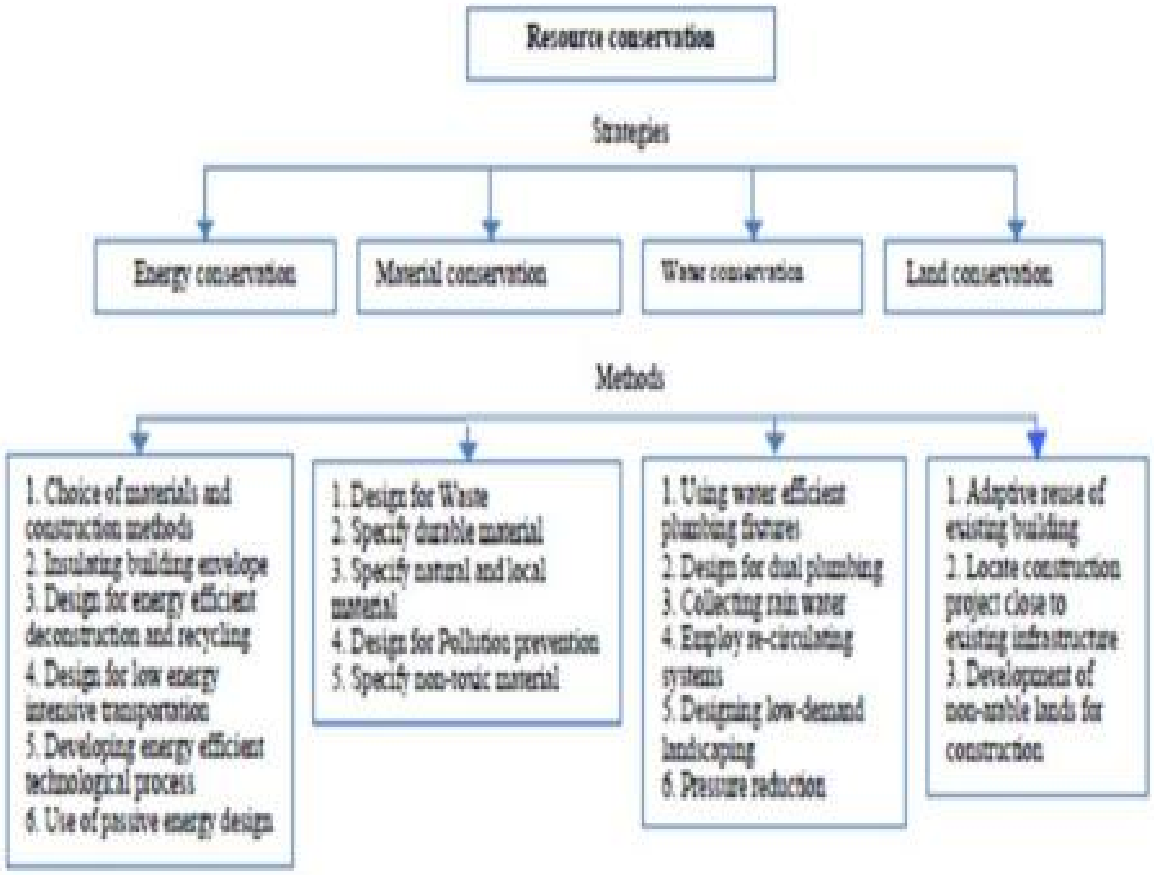

Figure 2.14 Strategies and Methods to Achieve Resource Conservation.

Source: Akadiri et al. (2012), pp.132.

Figure 2.14 highlights the strategies and methods for conserving non-renewable resources (energy, land, materials and water) used in the construction industry (Evelyn, 2014). In Figure 2.15, Akadiri et al. (2012) identified life cycle cost as an important tool for cost efficiency in construction projects and suggested three methods; initial cost, cost-inuse and recovery cost as the methods to be used in checking economic balances.

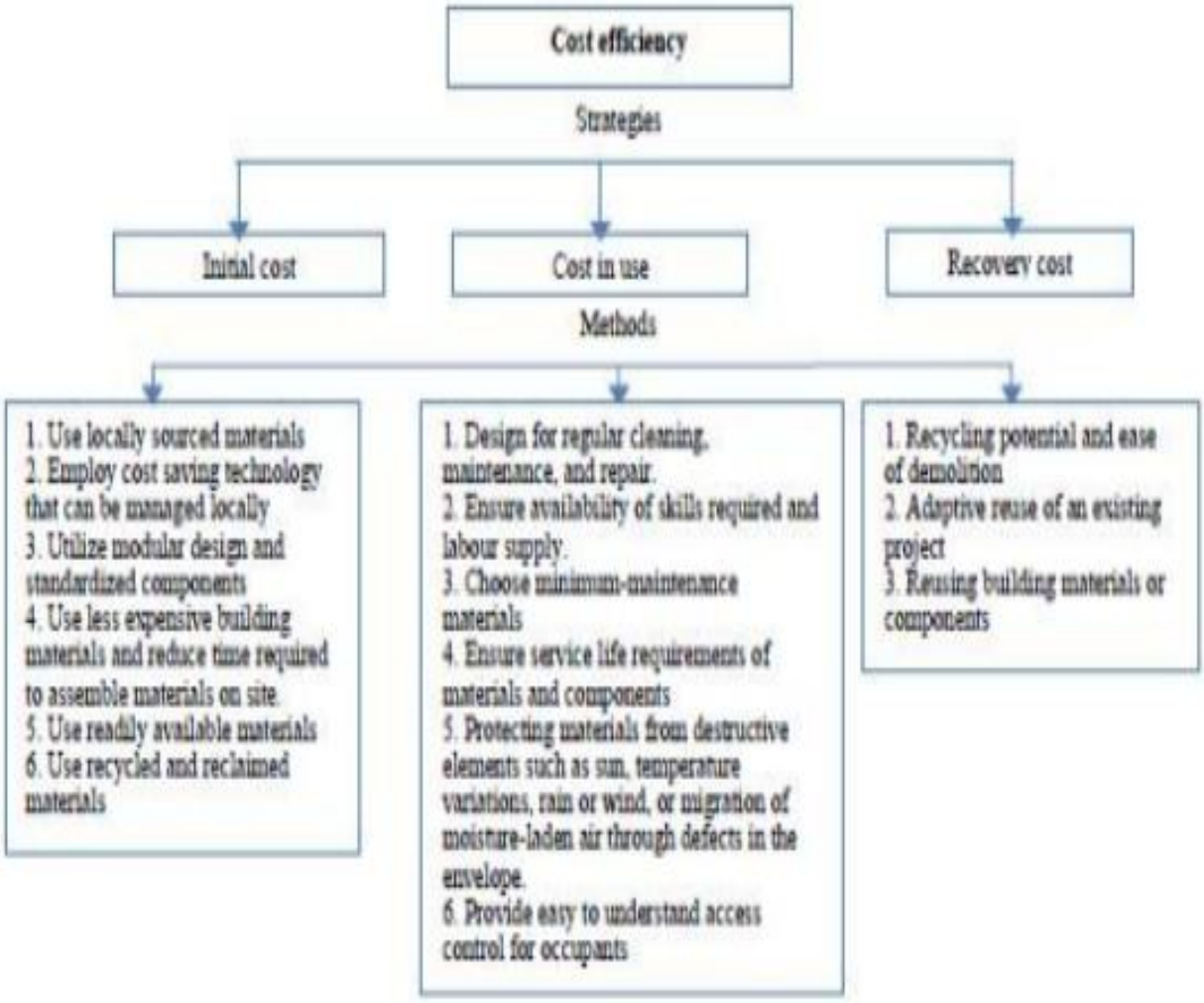

Figure 2.15 Strategies and Methods to achieve cost efficiency.

Source: Akadiri et al. (2012), pp. 140.

Figure 2.16 deals with the third objective (Design for Human Adaptation); this is particularly close to the main objective of this project. In this table the strategies are to protect human health and comfort and to protect the physical resources like buildings (Evelyn, 2014). In this regard the aim is to make sure that building designers ensure their design includes environmental quality and human comfort within and outside the built environment (Evelyn, 2014).

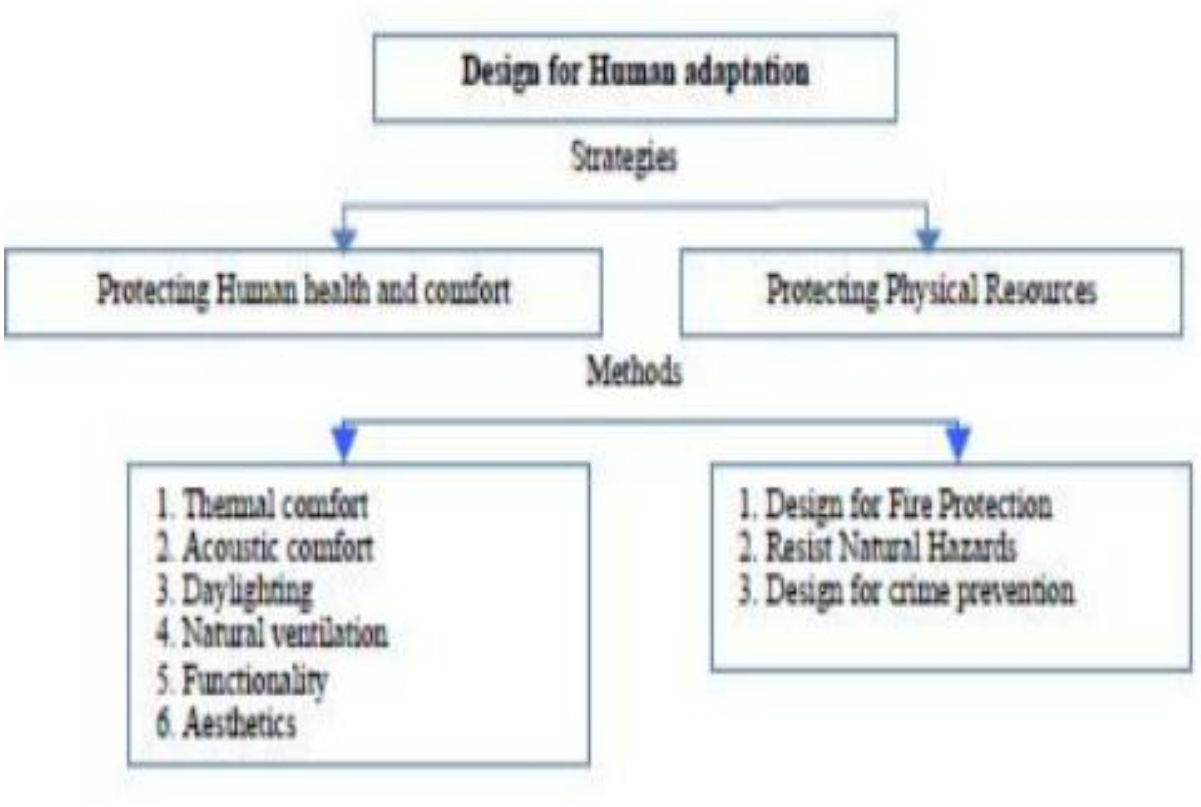

Figure 2.16 Strategies and Methods to achieve human adaptation.

Source: Akadiri et al. (2012), pp.143.

Sequel to the above Akadiri et al. (2012) suggests a general framework to improve construction practices through all the strategies and methods employed to balance economic, social and environmental performance. It is not in itself conclusive, rather was able to lay the ground work by which different professionals in the building industry have been challenged (Evelyn, 2014). Again, professionals are required to employ different sustainable methods and strategies within their specialisation to enable sustainable design and construction (Evelyn, 2014). However, Levine et al. (2007) noted that there is a broad array of accessible, cost effective and technical know-how which can lead to abating climate change in old and new buildings which are not widely and fully adopted but together with several new technologies are best when combined with integrated passive design which may achieve up to

80 percent reduction in building energy consumption and GHG emissions. The design inputs are therefore an important aspect of curbing climate change through adherence to sustainable principles (Evelyn, 2014).

2.7.2 Choice of building materials

At the early stage of the design process, the choice of building materials are made by the architect as these obviously have a direct bearing on energy; consumption, performance and ghg emissions (Evelyn, 2014). About three billion tonnes of raw materials are sourced yearly in the global economy and 40-50 percent is used in the manufacturing of building products and components worldwide (Evelyn, 2014).

The UNEP (2007) carried out research on the practical applications of low-energy on residential buildings in some countries (Belgium, Canada, Denmark, Finland, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland and USA), in order to develop practical solutions without the use of standard but passive design that included; super insulation, high-performance windows, transparent insulation, ventilation heat recovery systems, ground couple heat exchangers, sunspaces, thermal storage(building mass), active solar water systems, integrated mechanical system, home automation systems, photovoltaic systems, energy efficient lights and appliances. In their findings they came up with conclusions that in designing sustainable buildings, due considerations should be given to local climate, transport distances, availability of building materials and embodied energy content of materials (UNEP, 2007). Also, elaborate guidelines were listed for choosing building materials like (UNEP, 2007):

1. Designing for long life and adaptability: use durable low maintenance materials (UNEP, 2007)
2. Ensure materials can be easily separated (UNEP, 2007)

3. Avoid a bigger house than you need to save materials used (UNEP, 2007)
4. Modify or refurbish instead of demolishing (UNEP, 2007)
5. Ensure the re-use or recycle of materials from demolished existing buildings and construction waste (UNEP, 2007)
6. Use locally sourced materials where possible (including materials salvaged from site) to reduce transportation (UNEP, 2007)
7. Select low energy where materials (which may include materials with high recycle content) preferably based on supplier-specific data (UNEP, 2007)
8. Avoid wasteful material use (UNEP, 2007)
9. Specify standard sizes and don't use energy-intensive materials as fillers (UNEP, 2007)
10. Ensure that all off-cuts are recycled and avoid redundant structures. Some very energy intensive finishes, such as paints, often have high wastage levels (UNEP, 2007)
11. Select materials that can be re-used or recycled easily using existing recycling systems
12. Use efficient building envelope design and fittings to minimize materials (e.g. an energy-efficient building envelope can downsize or eliminate the need for heaters and coolers, water-efficient taps allow downsizing of pipes, etc (UNEP, 2007)
13. Ask suppliers information on their product if not provided. (UNEP, 2007, pp.19)

The building material guidelines suggested above would apparently form part of the primary data enquiry that will be sourced from built environment design professionals in Nigeria in order to ascertain their design considerations and specifications practices (UNEP, 2007). Although these material guidelines are impressive and their applications are successfully tested in some places around the world, no African country was involved in the

experimentation (UNEP, 2007). However, the opportunity is now present for practices in Nigeria to consider if they would like to adopt them for future practices (Evelyn, 2014).

2.8 SUSTAINABLE DESIGN GUIDE

A sustainable design guide offers built environment professionals the opportunity to consciously use sustainable principles for building designs (Evelyn, 2014). Smyth and Schroder (2004) suggested that design guide should: ...”promote environmentally sustainable development and to encourage people to design new residential buildings so that they interact positively with the various elements of their local environment. The result should be buildings that use less energy and have less damaging environmental impacts over their whole life than equivalent buildings designed without regard to these factors. Buildings can be designed so as to respond intelligently to the existing topography and climate (Smyth and Schroder, 2004). For maximum effect and economy the aim should be for integration of appropriate design and technology into the overall building form and not simply to apply technology as an afterthought or a ‘clip-on’. This may cost more initially but the long term running costs should be lower, leading to overall cost savings. A climatically responsive approach to building design will eventually help to generate a genuine local or regional architecture rather than a style of building imported from another place or time (Smyth and Schroder, 2004). However, this is not a building form or style guide, but is intended to be a selection of medium to long term potential energy and resource saving ideas that can be easily integrated into the design of a new building in the early stages at little or no extra cost.” (Smyth and Schroder, 2004, pp.3)

Therefore, a design guide should be aimed at promoting conscious design that reflects considerations for the sustainability of the environment as well as adapting to the conditions of the natural environment. A good example is represented in Figure 2.17 which shows a building conforming to the site contours and taking advantage of the topography to create functional spaces (Evelyn, 2014).

Figure 2.17 Example of a House that Responds to the Local Climate and Topography

Source: Smyth, B. and Schroder, J. (2004) pp.3

Furthermore, Bunz et al. (2006) in their study compared sustainable building design guides in three geographical regions; North America, Europe and Asia using case studies from seven countries; United States, Canada, United Kingdom, Germany, Netherlands, Japan, Hong Kong and Korea (Bunz et al. 2006). The first part of their findings suggests that development of the sustainable design guides from these seven countries was originated from the United Nations Earth Summit resolutions of 1992, and the subsequent recommendations were drawn from the Human Settlement section of Agenda 21 which outlines the (Bunz et al. 2006):

1. Regulation of energy-efficient design principles (Bunz et al. 2006);
2. Incentives to promote the continuation of traditional techniques, with regional resources and self-help strategies (Bunz et al. 2006);
3. Recognition of the toll that natural disasters take on developing countries, due to unregulated construction and use of inadequate materials and the need for

improvements both in use and manufacture of materials and in construction techniques, as well as training programs(Bunz et al. 2006);

4. Regulation of energy-efficient design principles (Bunz et al. 2006);
5. Standards to discourage construction in ecologically inappropriate areas (Bunz et al. 2006);
6. Cost and economies of scale (Bunz et al. 2006);
7. The restructuring of credit institutions to allow the poor to buy building materials and services (Bunz et al. 2006);
8. International information exchange among architects and contractors, on all aspects of construction related to the environment, particularly about nonrenewable resources (Bunz et al. 2006);
9. Exploration of methods to encourage and facilitate the recycling and reuse of building materials, especially those requiring intensive energy consumption in their manufacture(Bunz et al. 2006);
10. Financial penalties to discourage the use of materials that damage the environment (Bunz et al. 2006);
11. Decentralization of the construction industry, through the encouragement of smaller firms (Bunz et al. 2006);
12. Use of "clean technologies" (Bunz et al. 2006).

Secondly, Bunz et al. (2006) further divided the life cycle of a building into five phases, which are; the programming phase, design, building construction, building operation, and building demolition phases. This enabled them evaluate and compare similarities in the design guides from seven countries (Evelyn, 2014). They concluded that (Evelyn, 2014) …"The design phase is the most comprehensively addressed portion of the life cycle in most sustainable building guidelines and evaluation methods" (Bunz et al, 2006 p.34). Sequel

to Bunz et al (2006) assertion, it is deducible that the design stage of any building is the key stage at which sustainability concepts and principles are mainstreamed into building design.

Finally, Bunz et al. (2006) also concluded that a sustainable guide ensures that sustainable features are drafted into design in order to "help designers meet the needs of today, without adversely affecting future generations" (Bunz et al, 2006 p.61) and also the statement by Bunz et al. (2006) underpins the later research undertaken by Attia (2012) on how decision tools are necessary for architects because… "Architects are in constant search for a design direction to make an informed decision" (Attia, 2012. p.5). The above facts therefore underpin the premise on which the researcher decided to carry out this research study which will most certainly contribute to the framework design tool used by Nigerian professionals (Evelyn, 2014).

Furthermore, in another study undertaken by Carmody et al. (2009) at the University of Minnesota, USA, they examined 19 different guidelines, assessment tools and rating systems across 16 global regions. The study was informed because of the housing challenges experienced in South Korea (Carmody et al., 2009). Therefore, the quote supports the development and use of a sustainable design guide which is simple and easy to understand, use and encourages innovative ideas from built environment professionals because of its flexibility (Evelyn, 2014).

The list of the different weighted guidelines, assessment tools and rating systems studied by Carmody et al. (2009). Their conclusion provides a valid argument for sustainable design guide (Evelyn, 2014). Hence; "The 2030 Challenge is unlike other systems discussed in this report. It is not a sustainable building assessment or rating system. Rather, it takes the form of a building guideline focused entirely on energy issues, using a series of increasingly challenging energy performance benchmarks. The guideline calls for every new building

design to immediately reduce site energy-use-intensity derived from fossil fuels by 50%, followed by a 60% reduction in 2010, a 70% reduction by 2015, 80% by 2020, 90% by 2025, and 100% (or greenhouse-gas-emissions free) by 2030. In effect, the Challenge takes a "biocentric" approach, with the goal of reducing the building sector's greenhouse gas emissions to sustainable levels by the year 2030. However, the guideline uses existing buildings and practice as a reference point. Since the Challenge does not attach any prescriptive guidelines for how these performance benchmarks should be met, architects and developers have flexibility to meet the Challenge in a manner that best suits their individual project. This may include on-site generation of renewable energy, implementation of sustainable design strategies, improvements in energy efficiency, the purchase of a limited amount of renewable energy from the electric grid, or a combination of all these approaches. There is no official certification offered, and no documentation is submitted for any individual project. Rather, organizations such as architectural firms or developers commit to design and build buildings that meet the Challenge's energy performance benchmarks as part of their on-going practice. In addition, the 2030 Challenge is becoming the basis for various voluntary and mandatory government programs in states such as Minnesota and California". Carmody et al. (2009) pp.12- 13

A sustainable design guide therefore, helps to minimise GHG emissions, and offers benchmark design guides to design professionals. The last sentence of Carmody et al. (2009) quote above obviously shows indigenous adaptable design guides. But in this study, some localised sustainable residential design guides across the UK are also examined in section 2.8.2 in order to make a comparison and as a guide to generating potential design parameters for Nigeria (Evelyn, 2014).

2.8.2 Examples of some regional sustainable design guides

Design guide are usually derived from specific requirements of a region in order to address the specifics of that region (Evelyn, 2014). This has been acknowledged in the following quote which states that (Evelyn, 2014), "the evolution of guidelines is also driven by the desire for regional variation as well as accommodating new knowledge developed about best methods and practices" (Carmody et al, 2009; pp.5). This argument underpins the desire to obtain data across the different climatic regions of Nigeria (Evelyn, 2014). The rationale for the proposing a sustainable residential design guide for region is because a single guide would not be applicable to the three different climatic regions conditions and climatic peculiarities in Nigeria (Evelyn, 2014).

The researcher has selected four current sustainable residential design guides out of the 11 regions studied in England, and the findings tabulated in Table 2.4 (Evelyn, 2014). The four guides were randomly selected, because they were easily accessible from their individual official websites (Evelyn, 2014). Other available guides were not selected because the guides were targeted at specific building components (roofs, extensions, floors etc) and not to residential buildings as a whole (Evelyn, 2014).

The councils selected are; London Borough of Barnet, Castle Point Borough, Highland Council and West Lothian Councils (Evelyn, 2014). The parameters for each of the guide give an insight into the relevant areas to be considered in this research (Evelyn, 2014). It has also been observed that these guides and other guides in the UK are produced as a result of national planning policy framework (Department for Communities and Local Government, 2012). This therefore, suggests that a framework is needed to produce a guide (Evelyn, 2014).

Furthermore, this research observed that each of the four sustainable guide (and others) has an attached checklist to ensure compliance, monitoring and assessment purposes

by the different professions (Evelyn, 2014). This therefore, suggests that, the proposed sustainable residential design guide offers opportunity for other researchers to carry out similar research and possibly initiate and provide check list for drawing approval boards and agencies responsible for regulations in Nigeria (Evelyn, 2014).

Table 2.4 Four sustainable design guides in the UK and their design parameters

Councils / Parameters	London Borough of Barnet 2013	Castle Point Borough 2013	Highland Council 2013	West Lothian Borough 2013
Minimum Residential Space Standards	Minimum Residential Space Standards	-Privacy & Living Conditions - Enclosure & Boundary Treatment -Design Review	Buildings and their setting	Design and layout principle
Internal space layout	Internal Layout and Design	-Plot Size -Corner Plots -Detailing	Materials and traditional skills	-design and layout details -Design Codes
External space layout	Outdoor Amenity Space	-Amenity Space -Space Around Dwellings	The natural environment	Not considered
Natural light	Daylight, Privacy (minimum distance), Outlook and Light Pollution	-Building Lines -Roof Development - Parking & Access	Community facilities	amenity and privacy (daylight, sunlight &other privacy issues)
Local climate	Microclimate –Wind and Thermal Conditions	Not considered	Adapting to climate change	gardens and private open space
functionality	Lifetime Homes	Liveable Homes	-Making homes that last a lifetime -Working from home	adaptable buildings
accessibility	Wheelchair Housing	Not considered	Buildings fit for many purposes	Not considered
Energy efficiency	Energy Use in New Buildings	Energy Efficiency & Renewable Energy	-Energy efficiency -generating energy	energy efficiency
Water Efficiency	Water Efficiency standards	Water Efficiency standards	Making the most of water resources	water environment
Waste efficiency	Waste Strategy	Refuse & Recycling Storage	New ways with waste	impact of construction works
Air quality	Air Quality standards	Not considered	Unobtrusive developments	environmental considerations-air, noise, soil, light pollution etc
Noise pollutions	Noise Quality			
Flood strategies	Flood Risk, Sustainable Urban Drainage Systems and Water Quality	Not considered	Flooding	environment-mgt, SUDs, flooding etc
Biodiversity and Habitat Quality	Not considered	Landscaping	Valuing land as a scarce resource	protecting existing wildlife and natural habitats
Archaeological Investigation	Not considered	Not considered	Not considered	The historic environment
Pollution	Pollution Prevention, Contaminated Land Remediation and Construction Management	Not considered	Reducing construction waste	environmental assessment; construction &domestic waste
Transportation	Transportation	Not considered	Transport - Reducing the carbon footprint	transport assessments-assessments & safety
	www.barnet.gov.uk	www.castlepoint.gov.uk	www.highland.gov.uk	westlothian.gov.uk

Source: Compiled by the researcher, 2013

Also World Building Design Guide WBDG (2012a) has suggested that the built environment sector's framework should be developed as an output from the contributions made by the relevant professions in the sector (WBDG, 2012a). As such, an effective framework should be a product of interactive professional contributions (WBDG, 2012a).

According to Owens and Bressers (2013) the 'Contextual Interactive Theory' (CIT) employs the use of interactive activities in the development of a framework. Also other studies have suggested that CIT allow policy formulation to form part of a structured framework with other interactive processes and activities for the actualization of guides to reflect and suit research context from which the framework is developed (O'Toole, 2004; Kai, 2009). In their summary Owens and Brassers (2013) outlined the advantages of the CIT as follows:

- Ability to be adapted as an implementation tool
- Consistency
- Allows for comparative studies
- Replicable analyses
- Broad application and implementation
- Easy to identify strengths and limitations

Owing to these advantages and interactive participations of the built environment professional this research adopts the CIT as its underpinning construct for the development of the research's framework in chapter six.

This research thus, contributes by developing a framework in chapter six, from the outcome of findings from chapter five in order to aid the production of sustainable guides for the three climatic regions in Nigeria (Evelyn, 2014).

From Table 2.4 the key design issues or parameters used by the four sustainable guides were as much as possible grouped within the same column and cell (Evelyn, 2014). Although, in some cases similar parameters were grouped as an item but discussed separately, however, all guides have virtually the same parameters with occasional use of different words or terms (Evelyn, 2014).

Although, it is possible to achieve sustainability in the built environment through sustainable design guides, it is also important to identify the practical drivers, and the role they play (Evelyn, 2014). The London District Surveyors Association (LDSA, 2008) suggested that the drivers for sustainable design and construction practices should normally include:

1. Increased opportunities for development (LDSA, 2008).
2. Stakeholders and the public demands for development that is compliant with sustainability (LDSA, 2008).
3. Social responsibility-demand by clients for the integration of social and environmental considerations in order to ensure buildings have minimal running cost, aesthetics and healthy environment (LDSA, 2008).
4. Added value on quality and aesthetics to created spaces- This leads to higher returns on investments (LDSA, 2008).
5. Saving time and money- where a strong sustainability strategy is adopted for every development (LDSA, 2008).
6. Develop partnerships – where a guide is provided in order to ensure its mandatory usage in partnerships or collaborations amongst the built

environment professionals and government is encouraged (LDSA, 2008) with modifications

Although the guides suggested above by (LDSA, 2008) may have worked for England, arguably, it might not necessarily be holistically applicable to the three regions of Nigeria which are the primary focus for this research. One key reason could be because of variations in awareness levels, implementation of policies and acceptance of suggestions from regulatory bodies and perhaps topographies of both countries (i.e. Nigeria and the United Kingdom) (Evelyn, 2014).

2.9 STRATEGIES FOR CLIMATE CHANGE

This section discusses the two main strategies associated with tackling climate change; mitigation and adaptation (Evelyn, 2014). Both mitigation (avoiding the uncontrollable) and adaptation (managing the inevitable alongside the vital focus of social implications) are essential for tackling the challenges of climate change (IPCC, 2007; World Bank, 2009). Historically, mitigation and adaptation strategies were considered separately (Jones et al, 2007; Ayers and Huq 2009). However, adaptation has only recently been topical and relevant with the realization of a continuing increase of climate change incidences and its attribute to changes in human and ecological changes (Swart and Raes, 2007). Furthermore, the emergence of sustainable development alongside climate change considerations brought with it the challenges of incorporating the potentials of mitigation and adaptation strategies into the sustainable global agenda (Laukkonen et al, 2009).

However, earlier discussions (in section 2.3 to 2.7) have suggested that climate change is already evident and mitigation may therefore not be the sole option for stemming the challenges of climate change (Evelyn, 2014). Moreover, the earlier actions were not taken fast enough to reduce emissions thus making mitigation and adaptation to be applied as a

twin strategy in dealing with the challenges of climatic change (IPCC, 2007; Hamin and Gurran, 2009). Mitigation and adaptation have been briefly discussed to ensure a fuller understanding and clarity before balancing and integrating the two to draw out their advantages which will be pursued along with this project research's objectives (Evelyn, 2014).

2.9.1 Mitigation

Mitigation has been referred to as; the strategies or measures taken to help prevent or minimise the process leading to climate change (Nyong et al, 2007). The mitigation measures- which are most important include; carbon sequestration, clean development mechanism, joint implementation and use of reusable and non-polluting sources of energy(solar), wind and geothermal energy sources (VijiyaVenkataRaman et al, 2012). International targets have been set in 1997 by the Kyoto Protocol with a mandate period of between 2008 and 2012, during which time the developed countries should reduce their carbon emissions by at least 5% from their 1990 levels (UNFCCC, 2010). Earlier sections have established that the building industry has the greatest potential in mitigating greenhouse gas and carbon emissions and also emphasises the need to see what roles buildings play in mitigating climate change (Evelyn, 2014).

2.9.2 Mitigation in the building sector.

Basically, Cam (2012, pp.2) suggests that, "In the building sector, approaches to climate change mitigation must be in harmony with the wider sustainable development context". This demonstrates yet again that the emphasis is on the need for climate change strategies to comply with sustainable development, since the building sector has been identified as a major emitter of greenhouse gases leading to climate change globally (Evelyn, 2014). Thus, a great potential lies therein in tackling climate change (Evelyn, 2014). However, some barriers

associated with mitigation in the building sector have been identified and grouped by Cam (2012) to include, lack of awareness and access to technical knowledge, segmentation and fragmentation of the building sector, perceived financial disincentives and consumerism aspiration and rebound effect.

However, mitigation will be severely affected in the developing countries like Nigeria as suggested by the above barriers due to constraints associated with, limited and lack of accurate data (Ademiluyi, 2010) and acquired foreign (European) taste and preferences by Nigerians (Ekeng and Ewah, 2010). Despite these challenges Cam (2012) posits that energy used in buildings can be reduced by 60 percent by 2050, if actions within the sector are taken immediately to reduce their emissions.

One of such actions taken is presented in Urge-Vorsatz et al. (2007) study on 'Mitigating C02 emissions from energy use in the world's buildings'. It is also one of the few studies that covered residential buildings (Urge-Vorsatz et al. 2007). Their study was carried out to unlock the potentials in residential and commercial buildings based on 80 national and regional studies that span five continents, grouped into three economic regions; Developed countries (US, EU-15, Canada, Greece, New Zealand, Australia, Republic of Korea, UK, Japan and Germany), Economies in Transition (Hungary, Russia, Poland) and Developing Countries (India, Indonesia, and the Middle East as a group). They established and analysed the GHG emission potentials for each group as shown in Table 2.5, and they concluded that emission cuts are possible in three areas like reducing building consumptions, switch to lower carbon fuel and control of non-co_2 GHG in new and existing buildings (Urge-Vorsatz et al. 2007).

Further to the above, Urge-Vorsatz et al. (2007) in their conclusion suggested that, a huge reduction in C02 emission is achievable over the years with net negative cost, this recognizes

the fact that in most societies, particularly the advanced economies, new housing stock is usually about 1% of the total housing stock. Thus, old buildings remain significant to carbon reduction strategy. They further suggested the need for continuous research, although noted that the greatest challenge lay with retro fitting existing buildings, were 80 percent reduction is possible with new buildings (Urge-Vorsatz et al. 2007). They also suggested that relevant authorities' should carry out standard enforcement through the provision of assistance to the building design process (guide) and support energy services against energy efficiency barriers (Urge-Vorsatz et al. 2007).

Regrettably, the global outlook of Urge-Vorsatz et al. (2007) study is incomplete because of the obvious omission of Africa, for reasons best known to them. Therefore, their study and data presented could be said to be lopsided within the context of global data on GHG emissions from built environment. When critically viewed, it could be as a result of the near absence of specific data relating to buildings in Africa as observed earlier in the thesis. However, their study recommended further research to be done in order to provide assistance in the design process of buildings in form of design guides (Urge-Vorsatz et al. 2007). Thus, making this research project necessary, relevant and bridging the gap in their study (Urge-Vorsatz et al. 2007).

Table 2.5 Greenhouse gas emission reduction potential for the building stock in 2020

Economic region	Countries/country groups reviewed for region	Potential as a percentage of the national baseline for buildings	Measures covering the largest potential	Measures providing the cheapest mitigation options
Developed countries	US, EU-15, Canada, Greece, New Zealand, Australia, Republic of Korea, UK, Japan, Germany	Technical: 21–54%[a] Economic: 12–25%[b] Market: 15–37%	1. Shell retrofit, including insulation, especially windows and walls 2. Space heating systems and standards for them 3. Efficient lights, especially shift to CFLs and efficient ballasts	1. Appliances such as efficient televisions and peripheries (both on-mode and standby), refrigerators and freezers, followed by ventilators and air-conditioners 2. Water heating equipment 3. Lighting best practices
Economies in transition	Hungary, Russia, Poland, As a group: Latvia–Lithuania–Estonia, Slovakia, Slovenia, Hungary, Malta, Cyprus, Poland, Czech Republic	Technical: 26–47%[c] Economic: 13–37%[d] Market: 14%	1. Pre- and post-insulation and replacement of building components, especially windows 2. Efficient lighting, especially shift to CFLs 3. Efficient appliances such as refrigerators and water heaters	1. Efficient lighting and its controls 2. Water and space heating control systems 3. Retrofit and replacement of building components, especially windows
Developing countries	India, Indonesia, Argentina, Brazil, China, Ecuador, Thailand, Pakistan, Middle East as a group	Technical: 18–41%[e] Economic: 13–52%[f] Market: 23%	1. Efficient lights, especially shift to CFLs, light retrofit, and kerosene lamps 2. Various types of improved cook stoves, especially biomass stoves, followed by LPG and kerosene stoves 3. Efficient appliances such as air-conditioners and refrigerators	1. Improved lights, especially shift to CFLs light retrofit, and efficient kerosene lamps 2. Various types of improved cook stoves, especially biomass based, followed by kerosene stoves 3. Efficient electric appliances such as refrigerators and air-conditioners

Source: Urge-Vorsatz et al. (2007) pp. 387

2.9.3 Adaptation to Climate Change

It is argued that: "Developing countries are the most vulnerable to climate change impacts because, they have fewer resources to adapt: socially, technologically and financially. Climate change is anticipated to have far reaching effects on the sustainable development of developing countries including their ability to attain the United Nations Millennium Development Goals by 2015. Developing countries need international assistance to support adaptation in the context of national planning for sustainable development" (UNFCC, 2007; pp.5).

The quotation above demonstrates that adaptive measures within developing countries like Nigeria, and also points out the need for such measures to be simplified, efficient as well as cost effective. Thus, this underscores the purpose of this research which is to develop a framework that ensures the formulation of sustainable design guides which are simple, effective and efficient (Evelyn, 2014).

Adaptation is the actions taken by societies, individuals, groups and government, and are motivated by factors such as protection of economic well-being or the improvements of safety (Adger et al, 2005). Adaptation to climate change also refers to adjustments in natural and human systems in response to actual or expected climate change impacts, which moderate, harm or exploit beneficial opportunities (IPCC, 2007). Basically, adaptation can either be reactive or anticipatory (Evelyn, 2014). Reactive adaptation refers to the spontaneous adaptation which is an action taken after an observed change that triggers an unconscious action (Evelyn, 2014). On the other hand, anticipatory adaptation is seen as the proactive plans put in place to potentially correct climatic impacts (Evelyn, 2014). In this case it is put in place before the impacts of climate change therefore, a conscious action (Smith et al, 1997).

The United Nations Framework Convention on Climate Change, UNFCCC (2010) reports that adaptation is needed to tackle the impact of climate change which is necessary to increase resilience to future impacts for vulnerable populations, sectors, communities and ecosystems; and to enable climate-resilient development (UNFCCC, 2010). The report also stated that adaptation limits the vulnerability to climate change impacts and the most interesting aspect of the report is its specific reference to developing countries as "Assessing, planning and implementing adaptation actions is a necessity for all countries, particularly developing countries" (UNFCCC, 2010, pp. 12).

The measures to reduce GHG emissions (mitigation) as part of the climate challenge are laudable but adaptation has become an essential part of the challenge (Evelyn, 2014). Noting that attempts on reducing emissions are not insufficient as the research agenda is shifting from mitigation (controlling greenhouse emission) to adaptation (responding to climate change) due to the frequencies of occurrences of climate change (Evelyn, 2014). Adaptation is required to counteract the impact of climate change that mitigation cannot tackle; this synergy is possible for development (Klein et al, 2007). Similarly, further arguments for incorporating adaptation are necessary for the fact that climate change is already taking place and its occurrences are on the increase (Adger et al, 2007; Shaw et al, 2007; Solomon et al, 2009).

Adaptation is argued to be, tangible, easier to instigate, more approachable and more inclusive at all levels and therefore, has the advantage of incorporating local stakeholders (Laukkonen et al, 2009). The more recent opinions suggest that the advantages of adaptations outweighs that of mitigation, and are due to continuous historic emissions which makes adaptation unavoidable (Bond, 2010; Berrang-Ford et al, 2011; Bosello et al, 2011).

Sequel to the above therefore, adaptation builds adaptive capacity; increases resilience of individuals, groups and organizations or regions and it has the ability for continuality: which makes it possible to further research; activities, actions, decisions and attitudes that affect life, which reflects on social norms processes (Evelyn, 2014). It promotes society and communities' ability to cope, as well as providing about the risks posed by climate change (Tompkin et al, 2010).

2.9.4 Mitigation and Adaptation: Commonalties and Contrast

Furthermore, in an attempt to establish the similarities and differences between mitigation and adaptation, Jones et al, (2007, pp.686.) observed that up "to date, most work on adaptation and mitigation has dealt with each separately, leaving any potential links between the two relatively unexplored". Hence, this section is focused on exploring the potentials of combining mitigation and adaptation as this would lead to achieving the main objective of this research, especially as it relates to the design guide (Evelyn, 2014). The importance of engaging the twin strategies of mitigation and adaptation have been argued for by many successful climate change management Willbanks et al. (2003); Klein et al. (2007); Dowlatabadi, (2007) cited in Ayers and Huq (2009). Further argument suggests that without adaptation the most stringent mitigation efforts would be impervious to the impact and limits the attainment of sustainable development challenges of Climate Change (Ayers and Huq 2009).

However, although the twin strategies are not without areas of difference, it is the potential in their commonalities that are to be taken advantage of in this research project (Evelyn, 2014). Ayers and Huq (2008), Klein (2007) and Laukkonen et al. (2009) articulated the commonalities and contrasts in the integration of mitigation and adaptation measures for climate change, using developing countries as case studies. Although, the three studies were

conducted separately using different methods, their results are unanimous on the advantages and barriers to the potentials of integrating mitigation and adaptation strategies (Evelyn, 2014). Table 2.10 gives a summary of the differences and areas of commonalities of mitigation and adaptation (Evelyn, 2014).

After reviewing the IPCC Fourth Assessment Report on Climate Change 2007 (AR4 WG II), Klein et al. (2007) in an attempt to draw out the links between adaptation and mitigation of climate change concluded that the bases for synergy should be for the interactions of mitigation and adaptation strategies that when combined yields a much more effective impacts or effects greater than the impact of a single strategy and policies, and also:

1. Increased cost-effectiveness (Klein et al. 2007).
2. Provide no guarantee that resources are used in the most efficient manner when seeking to reduce climate risks (Klein et al. 2007).
3. Opportunities to create synergies are greater in some sectors (e.g., agriculture and forestry, buildings and urban infrastructure) but are limited in other ones (e.g., coastal systems, energy and health) (Klein et al. 2007).
4. The ability to create synergies is limited by the absence of a relevant knowledge base and of human, institutional and organisational capacity (Klein et al. 2007).
5. Increased spending on adaptation does not mean that less money is available for mitigation, or vice versa (Klein et al. 2007).

The third point above suggests therefore that the building and urban infrastructure sector is potentially capable of benefitting from the synergy that mitigation and adaption has to offer however, the fourth point suggests the problem lies with limitations from relevant knowledge and human capabilities (Evelyn, 2014). Conversely, other barriers Klein et al. (2007)

observed include the fact that different actors are involved in mitigation and adaptation, which can cause greater institutional complexity. It is therefore also doubtful if there are sufficient opportunities for synergies to achieve the necessary levels of mitigation and adaptation, hence the need for further research to test the applicability of this synergy (Evelyn, 2014).

Corroborating the research findings above, Laukkonen et al. (2009) concluded that mitigation and adaptation may be complementary but argued that there is the need for decisions to be determined at local levels through the use of simpler local tools, framework, methodologies and their dissemination to communities in order to identify the most effective strategy and or synergy. This would help the operator make choices and make decisions on how best to cope with the variability of a changing climate (Laukkonen et al. 2009). Thus, the applicability of the synergy can be tested across the three climatic regions in Nigeria (Laukkonen et al. 2009).

On the other hand, the study by Ayers and Huq (2009) was aimed at finding out the possibility of linking mitigation and adaption at project levels in the developing countries vulnerable to climate change impacts. Their study also noted that mitigation as a strategy has been much favoured than adaptation measures by the developed countries. This may be explained by the huge scope available for mitigation relative to adaptation possibilities (Evelyn, 2014). Their conclusions further shows that the synergies for mitigation and adaptation will allow for a faster implementation of climate change projects and sustainable development (Evelyn, 2014). In addition, this would most certainly bridge the gap between western priorities and global commonalities, Ayers and Huq (2009).

Furthermore, the three studies agreed that the advantages of the synergy for mitigation and adaptation outweigh the disadvantages (Evelyn, 2014). The building industry has great potential for successful synergies applications, balancing the proportional synergy

mix can only be determined at local level in relation to the impact level and therefore a justifiable mix must be robust and flexible (Evelyn, 2014). Finally, all synergies are a demonstration of combined efforts to limit GHG emissions and reduce effects of climate change (Evelyn, 2014). Thus, this research supports the adoption of the synergy of mitigation and adaptation concurrently within the built environment and particularly for the production of sustainable residential buildings (Evelyn, 2014).

2.9.5 Advantages and Disadvantages of mitigation and adaptation synergies

The following advantages of mitigation and adaptation synergy identified by Ayers and Huq (2009), Klein et al. (2007) and Laukkonen et al. (2009) include:

1. Synergy is essential for achieving the Millennium Development Goals (MDGs) because the synergy offers opportunity for sustainable development that leads to poverty alleviation (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).
2. The synergy allows for strategic complimentary application (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).
3. It makes sustainable development easier to be achieved through the implementation of mitigation and adaptation policies in built environments, especially in developing countries (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).
4. It is “crucial” for the built environment due to long life span associated with infrastructures (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).

Basically, the lack of co-ordination appears to be the principal disadvantage associated with mitigation and adaptation synergies, although both are quite relevant (Shaw et al, 2007). However, these disadvantages have been identified by Ayers and Huq (2009), Klein (2007) and Laukkonen et al. (2009) to include:

Lack of coordination in supporting the synergies (especially from the fragmentation in the building sector): This is due to the different professions that are in the built environment, with each profession having its on focus based on their professional requirements.

Secondly, institutional complexes arising from different operational level and actors: The differences in the professions in the built environment means that these professionals have their different professional institutions as such, it becomes difficult to harmonize their activities (Evelyn, 2014). Furthermore, a building designer may not be part of the actual construction team, maintenance and the deconstruction team which creates complexes for the industry (Evelyn, 2014).

Thirdly, dense-built environment can reduce the level of incorporation of urban green (this reduces the use of cooling aid and flooding):Where buildings in neighbourhoods are densely spread, it makes it difficult to introduce remedial and retrofitting strategies involving the creation of green spaces and open water surfaces that can control heat islands and flooding (Evelyn, 2014).

Finally, the uncertainty of climatic changes: Climate change impacts from earlier review are not 100% predictable, as such unforeseen extreme climatic changes may not be adequately planned for to mitigate and adapt (Evelyn, 2014).

Furthermore, Klein (2007), Ayers and Huq, (2009) as well as Laukkonen et al. (2009) believed that the effective implementation of the synergy will offer the following opportunities;

1. SMART planning (Specific, Measureable, Assignable, Realistic and Time) (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)

2. More conscious aesthetics buildings and landscape due to considerations for the natural environment (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
3. High valued and quality built environment (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
4. High potential cost benefit over time (against the seemly initial high cost) (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
5. Strategies that are operational at all levels (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
6. Intuitive appeal of conducting climate change policies (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
7. Simultaneous actions at all levels (individual, local, national and international (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009)
8. Overlap functions associated with the pillars of sustainability (economical, environmental and social considerations) (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).
9. Incorporating traditional local knowledge and stakeholders' participation in decision-making (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).

Hence, SMART planning is a multi-disciplinary initiative that involves planning professionals who work to merge and manage the aims and objectives of individual project to mitigate and adapt (Poister, 2008; Dwyer and Hopwood, 2010; Richman, 2011; Yemm, 2013). Subsequently, mitigation and adaptation strategies may not be easily overlooked because there is a high potential of check and balances (Evelyn, 2014). Furthermore, achieving the aims and objectives of any project within the built environment will make the project to explore and achieve the opportunity and potentials enumerated by Klein (2007), Ayers and Huq, (2009) and Laukkonen et al. (2009) above.

Also, Ayers and Huq (2009), Klein (2007) and Laukkonen et al. (2009), advanced some examples on the application of both synergies like; tree planting in cities including green roof garden, should be encouraged with tax breaks. This will certainly reduce urban heat island. This will serve as mitigation process because trees and green roof gardens will help absorb carbon from the atmosphere and then provide natural cooling for the environment. This helps to adapt to warmer climate and reduces flooding (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009). Secondly, open storm-water system: sinks carbon (using urban wetlands) and cools the environment through the use of open water surfaces (Ayers and Hug, 2009; Klein et al. 2007; Laukkonen et al. 2009).

Another example is the use of local and low water plants for landscaping and shading (adapts to rising temperature and mitigates the impacts) and finally, is the fact that urban density allows for shorter commuting distances which make it easy to implement the use of common energy schemes, thereby reducing urban heat island by the reduction in transportation emissions (Evelyn, 2014).

Harnessing the synergies between mitigation and adaptation is particularly beneficial in hot climates like that which obtains in Nigeria. Finally, the arguments for integrating mitigation and adaptation strategies geared towards addressing the problems caused by climate change arises from the non-overlapping functions of both strategies, which would be closed up when both strategies are engaged. Hence, this is one argument underscoring the decision to undertake this research in an attempt to bring both strategies together (Evelyn, 2014). This is consistent with Egenhofer, (2008, pp. 59) “We basically have three choices- mitigation, adaptation and suffering. We’re going to do some of each” (Egenhofer, 2008).

The above extract captures what this research project proposes to do; which is to employ the use of both mitigation and adaptation in order to alleviate the suffering created by

the non-overlap by integrating the two strategies (Evelyn, 2014). Looman (2007) also suggests that a climate-responsive building would generally respond to; the environment, climate, and occupants comfort in combination with passive energy strategies for optimal performance which are basically achievable through design.

Conclusively, the design process is therefore a key to achieving optimal performances of buildings that are capable of reducing emissions, adapting and reacting to climatic changes (Evelyn, 2014). This would be the main function expected from the design guide proposed in this study (Evelyn, 2014).

2.10 CHAPTER SUMMARY AND CONCLUSIONS

Findings from the literatures covered are indicative that climate change research is increasingly gaining momentum in the built environment because of the pivotal role of the built environment, since both are source and solution to global environmental degradation, particularly with regards to climate and the attendant effects (Evelyn, 2014).

Firstly and quite significantly, a wide range of literatures covered are based on findings from the developed countries, which may not be directly applicable in the developing countries but allows research validation and reference usage (Evelyn, 2014). It also highlights possibilities of drawing areas of common grounds and some of the findings could be applied to addressing Nigeria climate change challenges (Evelyn, 2014). This becomes necessary because there is currently very limited research that has been done in the area of climate change in sub-Saharan Africa, were limited research data exists on the interrelationship between climate change and buildings in Africa (De Wilde 2012). Therefore, this research would attempt to undertake an exploratory and pioneering study in the field of Climate Change and buildings in Nigeria (Evelyn, 2014).

Secondly however, perceived cost should not out-weigh the potential benefits that are associated with tackling climate change (Reuse, 1993), hence using design approach to reduce GHG emissions (mitigation) as well as to cope with vulnerability (adaptation) of climate change on buildings which should be an economic option for a developing country like Nigeria.

Thirdly, the discussions in section 2.5 suggest that buildings are the main GHG carbon emitters but the bulk of the emissions are from residential buildings (Evelyn, 2014). This is also important because human beings spend most times of their lives inside houses as noted earlier in section 2.2 (Evelyn, 2014).

Conclusively, the synergy between mitigation and adaptation measures can be used effectively to harness and address the challenges of climate change through sustainable design, and one of the ways this can be achieved is through the development and use of an acceptable design guide (Evelyn, 2014). Generally, it is clear that design professionals have a fundamental role to play in advancing mitigation and adaptation strategies that will ameliorate the impacts of climate change on buildings, and the best phase to do this is at the design phase (Evelyn, 2014).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology that was employed to collect, collate, analyze and interpret the research findings. Section 3.2 highlights the data types and sources, which includes the primary sources and secondary sources of data. 3.3 discussed the research data matrix philosophies that underpin this research. 3.4 discussed the research population gives an overview of the research methodology. 3.5, 3.6 & 3.7 examined the sampling frame, sample size and sampling techniques used for the research. 3.8 highlight data collection instrument. 3.9 discuss procedure for data collection. 3.10 states method of data analysis and finally 3.11 discussed data processing and analysis.

3.2 Data Types and Sources

Traditionally, research methods are basically qualitative and quantitative in nature also known as primary and secondary sources of data. These involve the way data are collected, analysed and interpreted. For this research work qualitative data was adopted, this is because this study is subjected to observing, describing experience, texture etc. this data is collected through qualitative observation.

The data sources for this research were commulated from qualitative observation of the two study areas which are;

1. The Centenary Celebration of Egedege N'okaro , Benin City, Edo State and
2. National Museum, Benin City Edo State.

3.3 Research Data Matrix

The research data matric of this study is how climate change has an impact on building designs and architectural environment tries to comprehend the ramifications of these changes as well as how the city's architectural landscape has been shaped by global forces

3.4 Research Population

For the population of study of this research work, because of the design and method of this study which is mostly observation and conclusion drawn. The population of the study are basically conventional buildings methods, materials, and design concepts used in Benin City's historical architectural style.

3.5 Sampling Frame

It is an established fact that samples and population form a critical aspect of data collection in any research. For the sampling frame of this research work, the design and method of this study which is mostly observation and conclusion drawn.

3.6 Sample Size

An important aspect of a research is the sampling consideration. Since this projected is limited by time and funds considerations are based on what methods best suit the research. The sampling size for this study are two prominent places in Benin City which are;

1. The Centenary Celebration of Egedege N'okaro , Benin City, Edo State and

2. National Museum, Benin City Edo State.

3.7 Sampling Techniques

The sampling techniques of collecting data for this study was the observation method of data collection, this involve going to the specific locations (these are called case study (s)), observing how the location is significant to the study and also taking significant pictures to enhance the study.

3.8 Data Collection Instrument

Instruments used for the collection of data for this study include interview with various categories of indigenous home owners of various class. The design plans were observed and conclusions drawn.

3.9 Procedure for Data Collection

The procedure for data collection to this research is the qualitative approach, qualitative research is the collection, analysis, and interpretation of comprehensive narrative and visual data to gain insights into a particular phenomenon of interest. Qualitative research can be characterized as the simultaneous study of many aspects of a phenomenon and the attempt to study things as they exist naturally. This approach uses inductive reasoning.

3.10 Data Processing and Analysis

The research adopted two variables for this study, which are the independent and the dependent variables. The independent variable of this study is the study of Benin City's Changing architectural scene and cultural preservation while embracing the opportunities

provided by globalization, while the dependent variable of this study is the impact of globalization on architecture in Benin City.

CHAPTER FOUR

ANALYSIS, FINDINGS AND DISCUSSION

4.1 CASE STUDY ONE:

Name: The Centenary Celebration of Egedegbe N'okaro.

Location: Benin City, Edo State.

Architect: Unknown

Brief Intro: This centenary is the hundredth anniversary of Egedegbe N'okaro, and this building was built to continue celebrate his life lived on earth. This is significant to our study because its an ancient building, especially in Edo State and a result of that, the building has experienced a lot of climate changes which are seen obviously on the building physically.

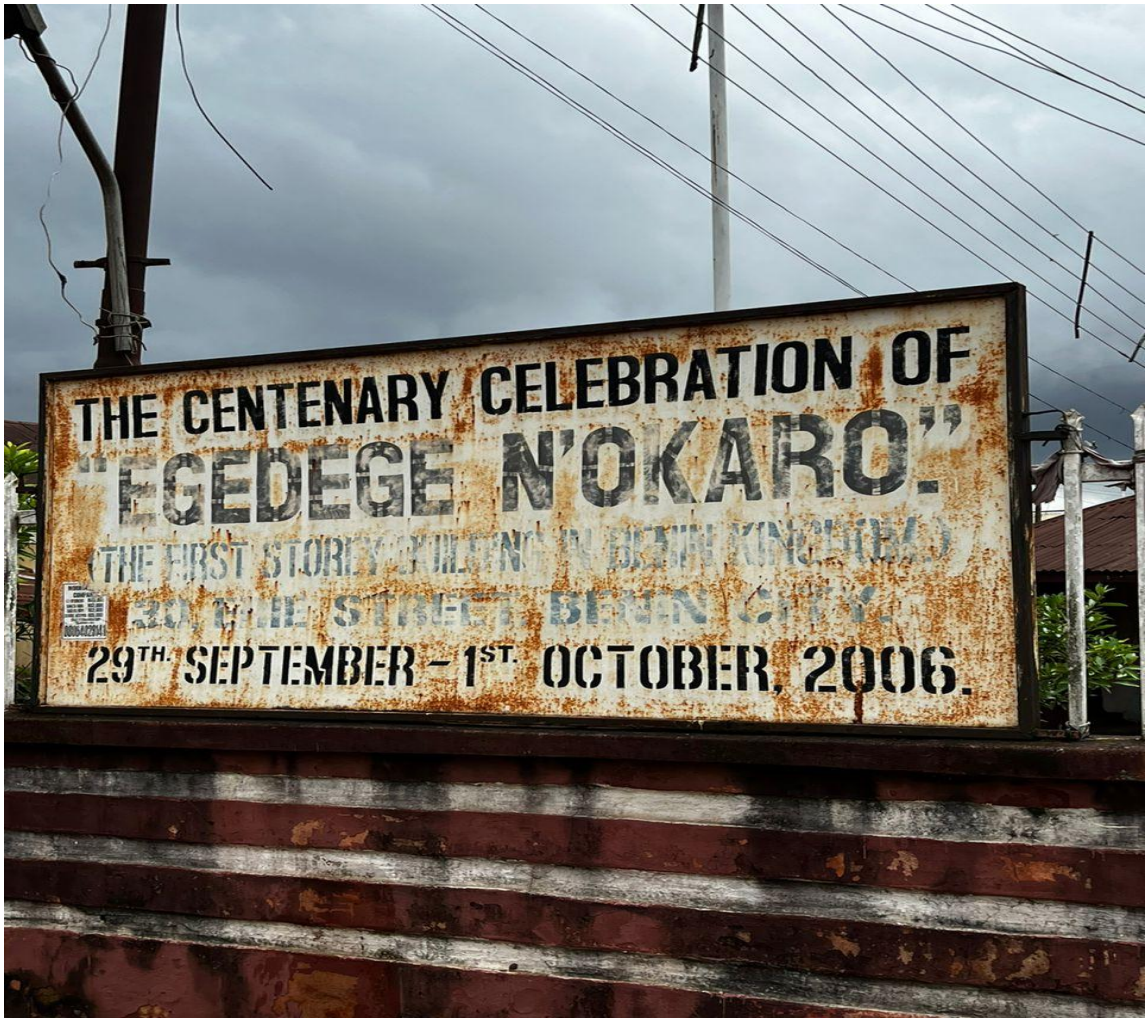

Plate 1: View of the entrance showing the signpost

Plate 2: Front view

Plate 3: Inside view

Plate 4: Roof view

4.2 CASE STUDY TWO:

Name: National Museum.

Location: Benin City, Edo State.

Architect: Unknown

Brief Intro: This building is also one of the most significant building here in Edo State, this is because of how long it has been built and has stayed, also how climate change has affected the building for the period of time it has been.

Plate 5: Front view

Plate 6: Back view

Plate 7: Left Elevation view

Plate 8: Inside view

4.3 SITE ANALYSIS

The site is considered to have various elements for the execution of the individual buildings which includes.

CLIMATE: The climate is tropical in Benin. The summers are much rainier than the winters in Auchi. The climate here is classified as Aw by the Koppen-Geiger system. In Benin City, the average annual temperature is 25.9 °C. Precipitation here averages 1389 mm. During the dry season, the area experiences excessive sunlight which keeps the environment relatively hot. During the wet season. there is usually heavy down pour which does not fall for a long time.

TEMPERATURE

The temperature in the area differs from season to season; the temperature of the atmosphere influences the amount of water present in the atmosphere at a particular time. During the dry season the average temperature in the area is 29°C, while at wet season the temperature in the environment is 20°C (average).

RELATIVE HUMIDITY

The humid condition in the area varies from season to season. The humidity is relatively high in rainy season (wet season) due to excessive rainfall. While the humidity is relatively low and dry during the dry during the dry season due to the hot and dry wind brought about from the North-hast, and at that period of time it brings about the Harmattan,

RAINFALL

The predominant type of rainfall in the region or area during rainy season is usually high especially at early stages of the season towards the end of the season; the rainfall is characterized by the enormous intensity of high thunder storm. High temperature and dry wind from the North-East can reduce the amount of rainfall to about 60% to 50% during the dry season and the number of the rainy days is up 6 days per month. While during the wet season, the number ranges from 17-26 days per month. The South-West trade wind brings torrential rainfall to the zone.

PREVAILING WIND

The most prevalent wind is the South-West wind which is accompanied by cold air and rainfall. However, the area usually experiences dry wind as a result of the North-East wind which is accompanied by harmattan. The wind is actually cold and comforting. In Benin City the hottest months are usually February to April, Harmattan months are the cooler months in Benin City and arc from October to January, when dry winds from the northern Sahara regions blows.

SOIL TYPE AND CONDITIONS

The site consists of literate soil with adequate natural drainage capacity.

VEGETATION

There are trees, shrubs, greens present on site which are of relevance to the building construction by serving as shades, adding Aesthetic values etc.

SOLAR RADIATION

The sun rises from the east by 6:30am and sets on the west by 6:30pm every day.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The following are the summary of findings of this project work;

- Climate change is no longer a myth or subject for debate but rather a subject for action (Evelyn, 2014).
- There is a two way relationship between climate change and buildings (Evelyn, 2014).
- There is huge evidence of the negative impacts of climate change globally and particularly in Nigeria (Evelyn, 2014).
- There is very little research activities in the subject of climate and buildings in the sub-Saharan region of Africa (Evelyn, 2014).
- Sustainability has been acknowledged as a global strategy for tackling environment development due to the challenges of climate change (Evelyn, 2014).
- While the developed countries have employed the use of design guide to provide sustainable building designs guides and for sustainability of the built environment, there is no known design guide in Nigeria (Evelyn, 2014).
- Information, subject knowledge, location and stakeholders' collaboration have been identified as key to achieving sustainability in the built environment (Evelyn, 2014).
- There is no known data on the carbon emissions specifically from residential buildings in Nigeria (Evelyn, 2014).
- The twin strategies of mitigation and adaptation have huge potentials to reduce and minimise the impacts of climate change on buildings vice versa (Evelyn, 2014).
- 20% of design decisions has 80% influence on the entire design of buildings (Evelyn, 2014).

- Design decision tools are limited globally and lacking in Nigeria (Evelyn, 2014).
- Divergence views and focus amongst the built environment professionals globally has slowed down the progress of achieving environmental sustainability (Evelyn, 2014).
- Established the research problem and this research context (Evelyn, 2014).
- Established the unit of analysis for this research project (Evelyn, 2014).
- That there exist a relationship (causal and effects) between climate change and buildings globally (objective 1 and research question 1) (Evelyn, 2014).
- That there is little knowledge and information on the relationship between climate and buildings by the built environment professionals in Nigeria. However, the participants are willing to change their level of awareness in this regards (objective 1 and research question 3) (Evelyn, 2014).
- There are regional differences on the impacts of climate change on residential buildings in Nigeria. Hence, in the same way there are differences on the climatic design parameters for the three climate regions in Nigeria. Thus, Regional design parameters were identified (Objective 2 and research question 4) (Evelyn, 2014).
- Participants rated highly the potentials of the proposed use of residential design guide but also pointed out the likely challenges that would serve as impediments (objective 4 and research question 5) (Evelyn, 2014). These includes:
    - Time lapse; due to unnecessary institutional delays (Evelyn, 2014)
    - Corrupt practices are found at the three tiers (Federal, state and local government) of governance(Evelyn, 2014)
    - Weak or faulty institutional structures (Evelyn, 2014)
    - Lack of information on the state of the proposed policy draft document on climate change and buildings (Evelyn, 2014)

- Lack of effective collaborations amongst professionals within the built environment in Nigeria was also identified (objective 5). The way forward in this regards was suggested as follows (Evelyn, 2014):
    - Encourage effective collaborations amongst the built environment professionals by creating interactive fora (Evelyn, 2014).
    - Participants also suggested that environmental issues should not be politicized (Evelyn, 2014).
- Although the Nigerian government and policy makers have the capacity and human resources to initiate, monitor and enforce the implementation of sustainable actions, yet there are no visible actions in this regards (objective 5) (Evelyn, 2014).

5.2 CONCLUSION

The limited research information and data in this subject in Nigeria was one of the key motivations for undertaking this research. The concurrent embedded strategy shaped the research investigations and findings (Evelyn, 2014).

These findings revealed that, the design parameters for each of the three climate regions are primarily dependent on the impacts of climate change impacts on each region. Although there is no known sustainable design tool in Nigeria, the participants overwhelmingly supported the proposal for a design guide as a decision tool. Theoretical findings have identified effective collaborations as a key to achieving sector based successes on sustainable development. The primary findings on collaboration were validated by the participants' responses and particularly the fact that they were interested in providing suggestions for achieving effective collaborations. It is on these premises that the researcher is confident on the potentials of the framework developed and likelihood that the framework would be adopted in the near future by these stakeholders (Evelyn, 2014).

In the overall, this research and its findings are aimed at promoting and enhancing the sustainability of the built environment. Therefore, there is need for other researchers in Nigeria to take up such challenges and embark on more research studies and as a result provide data as tangible evidence to argue for more government actions for the overall good of sustainable development in Nigeria (Evelyn, 2014). Thus, the research aim is achieved with the formulation of a sustainable residential design framework. Also, all the research objectives and research questions were addressed as stated at different sections of this thesis (Evelyn, 2014).

5.3 RECOMMENDATIONS

Following discussions on the subject of climate change and buildings in Nigeria and the major findings of the research, some recommendation are imminent (Evelyn, 2014). The recommendations are presented as follows (Evelyn, 2014):

- **Recommendations for government and policy makers**
    - It is necessary for the government to encourage active participation of the built environment professionals (stakeholders) on its policy formulation teams in order to encourage interactions and collaborations (Evelyn, 2014).
    - There is the need for the Nigerian government to encourage institutionalized climate change initiatives at all tiers of government. In order to ensure effective monitoring, evaluation, control mechanism and implementation of climate change initiatives (Evelyn, 2014).
    - There is the need to facilitate and quicken the actualization of the seemingly 'comatose' climate change policy draft and thereafter, to carry out an immediate review in conjunction with professional representatives and other relevant stakeholders (Evelyn, 2014).

- To set machinery in place to check and eradicate corrupt practices, especially at building design approving boards and planning authorities (Evelyn, 2014).
- To fund climate change information and awareness campaigns and research activities (Evelyn, 2014).

- **Recommendations for the built environment professionals**
  - To facilitate the adaptation of the developed framework as a professional body to avoid unnecessary delays (Evelyn, 2014).
  - To raise the awareness and knowledge of its members on climate change and buildings at different platforms of professional development (Evelyn, 2014).
  - Employ the use of its members as vanguards for sustainable professional practices in all the 36 states of Nigeria including the Federal Capital Territory (Evelyn, 2014).
  - To encourage researchers to disseminate productive research findings to its members during professional deliberations and at their traditional Annual General Meetings (AGMs) (Evelyn, 2014).
  - To encourage collaborations within and outside individual professions within the built environment and related sectors (Evelyn, 2014).
  - To reward sustainable good practices and methods (Evelyn, 2014).
  - To showcase and celebrate localised research activities, innovations and milestones within the building sector (Evelyn, 2014).
  - To be willing participants, promoters and educators on government sustainable initiatives (Evelyn, 2014).

5.4 CONTRIBUTION TO KNOWLEDGE

This project is a pioneer research undertaken on the subject of climate change and buildings in Nigeria. The research is also able to achieve its intended research aim and objectives,

through a mixed method investigation which explored the concurrent embedded strategy. Subsequently, the research developed a framework that would aid in adopting specific sustainable residential design guides for each climatic region of Nigeria (Evelyn, 2014). Hence, the novelty in this research project. The research has contributed to the body of knowledge as follows (Evelyn, 2014):

- The framework: This would help facilitate design decisions tools (Evelyn, 2014).
- This research has added value to the body of knowledge and for Nigeria in particular with its data (Evelyn, 2014).
- Climatic design parameters for the HCR, TSC and TRC have been established (Evelyn, 2014).
- Findings would provide data and reference for future research and testing (Evelyn, 2014)
- The study has helped raise awareness of climate change and buildings by various explanations given to participants during the field studies (Evelyn, 2014).
- Three peer review papers were published as a result of this research and future publications are expected relating to this research and feedback on the framework developed (Evelyn, 2014).
- Research findings are relevant for academic purposes, public and private practices and for policy formulations (Evelyn, 2014).
- Findings from this research involved professionals from all the three practice types (academic, public and private) and therefore cuts across varied professional focus. Hence, its potential and relevance to those practices (Evelyn, 2014).
- The research instruments were developed mainly for the purpose of this research project (Evelyn, 2014).

5.5 AREAS FOR FUTURE RESEARCH

This research project is not a final solution but an on-going contribution to the body of knowledge (Evelyn, 2014). As such, future research is suggested to be directed towards the following (Evelyn, 2014):

- To improve upon this research possibly through the use of new technologies to produce software applications (Evelyn, 2014).
- Future research can be directed on the impacts of climate change on traditional architecture in Nigeria (Evelyn, 2014).
- Collaborative research is also necessary to have a complete sector based data (Evelyn, 2014).
- Case study investigations with similar context are possible (Evelyn, 2014).
- Testing of the framework by the researcher and other researchers is encouraged (Evelyn, 2014).
- More publications are anticipated from the findings from this research project (Evelyn, 2014); particularly the researcher intends to undertake studies on the application of the proposed framework (Evelyn, 2014).

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